MARKET AND VALUE CHAIN ANALYSIS OF SEAWEED IN BANGLADESH

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This is to certify that we have examined the above Master's thesis and have found that it is complete and satisfactory in all respects and that all revisions required by the thesis examination committee have been made

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Abstract

Seaweed, a multicellular marine macroalgae, generates valuable resources that are used for a variety of applications, mostly in food and medicine. Surveys were conducted in Cox's Bazar and Bandarban districts between April 2022 and November 2022 to assess the marketing system, farming and marketing expenses, marketing margin, and to analyze the value chain of seaweed. The marketing margin, net return, return on investment, and farmer's shares were determined using many pertinent formulae and procedures. Nine marketing channels were established for promoting and selling seaweed produced in the Cox's Bazar coastal region. Of the identified seaweed marketing routes (a-i), channel ‘e’ was the longest and accounted for the biggest proportion (67%) of the total crop that reached the target customers. Seven participants engaged in seaweed value chain activities were identified, including farmers/wild stock harvesters, local market retailers, farmgate wholesalers, distance market wholesalers, distance market retailers, seaweed product developers, and consumers. The farmers achieved an average net return of 6064.66 Tk. and a return on investment (ROI) of 104.59% by cultivating seaweed in a 24m^2 area for a period of 5 months. Although wholesalers in distance markets had the greatest marketing expenses, retailers in distant markets achieved the best marketing margin, net return, and return on investment (ROI) compared to other intermediaries. The distant market merchants contributed the maximum value per kilogram of seaweed, whilst the farmgate wholesalers added the lowest value. As a result of a limited local market and insufficient connection between farmers and distant market participants, farmers were compelled to sell a significant amount of their overall produce at a reduced price to farmgate wholesalers. Hence, the proportion of the consumer's price that goes to the farmer at the retailer level in distant markets is around 64.14%, while the remaining part of over 35% is allocated to market intermediaries. Several solutions were discerned based on the perspectives of seaweed growers and sellers in Bangladesh, aimed at enhancing seaweed growing, market demand, and pricing. The recommendations derived from the perspectives of market participants should be promptly implemented by the appropriate bodies to enhance the seaweed industry.

Keywords: Seaweed, value chain, market channel, marketing margin, (ROI%), Farmer’s share.

Chapter 1: Introduction

Seaweeds are photoautotrophic multicellular macroalgae that can be found on rocky coasts and solid substrates down to the photic marine ecosystem's lowest point (Dring, 1991). In terms of physiology and morphology, seaweeds differ from freshwater algae and terrestrial plants (Creed et al., 2019). Seaweed has no root systems, leaves, stems, fruits, or seeds (Round, 1976). They grow in the intertidal and subtidal zones of the sea and possess photosynthetic pigments, allowing them to photosynthesize and create food (García-Poza et al., 2020).

Brown algae (Ochrophyta-Phaeophyceae), red algae (Rhodophyta), and green algae (Rhodophyta) are the three types of seaweeds (Chlorophyta). These organisms create a variety of structural molecules (primary metabolites), such as proteins, lipids, and carbohydrates, as well as other bioactive substances (secondary metabolites) with applications in a variety of fields (food, feed, agriculture, cosmetics, pharmaceutical and biotechnological) (Leandro et al., 2019).

Seaweeds are commonly used to extract phycocolloid, also known as seaweed gum. The greatest market for tropical seaweed is this phycocolloid. Agar (produced from red seaweed), carrageenan (derived from red seaweed), gelatines (derived from red seaweed), and aligns are the four major types of phycocolloids (derived from brown seaweed). The Asia-Pacific region is the world's leading producer of phycocolloids and carrageenan one of the four varieties of phycocolloids, is frequently produced from seaweeds (Sarker et al., 2021a). *Gracilaria* sp. are one of the main producers of agar due to their fast growth and large agar content being responsible for 80% of the global production of this phycocolloid (Arbit et al., 2019). *Gracilaria* and *Gracilariopsis sp*. are red algae (Rhodophyta) currently accepted taxonomically, with 185 and 24 species respectively (Guiry and Guiry, 2020). *Gelidella* and *Gracilaria* sp. are extensively used not only for the production of agar but also for the treatment of gastrointestinal disorders (Armisen, 1995).

Seaweeds are now considered the food supplement of the twenty-first century due to their superior nutritional profile. Demand for seaweed and seaweed products was higher than supply as early as the 1970s, and cultivation was considered as the best way to expand production (Ghose and Hossain, 2020). The global seaweed business is quickly expanding due to the significant economic value of seaweeds. Seaweed

cultivation grew by 50% in the last two decades due to growing demand (Nayar and Bott, 2014). Seaweed production, for example, has more than tripled since 2000, from 10.6 million tonnes to 32.4 million tonnes in 2018. The vast majority of these global products (97.1%) come from offshore and onshore farming, with only 2.9 percent coming from wild harvest (FAO, 2020). Total world seaweed production in 2016 was around 28.85 million tons, up from 14.65 million tons in 2007, indicating a 97% increase in production over the previous decade. The global market for seaweed has expanded dramatically as a result of its production. Seaweed's entire market size increased from $ 6.08 billion in 2007 to $ 11.45 billion in 2016 (Ghose and Hossain, 2020).

Throughout the world, suitable area for seaweeds culture covers 48 million km^2 of marine ecosystem in 132 countries, though only 37-44 countries are currently active in seaweed production (Froehlich et al., 2019). Furthermore, Asian countries account for 99 percent of global production, including China (47.9%), Indonesia (38.7%), the Philippines (4.7%), the Republic of Korea (4.5%), the Democratic People's Republic of Korea (1.6%), Japan (1.3%), and Malaysia (0.7%). Additionally, aquatic plant trade climbed from USD 60 million in 1976 to over USD 1 billion in 2016. Red seaweed accounts for 53% of global production (Mensi et al., 2020).

Bangladesh is situated in the north-east side of the Bay of Bengal, with a wide maritime area known as the northern Bay of Bengal (Sarker et al., 2018). Bangladesh's coastal and maritime areas cover an area of around 119,000 square kilometers, with three coastal zones (southwest, central, and southeast coasts), a 710-kilometer-long coastline, and a 37,000-square-kilometer-long extended shelf (MoFA, 2016). Furthermore, this huge coastal area is blessed with an abundant reservoir of commercially significant living and non-living resources (Islam and Shamsuddoha, 2018). The establishment of mariculture is one of the feasible strategies for sustainably expanding Bangladesh's ocean-based economy. The maritime area of Bangladesh, which is rich in marine life resources (fisheries, mangrove forests, coral ecosystems, plankton, seagrass, and seaweeds), provides an ideal environment for mariculture (Sarker et al., 2018).

Around 200 seaweed species (47 green, 59 brown, and 94 red) from 77 genera were identified around Bangladesh's coast (Islam et al., 2019). Bangladesh Fisheries

Research Institute (BFRI) selected ten seaweed species for commercial production. Among these species, *Hypnea* sp. was found all year. *Gracilaria* sp. were found between September and March, *Gelidium* sp. were found between October and March, *Enteromorpha* sp. were noticed between January and March, *Halimeda* sp. were found between December and February, Padina sp. and *Dictyota* sp. were observed between November and February, *C. racemosa* was noticed from December to February, *Sargassum* sp. from November to March, *Kappaphycus alvarezii* from November to March, and *Porphyra* sp. from December to March. A variety of techniques are being assessed in the commercial mariculture of seaweeds (Sarker et al., 2021a).

Bangladesh is still in the early stages of seaweed aquaculture but a growing industry (Sarker et al., 2019). Though the overall global production and market size of seaweed have increased significantly over the years, Bangladesh has not made significant contribution yet. In 1989 seaweed culture methods were yet to be introduced in Bangladesh and approximately 15 metric tons of seaweeds (all varieties) were produced in 1990 (Ghose and Hossain, 2020). It is estimated that annually 390 MT seaweeds (wet weight) are produced in the coastal waters of Bangladesh (Hossain et al., 2020). Most of the seaweed farming sites is located in the south-east coastal zone of Bangladesh. Nuniarchara coast of Cox's Bazar have been suggested as top ranked sites as followed by St. Martin's Island, Teknaf coast, Reju Khal and Inany beach (Hossain et al., 2020).

Bangladesh has a coastal zone covers about 47201 km^2 area which is about 32% of the country (Sarker and Mahmudul Islam, 2020). The coastal area has a population of 35 million people, representing 29% of the country's overall population (Sarker et al., 2018). Coastal areas with sand and mud beaches, estuaries, and mangrove swamps provide substrate and habitat for the cultivation of diverse seaweeds (Ahmed and Taparhudee, 2005). In comparison to the rest of the country, Bangladesh's coastline zone survives with a lower income level. Marginalized coastal communities are mainly engaged with fishing, agriculture, livestock rearing and day laboring (Sarker et al., 2021b). Seaweeds are currently sold locally and a proper value chain for seaweed marketing is still missing (Ahmed et al., 2022). Seaweed cultivation offers a lot of potential to help Bangladesh's poor coastal communities get rid of poverty and assist in achieving the goal of blue economy.

Several studies conducted on seaweed in Bangladesh in context with adapting seaweed culture techniques, factors (lunar cycle, harvest interval and seedling distance) affect in production, potentiality and prospects of seaweed culture, the present status of naturally occurring seaweeds, socioeconomic factors that influence the profitability of seaweed farming in the Saint Martin, socio-economic status of seaweed industry in Bangladesh. In 2016, present status of naturally occurring seaweeds flora and its utilization pattern in Bangladesh was investigated (Sarkar et al., 2016). Another study was conducted by Ghose and Hossain (2020) to identify the socioeconomic factors that influence the profitability of seaweed farming in the Saint Martin Island of Bangladesh (Ghose and Hossain, 2020). Another study was conducted to adapt seaweed culture technique using horizontal coir rope floating net in suitable sites of the Cox's Bazar coast of Bangladesh (Islam et al., 2019). The socio-economic status of seaweed industry in Bangladesh is investigated by Ahmed et al. (2022). Most importantly in other study assessed present status with major challenges of seaweed production, processing, socioeconomic status of seaweed farmers and marketing of seaweed (Hossain et al., 2020). However, some of previous study confined with income and cost benefit analysis of seaweed farmers. Therefore, still now there is a lack of information on the overall market scenario with all market actors involve from farmers to consumers and value addition in every marketing stages.

Therefore, the study was conducted to measure the existing farming and marketing system, farming and marketing cost, marketing margin and to examine the value chain of seaweed aiming to evaluate the value addition in different steps of seaweed marketing. With the following goals in mind, the study will surely be important to seaweed farmers, entrepreneurs, and policymakers in planning the future of farming, import, export, and price stabilizing actions. Moreover, precise market and value chain analysis data on seaweed in Bangladesh will assist in market actor linkage with farmers to achieve the desired price which will influence seaweed farming and contribute to securing the nation's blue economy goal.

1.1 Objectives of the study are:

- To map the seaweed value chain and estimate the value addition by different market actors in different steps of marketing.

- To evaluate perceptions of value chain actors regarding strategies that can increase/ improve seaweed farming, market demand and price in Bangladesh.

Chapter 2: Review of Literature

2.1 Major uses of seaweeds

Seaweed and humans appear to have interacted as early as the Neolithic era, although the oldest written accounts of its use by humans are from China, some 1700 years ago (Yang et al., 2017). According to Delaney et al. (2016) coastal communities have been gathering a broad range of seaweeds from all algal groups for many years. At first, seaweeds were mostly utilized in homes for food and feed, but later on, industrial uses (fertilizers, gels) were discovered (Delaney et al., 2016). Seaweeds generate a diverse and adaptable biomass that has several uses. Fresh, dried, powdered or flakes, salted, canned, liquid extracts, or as prepared foods are just a few of the many ways they can be utilized. Among other things, they can be processed to make feeds, fertilizers, biofuels, pharmaceuticals, beauty products, food additives, and nutraceuticals (Anis et al., 2017; Buschmann et al., 2017). They have previously been used as human food, a source of hydrocolloids, fertilizers, and animal feed. Macroalgae contain a diverse range of compounds, including pigments (e.g., phycobiliproteins and carotenoids), phenolic compounds (e.g., phlorotannin and bromophenols), nitrogen compounds (e.g., alkaloids), polysaccharides (e.g., agarans, carrageenan, and alginate) (Stengel et al., 2011). Moreover, some of the bioactive compounds including antioxidant, antibacterial, antiviral, anti-aging, anti-inflammatory, and anticancer available. Because of the presence of these bioactive components, macroalgae are increasingly being used in the development of dietary supplements, functional foods, pharmaceuticals, cosmetics, and other industrial applications (Ariede et al., 2017). Early uses of seaweeds for medical purposes include the Chinese usage of dehydrated *Laminaria* stipes to expand the cervical cavity in difficult childbirth, brown algae for goitre, and *Gelidium* for digestive ailments (Levine & Fleurence, 2016). The genus *Gracilaria* is an important marine bio-resource because some members account for approximately 80% of global agar

production. Besides, *Gracilaria* species are also used in traditional medicine and human diet in many places around the world (Torres et al., 2019).

Seaweeds are high in vital amino acids, minerals, vitamins, beta-carotene, carbohydrates, and protein. Seaweeds have gained recognition as the 21st-century dietary supplement due to their superior nutritional profile to ensure food security. Seaweed can become a good diet in food systems that meet the nutritional needs of a world population predicted to reach over 9 billion before 2050 while producing fewer greenhouse gas emissions (von Braun et al., 2021). Seaweed has been suggested to have the potential to become “an important new crop” for low- and middle-income nations, given that eight countries in Africa and Asia would account for more than half of the projected global population growth until 2050 (Msuya et al., 2022). However, seaweed is extensively grown off the coast of nations like China, Japan, and Malaysia in eastern Asia, where it has long been an integral part of traditional diets (Trono, 1990).

According to Ferdouse et al. (2018), the primary applications of brown seaweed in food products for humans include agar, also known as "vegetable gelatin," which is used to make candies and jellies, alginate, a stabilizing and thickening agent used to make fruit juices, ice cream, jelly, syrups, and some bakery goods, and carrageenan, a water binding agent used to keep solids in suspension in dairy products. Other applications include the production of liquid and dried fertilizers, some pharmaceuticals, and livestock feed (low grade kelp is used as a feed supplement for farmed abalone in China and has the potential to be used as fermented seaweed flour in fish feed in Turkey) (Saade et al., 2020). Similar to the brown kind, red algae are highly regarded for their ability to produce agar and carrageen. Carrageen is commonly made from so-called Irish moss (*Chondrus crispus*), while dulse (*Palmaria palmata*) is marketed as a plant-based bacon replacement (Ferdouse et al., 2018). Certain species, such *Chondracanthus chamissoi*, are utilized in Peruvian cuisine, particularly in the preparation of ceviche.

Green seaweed types are used as "sea vegetables" in salads; however, due to high prices (US$ 0.79/kg (wet weight) in 2019 for green seaweed compared to US$ 0.47/kg for brown and US$ 0.39/kg for red), demand for "fresh" (unprocessed)

seaweed is limited to populations with a long-standing tradition of including seaweed in their diets (Cai et al., 2021).

Many essential ecosystem services, like as nutrient uptake and oxygenation, are provided by the commercial production of seaweeds. For a wide variety of fish and invertebrates that are crucial to conservation, the commercial production of seaweeds provides ecosystem services like food, shelter, and escape (Vásquez et al., 2014). According to Skjermo et al. (2014) large-scale seaweed farms can provide new habitats for a variety of species, promoting biodiversity.

In 2017, Sarkar et al. carried out experiment at the Bangladesh Agricultural University (BAU), Mymensingh, the Fish Processing Laboratory produced four value-added seaweed food products: seaweed jelly, soup, ice cream, and curd; two functional food products: seaweed singara and samucha/samosa; and two cosmetic products: seaweed face pack and shampoo. The seaweed powder *Hypnea sp.* was utilized in the production of each and every product. Consumer acceptability was 66.67%, 50%, 41.67%, and 83.34% for seaweed jelly, soup, ice cream, and curd, in that order. There was 100% acceptance for seaweed singara and suma/samosa. 100% of consumers approved of the seaweed face pack, whereas 66.67% approved of the shampoo. All of these goods could therefore be manufactured on a commercial basis (Sarkar et al., 2017).

After conducting a survey, Sarkar et al. (2016) found that 193 different kinds of seaweed are naturally occurring in Bangladesh. Additionally, this study has brought attention to the traditional use of seaweed in Bangladesh and has shown that the Mog and Rakhaine, as well as other tribal tribes on Saint Martin Island, have long used seaweed as a salad and sauce. In addition to this kind of use, young girls and post-pregnant women occasionally use seaweeds as a medicinal food. Traditionally, adult females have occasionally consumed boiled seaweed for health. There, plant manure made of rotted seaweeds is utilized to grow vegetables (Sarkar et al., 2016).

2.2 Culture methods of seaweed

The majority of the seaweed produced until around 1980 came from the collecting of wild stocks, however certain countries, including the Philippines and Indonesia, engaged in minor cultivation (Trono, 1990). On the other hand, the seaweed businesses in Europe, Canada, and Latin America continue to depend on the

extraction of natural resources (Rebours et al., 2014). The production of microbiology-grade agar may be severely impacted by the massive reduction in *Gelidium* spp. beds caused by overharvesting in Japan and Morocco (Callaway, 2015). To meet the global seaweed demand for phycocolloid extraction several seaweed culture methods developed. The vast majority of these global products (97.1%) come from offshore and onshore farming, with only 2.9 percent coming from wild harvest (FAO, 2020).

Seaweed cultivation can be done offshore, onshore, or in aquaculture integrated systems. The species, location of the farm, and cultivation facilities all influence seaweed culture. Main techniques of seaweed cultivation adapted from (Radulovich et al., 2015) and (Sudhakar et al., 2018) are: Line cultivation: Off-bottom, Submerged hanging line, Floating line (long-line). Net cultivation (depth, floating at the surface or slightly submerged). Floating raft cultivation, Tank or pond cultivation, Rock-based farming by direct planting on the ocean bottom or attached to artificial substrate.

The methods used to cultivate seaweed vary greatly. The location of a farm and cultivation facilities (in the open sea or on land), the productivity and adaptability of a species (it may be slow growing, fast growing, or require high nutrient levels), the dimensional characteristics of an aquatic ecosystem (size and depth), temperature conditions, nutrient enrichment, water movement, and degree of wave action all influence the selection of a seaweed species for cultivation. *Gracilaria* sp. are grown in seabed in Chile, Vietnam, and several other countries. Gracilaria sp. are often grown using nets or racks made of bamboo poles with ropes stretched between them and cut strands of *Gracilaria* are connected to the ropes (Titlyanov and Titlyanova, 2010). In offshore cultivation of seaweeds can grow on the seafloor (attached to a hard substrate) or on long-lines (anchored lines or nets that are either seeded or have individuals tied to them for grow-out) (Currie, 2018). Attaching seaweeds to ropes, lines, or nets is a popular method of cultivation due to the low cost of installation and maintenance (Fernand et al., 2017).

The structures and seaweeds in the farming systems are vulnerable to the most extreme effects of ocean and adverse environmental conditions. Macroscopic organisms such as bryozoans, epiphytic seaweed, hydroids, snails, and blue mussels can foul seaweed cultivation, causing deterioration of algal tissue and high biomass

loss (Handå et al., 2013). The availability of nutrients in the ocean, as well as the difficulty of controlling epiphytes, can be a problem, limiting the yield of seaweed aquaculture in these farms (Fernand et al., 2017).

As a simplified representation of seaweed cultivation, seaweeds may also be utilized in an integrated multitrophic aquaculture (IMTA) to address some environmental problems related to animal aquaculture, such as eutrophication of the water from feed supplementation and excretion (Granada et al., 2016). The nutrient output of the animal (fish, for example, or mollusks), which is high in dissolved ammonia and phosphate, is integrated into the water in IMTA systems, where it transforms these chemicals into beneficial biomass while preserving stable levels of oxygen, pH, and CO_2 (Fernand et al., 2017). It has been shown in China that industrial seaweed farming, especially within an IMTA framework, can lessen overall environmental pressure (Feng et al., 2004, Yu et al., 2015). Furthermore, large-scale offshore seaweed farming could be used as a technique to mitigate global climate change and sequester carbon (Duarte et al., 2017).

The Integrated Multi-Trophic Aquaculture (IMTA) idea is used in Portugal for the sustainable production of seaweed and seaweed-based goods. This approach farms seaweeds next to several species at different trophic levels, which reduces the amount of waste generated by aquaculture (Troell et al., 2009). The practice of IMTA is conducted on land in a regulated setting and is certified organically for quality, traceability, supply stability, and low carbon impact. A similar IMTA strategy has led to the establishment of *Ulva* cultivation in South Africa (Bolton et al., 2009).

Gracilaria edulis culture was carried out using a floating raft method to improve biomass production in the Gulf of Mannar on India's south-east coast. In this cultivation January–February had the lowest biomass (1.5 kg fresh wt. m^{-2}) and daily growth rate (DGR) (2.6% day^{-1}), which was significantly different from other maximum cultivation periods (Ganesan et al., 2011). Besides, cultivation in the subtidal region produced significantly more biomass (12.5 kg fresh wt. m^{-2}) and DGR (7.40 % day^{-1}) than cultivation in the intertidal region (4.40 kg fresh wt. m^{-2}) and DGR (5.10% day^{-1}).

Another study was conducted to determine the difference in growth rate of *Gracilaria verrucosa* in different spacings cultivated using the bottom off method in Saleh Bay,

Bajo Island, Kwangko, Dompu, Nusa Tenggara Barat. This research is *Gracilaria verrucosa* cultivation at different spacings have no effect on growth rate (Annas et al., 2019). However, the highest Agar percentage find in the 20 cm treatment, which is 24.93%.

Bangladesh's seaweed culture is still in its early phases. However, a few researchers are involved in seaweed cultivation on Bangladesh's south-eastern and south-western coasts, as well as seaweed cultivation methods using local ingredients such as bamboo and rope (Siddiqui et al., 2019). The culture of a red seaweed, *Hypnea* sp., was conducted in three locations along the Cox's Bazar coast: Saint Martin Island, Inani, and Bakkhali, using a net method of (4 × 4) m coir rope net. The biomass yield of *Hypnea* sp. (3.81kg fresh wt. m^{-2}) was highest in Saint Martin, followed by Bakkhali (3.34) and Inani (2.70) (Islam et al., 2017).

Another research was designed on *Gracilaria tentuistipitata* to find out effect of different factors such as influence of lunar cycle, harvesting interval,rope type and seeding gap on the production of *G. tenuistipitata* in coast of Cox's Bazar (Bokhtair et al., 2021).In this study when the seeding and harvesting times were chosen with the moon cycle in consideration the results predict that fresh yield become to 14.43 percent higher. In terms of harvesting interval is 30 days, is the best to harvest the seaweed. It is also encountered that semi floating single line systems surpass semi floating double line systems in terms of yield performance.

According to Ahmed et al. (2022) study, which was focused on understanding the challenges associated with seaweed farming on Bangladesh's southeast coast as well as the cost and marketing channels of the currently used culture methods. They found the southeast coastal region's farmers presently cultivate seaweed using long-line and horizontal net techniques. The economic viability of these cultural practices was also discovered by the investigation. They also found that from September to March *Gracilaria* sp. is being cultured by farmers in southeast coast. While *Hypnea* is cultivated year-round, *Porphyra* is suitable for farming from December to March.

2.3 Current productions and trades of seaweed

The demand for seaweeds around the world has been rising as their use outside of their traditional uses has increased (Hafting et al., 2015). According to FAO (2016), with an overall production of nearly 23 million tonnes in 2014, China and Indonesia

are among the biggest producers of seaweed. 27% of the world's aquaculture production is derived from macroalgae, which constitute significant marine natural resources. China is a major producer of red algae from the genera *Gracilaria* and *Pyropia* as well as kelp (*Saccharina japonica* and *Undaria pinnatifida*) for human consumption. However, Indonesia is mostly known for producing the carrageenophytes *Kappaphycus* and *Eucheuma* (FAO, 2016). According to FAO more than 90% of the demand for *Porphyra* spp., *Saccharina japonica*, and *Undaria* spp. commonly known as nori, kombu, and wakame came from Japanese farms along the shore (Ferdouse et al., 2018). *Saccharina, Undaria, Porphyra, Eucheuma/Kappaphycus,* and *Gracilaria* make up the top five genera, which account for almost 98% of the world's production of cultivated seaweed (Pereira & Yarish, 2008). Currently, about 220 species are valued commercially, but only five species account for about 95% of the total amount produced by farming (Cai et al., 2021).

The top producing nations for seaweed in 2014 were China and Indonesia with over 10 million tonnes each, followed by the Philippines and the Korean Republic with over 1 million tonnes, and the Democratic Republic of Korea, Japan, Malaysia, and Zanzibar with over 100,000 tonnes each. Only Chile, with 12836 tons of farmed *Gracilaria*, has been listed in the farming for the Americas. Seaweeds are produced in very small quantities in the majority of European and African nations (FAO, 2016).

In 2017, the total amount of seaweed produced worldwide was 32.9 million tonnes, of which 31.8 million tonnes (or 96.6 percent) came from aquaculture where as 1.11 million tonnes of seaweed were harvested from wild (FAO, 2019). According to FAO (2021) in 2019, about one million tonnes fresh weight of non-farmed seaweed (wild seaweed collecting) were produced. Although the amount of seaweed produced naturally remained at 1.1 million tonnes for fifty years, the amount produced by cultivation increased to 35.8 million tonnes in 2019, making up 97% of the world's total seaweed production. The amount of seaweed farmed globally increased 1000 times between 1950 and 2019 from 34.7 thousand tonnes to 35.8 million tonnes (FAO, 2021). The global market was valued at US$ 11.8 billion in 2019 and is expected to reach US$ 22.13 billion by 2024, assuming an annual growth rate of 8.9% (Mac Monagail et al., 2017; Cotas et al., 2020).

Laminaria saccharina, commonly known as kelp, and *Undaria pinnatifida*, commonly known as wakame, are the two-primary species of brown seaweed that make up around 47% of the world's farmed output in 2019. By weight, red seaweed produced around 52% of all seaweed produced worldwide in 2019 (Cai et al., 2021). Green algae production has been gradually declining since a peak in 1992; in 2019, it accounted for just 0.05% of the total supply of seaweed (17,000 metric tons) (Koch et al., 2021).

Data from the FAO show that 27 different types of seaweed were farmed worldwide in 2019. Only five genera *Laminaria* (35.4%), *Kappaphycu*s and *Eucheum*a (33.5%), *Gracilaria* (10.5%), *Porphyra* (8.6%), and *Undaria* (7.4%) accounted for more than 95% of the world's production from seaweed farming in 2019 (FAO, 2021).

The European Commission (2016) acknowledged that algae, specifically seaweeds and microalgae, hold great potential for enhancing food security. Collectively, these algae could produce 56 million metric tonnes of protein by 2054, accounting for 18% of the world market for alternative proteins.

According to FAO (2021), Asian markets are now driving global development in the seaweed business and accounted for more than 97% of global seaweed output in 2019. The four countries that comprised the majority of the production (more than 90%) in Asia in 2019 were China, Indonesia, Korea, and Japan. The world’s largest producers of seaweed are China and Indonesia, whose combined production topped 30 million tonnes in 2019 and brought in USD 578 million from the sale of seaweed and seaweed-derived hydrocolloids abroad. In 2019, China harvested and farmed over 20.29 million tonnes of seaweed, with cultivation accounting for 99% of the country's total production. Indonesia is well-known for producing carrageenophytes *Eucheuma* and *Kappaphycus*, which contributed to its USD 329 million in export revenue in 2019 and 9.92 million tons of seaweed were produced via aquaculture in Indonesia in 2019, accounting for 28.6% of the world's total production of cultivated seaweed (FAO, 2021). The Republic of Korea and the Philippines rank third and fourth, respectively, in the FAO report for seaweed output, with 1.81 and 1.49 million tonnes of yield from farmed seaweed in 2019. Besides, in the global seaweed farming sector, the Democratic People's Republic of Korea and Japan ranked fifth and sixth,

respectively, with 0.60 million and 0.35 million tonnes of production in 2019 (FAO, 2021).

Contributions to the global seaweed production in 2019 came from the Americas and Europe, at 1.4% and 0.8%, respectively. Cultivation made up just 4.7% and 3.9%, respectively, of the total seaweed production in these two regions; the majority of seaweed production was obtained by natural capture (Cai et al., 2021).

According to Hossain et al. (2020) in Bangladesh 300 households grow seaweed at Nuniarchara, Inany beach, and Rezukhal on the coast of Cox's Bazar, between November and April, with four to six harvesting seasons. Around 390 MT wet weights (or 97.5 tonnes dry weight) of seaweed are produced annually, primarily from *Hypnea*, *Gracilaria*, and *Ulva* that has used in feed, food, cosmetics, and pharmaceuticals (Hossain et al., 2020).

2.4 Seaweed marketing systems in Bangladesh

According to Ahmed et al. (2022) study, the present scenario of seaweed sales is local, and there is still no sufficient value chain in place for seaweed marketing. 60% of the local small farmers sell their seaweeds to the tribal populations. Approximately 60% of seaweed farmers sell their harvest to local entrepreneurs who then export it outside of Bangladesh. However, 100% of business enterprises export, and manufacture products using seaweed, and also sell their seaweed to restaurants.

Farmers and collectors of seaweed often become trade brokers or agents, which are eventually crucial to the seaweed supply chain and sales networks (Farhaduzzaman et al., 2023). Also found, around 80% of seaweed farmers sell their products to traders, 5% to local agents, and 15% to people living in neighboring communities. Farmers got price for dried *Gracilaria lemaneiformis* seaweed 183.7 Tk./Kg. and 135.0 Tk./Kg. for *Ulva intestinalis*. According to Farhaduzzaman et al. (2023) study, farmers who respond to investigations sell their produce to dealers in Cox's Bazar, Bandarban, Rangamati, and Khagrachari in the following percentages: 20%, 40%, 105, and 10%, respectively.

Better organization is still needed for seaweed production, gathering, marketing, and processing in Bangladesh’s coastal regions. Besides, seaweed farmers and collectors usually become middlemen via dealers or brokers, who are essential to the market

systems and seaweed supply chains (Akhtar et al., 2022). This study also added, retailers are the buyers for 64% of seaweed produce's produce. Besides, purchasers of seaweed include some agents (42%) and consumers in the area (18%). According to this study, farmer received 30 to 50 BDT per kilogram for fresh seaweed and 200 to 300 BDT for dry seaweed.

According to the responses from farmers, there are two to five channel members in Bangladesh that distribute fresh and dried seaweed. A variety of unusual seafoods, like as seaweed, oysters, mussels, clams, sea anemone, and sole fish, are sold at the early morning market, known locally as Mog Bazar, which takes place in Cox's Bazar town only on Saturdays and Tuesdays. In this local market, fresh Gracilaria spp. seaweed sells about BDT 60 per kg, while dried seaweed prices about BDT 300 per kg. (Hossain et al., 2020).

Chapter 3: Materials and Methods

3.1 Study area

This study was carried out in the Cox's Bazar and Bandarban districts under the Chattogram division of Bangladesh. Those two districts (Cox's Bazar and Bandarban) are in the southeast zone of Bangladesh. Cox's Bazar district is located between the latitudes of $20^0$43' and $21^0$56' north and the longitudes of 91°50' and 92°23' east. One of the most significant sources of income for the rural inhabitants in this region is fishing. Concerned with the global demand, our country cultivates seaweed in several coastal regions largely in Cox's Bazar (Hossain et al., 2020). One of the most significant sources of income for the rural inhabitants in this region is fishing. Now a significant number of people are involved in cultivating and business of seaweed. Besides males, females also get involved in this sector and support families with extra income. Various habitats found in Cox's Bazar consist of estuaries, mangroves, wetlands, mud flats and tidal flats that can support a wide range of biota.

Another district, Bandarban is located in between 21°11' and 22°22' north latitudes and in between 92°04' and 92°41' east longitudes. Bandarban is the south district of Chattogram Hill Tract besides Cox's Bazar district. Tribal communities inhibit in the Bandarban district hill region are traditionally used to consuming seaweed in various

foods in their regular diet. In this study, several sites were purposely selected based on seaweed production data (farmers and wild harvesters) and market data were Nuniarchora (Cox's Bazar Sadar town), Khurushkhul, Reju khal Sonapara of Cox's Bazar district. Besides, upazial sadar bazar of Bandarban Sadar, Alikodom upazila under Bandarban district of Chattogram Hill Tract are chosen for collecting consumers and market data (wholesalers, retailers) of seaweed.

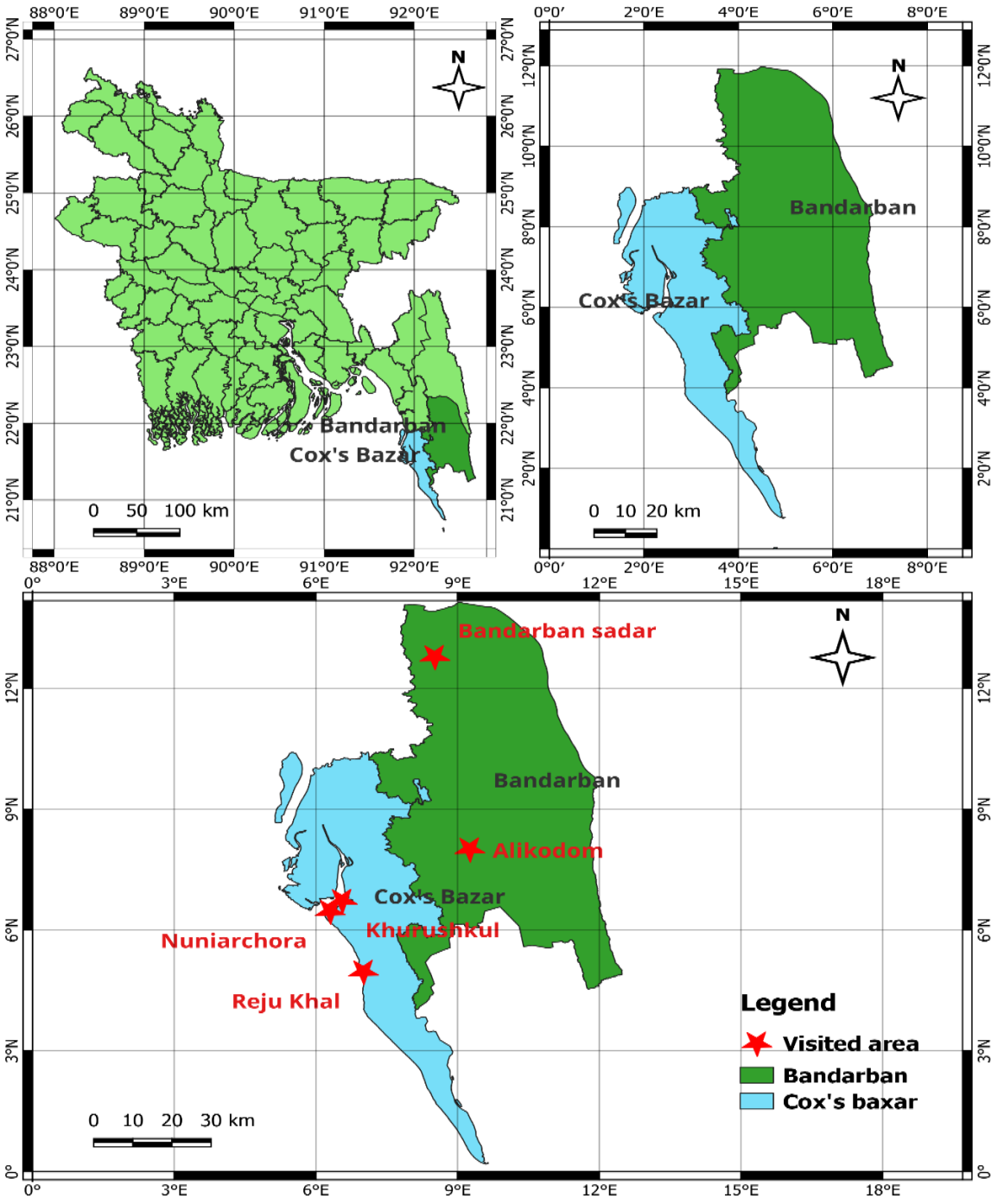

Figure 1: Study area map

3.2 Methods for data collection

Primary data on seaweed production and marketing in Bangladesh were collected through questionnaire interviews, focus group discussion (FGD), on-site observation and informal meetings with relevant stakeholders in Cox's Bazar and Bandarban from April 2022 to November 2022. The population for this study includes seaweed farmers and wild source harvesters as well as seaweed sellers or various market participants (local market sellers, wholesalers and distance market retailers). Also, a questionnaire interview was taken from random seaweed consumers which was a part of this experiment. Other stakeholders include NGOs, researchers, commercial entrepreneurs involved in seaweed product development and local leaders/ senior citizens.

3.2.1 Questionnaire preparation

A semi-structured questionnaire was prepared for the questionnaire survey having open-ended and closed-ended questions. The questions were semi-structured, so the interviewee could choose an answer from the options or he could describe if needed. The prepared questionnaire was divided into four sections: 1) a questionnaire for seaweed farmers/ wild harvesters, 2) a questionnaire for local markets and retailers, 3) a questionnaire for wholesalers and 4) a questionnaire for consumers. The specific section of the questionnaire was used for questionnaire interviews of market actors. Each section of the questionnaire belonged to three sub-sections: 1) general information, 2) seaweed-related information and 3) other information. Most of the questions related to seaweed-related information were score-based where 0 represents the lowest score and 4 denotes the highest score.

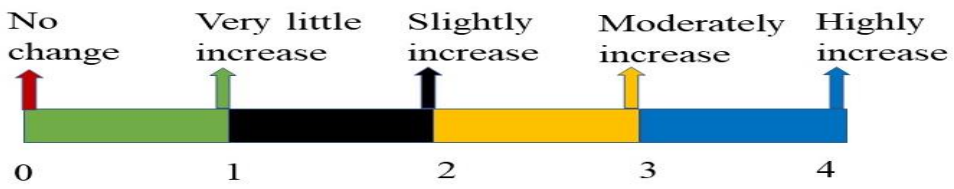

Figure 2: Score scale of questionnaire

3.2.2 Field survey and interviews

The required information and data were collected by field survey through personal visits to the selected study area. A significant portion of this research data came from

in-depth interviews. Focus was always placed on conducting an in-depth interview to investigate every factor and to understand the participant's responses, expressions, feelings, opinions, and beliefs during the field survey and interview. Most interviewees came from Nuniarchora, Cox's Bazar communities engaged in seaweed farming and wild stock harvesters. Field surveys and interviews were conducted with 40 seaweed producers (including farmers and wild stock harvesters) in Nunirchora, Rejukhal (Sonapara), Khurushkhul rastarpar of Cox's Bazar District. Besides, 11 seaweed retailers (local market retailers in Cox's Bazar and distance market retailers in Bandarban) and 6 wholesalers were covered by a questionnaire survey to gather market data. Randomly 36 seaweed consumers survey covered in Bandarban at Mog Bazar Bandarban Sadar, Alikodom Upazila Bazar and Lama Upazila Bazar during the moment consumers came to purchase seaweed from retailers.

Figure 3: Questionnaire survey

During a questionnaire survey conducted with seaweed farmers and wild stock harvesters gathered information on current practicing culture methods, species and the method having the best production, seaweed marketing system, price and their target customers, farmers' observation on seaweed collection, production, market condition and strategies can improve the seaweed farming. Besides, data gathered from seaweed sellers through a questionnaire survey on where they bought and purchase price, their cost incurred per kg and selling price, their satisfaction with market demand and possible strategies can improve the demand and price in Bangladesh. Consumer data was gathered by a questionnaire on the uses of seaweed in their food items, how many

months they prefer to consume seaweed, price variation around the year, their satisfaction with hygiene and post-harvest activities, and their thoughts which can increase acceptance of seaweed to consumers.

3.2.3 Focus group discussions (FGD)

Focus group discussions were also executed with 6 to 8 participants of different age groups with male-female participation. Participants of the FGD were relevant stakeholders, such as seaweed farmers or wild harvesters, local market retailers, and community leaders/ senior citizens. Focus group discussion bring people together to discuss a particular topic of interest while sharing similar experiences or backgrounds. So, this tool is used for open discussion to gather semi-structured qualitative data on challenges and constrain faced by seaweed farmers in cultivation and marketing, how they overcome those challenges, and their needs and thoughts to increase seaweed price and market demand.

For data validation, informal meetings with key informants such as 2 non-government organization officials, 2 commercial entrepreneurs who are developing seaweed-based products, 3 researchers, and 3 local senior citizens of the seaweed farming area were carried out. Furthermore, from meetings information was gathered on problems that exist in seaweed marketing, the value chain in Bangladesh and suggestions to increase the farming, demand and price of seaweed.

3.2.4 Observation

For gaining an additional understanding of the study and observing evidence, direct participation in observation is applied in the study area. This observation tool assists in supplying further details of information. Therefore, enough time was given to monitor the daily activities of seaweed farmers and sellers. To conduct participant observations, in this study accompanied seaweed farmers and wild stock collectors at the harvesting site while they collected and dried their harvested seaweed. Besides, I performed observations by accompanying seaweed sellers in their daily activities. Through informal conversation, this kind of observation facilitates familiarization with the farmers and sellers. All these activities helped to gain insight and information and thereby increase the validity of the collected data.

3.3 Method of data analysis

Data was gathered using a pre-made, semi-structured questionnaire following the requirements for the study. The data that was gathered from the participants was instantly recorded as a note. In most cases, handwritten and recorded data had been put into the data sheet soon after the sample site visit. Such structures of data assist in both preventing data loss and making data verification easier. The statistical program Microsoft Excel 2016 was used for data sheet preparation. Descriptive statistical approaches including mean, maximum value, minimum value, percentages, and standard error were used to analyze and describe the socio-economic and demographic characteristics of the sample seaweed farmers using IBM SPSS Statistics 22 version. For the value chain mapping of seaweed, the actors in the chain were identified and then the product flow was mapped in the value chain. A value chain map showed a series of functions, phases of value addition, the circulation of the product, important actors and their relationships, and the economic activities at each stage with the associated financial and physical flows. The net profit of seaweed at the farmer's level was calculated using the following equation (Sharma et al., 2023).

$$\pi = P_F . Q_F - (TVC + TFC) \quad \ldots\ldots (1)$$

Here, π = Profit of the seaweed farmers (Tk./ $24m^2$); P_F = Price of the produce (Tk./Kg.); Q_F = Quantity of the produce (Kg. / $24m^2$); TVC = Total variable cost (Tk./ $24m^2$); TFC = Total fixed cost (Tk./ $24m^2$).

Value addition at the trader's level was calculated using the following formulas:

$$GMM = \text{Selling price} - \text{purchase price} \quad \ldots\ldots (2)$$

$$NMM = GMM - MC \quad \ldots\ldots (3)$$

Here, GMM = Gross marketing margin (Tk./Kg.); NMM = Net marketing margin (Tk./Kg.); MC = Marketing cost (Tk./Kg.).

$$\text{Return on Investment (ROI)} = \frac{\text{Net margin (Tk./Kg.)}}{\text{Total operating capital (Tk./Kg.)}} \times 100 \quad \ldots\ldots (4)$$

Farmer's share in sales price (%) calculated by the following equation (Ahsan et al., 2016)

$$\text{Farmer's share in sales price (\%)} = \frac{\text{Fishermen sells price}}{\text{Consumer purchase price}} \times 100 \quad \ldots\ldots (5)$$

3.4 Ensuring good scientific practices

Considering the fact data validity and reliability of this survey-based research work, several measures were applied throughout the qualitative and quantitative data collection during the field survey. Considering in-depth interviews, this study allowed open-ended discussion though aimed at semi-structured questionnaire interviews with participants. Furthermore, participants were free to speak following the actual circumstances. During the interview process, conversation was recorded in notes and photographs were taken on mobile with a GPS camera when necessary. An informal discussion took place with community leaders and elders before data collection to explain the goal and obtain approval for survey work with seaweed farmers in their locality. It is important to say that each participant (seaweed farmers, sellers and consumers) provided the appropriate ethical permission for this experiment to be conducted. To ensure clarity and cross-checking, interviewees were informed of the preliminary findings at the end of the interview.

Most of the seaweed farmers and wild stock harvesters were eager to participate in explaining and discussing questionnaire interviews. Most importantly interview used local language which allowed interviewees more flexibility and avoided the misunderstanding of questions. Interviews were conducted at their preferred time with less workload in culture sites and other places. In most cases, interviews were conducted with men while they were gossiping in tea stalls and female farmers interviews were taken in the houseyard. All the seaweed sellers' interviews were taken in their selling place in Bazar during the time of less work pressure. It is noted that confirmation was received from the participants of this study to use and publish their responses publicly as used for research purposes.

Chapter 4: Results

4.1 Socio-demographic characteristics of farmers (seaweed farmers and wild harvesters)

Seaweed farmers and wild stock harvester's average age was 39.15 years, with the 31 to 45 years age group consisting of 42.8% which dominated the group. The maximum age of the farmers was 70 and the minimum age of the farmers was 18 years, on the other hand, only 5% of the farmers were older than 61. Around more than half (52.5%) of seaweed farmers were illiterate and this group didn't achieve a single year of education from any educational institution. Although 47.5% of the farmers had some kind of formal education having several years of school going. A large number of the participants (82.5%) of the seaweed farming and wild stock harvesting group had phones, whereas 17.5% of people didn't use phone use.

In Bangladesh's coastal region, seaweed is mostly produced in two ways: wild or natural production harvest and cultivation. Coastal people have been collecting natural seaweed produced in the wild before cultivating it. Among the participants, 60% of participants were involved in both farming and wild stock harvesting, whereas 32.5% and 7.5% were involved in farming and wild stock harvesting, respectively. Along with men, women are also involved in seaweed farming and wild stock harvesting. Among the participants, the majority were (70%) female and the remaining 30% were male. All of the seaweed farmers and wild stock harvesters had taken seaweed farming as their secondary occupation whereas the majority of the male and female farmer's primary occupation was fishing and housewife, respectively. Among the respondents, 67.5% of seaweed farmers primary occupations were housewives, 20% were fishermen and 10% were involved in other services such as daily labor, business, student etc.

Table 1: Socio-demographic characteristics of Farmer (Seaweed Farmers and wild Harvesters). (Std. dev.=Standard deviation)

Farmers have been harvesting natural stocks for fifteen years, but they have only begun to cultivate seaweed in the last ten years. The average seaweed farming experience of seaweed farmers was 4.45 years where the minimum experience years was 2 and the maximum experience years was 10. The majority of the farmers (81.6%) had farming experience ranging from 2 to 5 years whereas the remaining 18.4% of farmer's farming experience ranged from 6 to 10 years. Among the wild stock harvesters, 59.3% of wild stock harvesters were harvesting for the last 1 to 5 years, 25.9% were harvesting for the last 6 to 10 years and the remaining 14.8% were involved for the last 11 to 15 years.

Variable	(Mean± Std. dev.)	Max	Min	Percentage (%)
Age	(39.15±13.02)	70	18	16-30 years 32.2%
				31-45 years 42.8%
				46-60 years 20%
				61-75 years 5%
Education	(0.53±0.50)	1	0	Literate (1) 47.5%
				Illiterate (0) 52.5%
Phone use	(0.83±0.39)	1	0	Yes (1) 82.5%
				No (0) 17.5%
Farmer type	(1.48±0.65)	3	1	Both (farming & will harvesters) (1) 60%
				Farmer (2) 32.5%
				Wild harvester (3) 7.5%
Gender	(1.70±0.47)	2	1	Male (1) 30%
				Female (2) 70%
Primary occupation	(3.25±1.22)	4	1	Housewife (4) 67.5%
				Fisherman (1) 20%
				Other service (3) 10%
				Seaweed farming (2) 2.5%
Experience in farming	(4.45±2.00)	10	2	1-5 years 81.6%
				6-10 years 18.4%
Experience in wild stock harvesting	(5.85±3.69)	15	1	1-5 years 59.3%
				6-10 years 25.9%
				11-15 years 14.8%
Farming types	(1.66±0.86)	3	1	Long line bottom (1) 59.5%
				Long line(raft) (2) 16.2%
				Off bottom net (3) 24.3%
Culture area distance from farmers/ wild harvester's home (km)	(1.40±0.38)	1	2.5	1 km 35%
				1.5 km 55%
				2 km 5%
				2.5 km 5%
Local market distance(km)	(6.25±5.53)	18	2	(2-9) km 75%
				(10-18) km 25%
Cultivation months by farmers in year	(0.92±0.28)	1	0	6months/year (1) 91.9%
				5months/year (0) 8.1%
Harvest frequency per month	(0.81±0.40)	1	0	2 time/month (1) 81.1%
				3 time/month (0) 18.9%
Wet seaweed needed for 1 kg dry production	(0.35±0.49)	1	0	7 kg need (1) 35%
				8kg need (0) 65%
Seaweed consumption in family	(0.94±0.27)	1	0	Yes (1) 92.5%
				No (0) 7.5%

Three types of seaweed cultivation methods were widely practiced by seaweed farmers in the several sites of Cox's Bazar coastal region: 1) Long line (Off-bottom); 2) Horizontal net (Off-bottom) and 3) Floating long line (Raft) method. Farmers got

training conducted by several NGOs (Non-Government Organizations) on the above three seaweed farming methods. Besides, most of the farmers got farming input support provided by several non-government organizations to start seaweed farming as they were involved in project-based cultivation. Among the seaweed farmers, 59.5% were farmed by using the long line (bottom) method, 24.3% were farming in the horizontal net method (Off-bottom net) in the intertidal zone and the remaining 16.2% farmers were farming floating long line (raft) in sub intertidal zone. The floating long line (raft) method of seaweed farming was found in three sites in Nunuarchara, Khurushkul (Rastarpara) and Rejukhal (Sonapara). This long-line raft method is the newest technique for seaweed farmers of the southeast coast of Bangladesh as they started this method two years ago.

The average culture area distance from farmers and wild stock harvester's home was 1.40 km where more than half of farmers (55%) distance was 1.5 km and 35% of farmers distance was 1 km. About 75% of farmers and wild stock harvesters lived 2 to 9 km from the nearest local market where seaweed is sold by local market sellers. The remaining 25% of farmers lived within a 10 to 18 km distance from the local market. Seaweed farmers are involved in seaweed farming around 5 months to 6 months in a year. Most farmers (91.9%) claimed that 6 months actively participate in seaweed farming from October to March. Farmers got 2 to 3 harvests from their culture plot every month depending on the seaweed growth rate. Farmers harvest seaweed every 15-day intervals for 2 harvests in a month whereas, for 3 harvests in a month they harvest seaweed from culture plots every 10 days interval. A large group of seaweed farmers consisted of 81.1% who got 2 harvests in a month every 15 days intervals and the remaining 18.9% got 3 harvests per month. Seaweed can sell in both wet and dry form but most of the time farmers can't sell all of the harvest in wet form and need to dry. Considering this regard, harvested seaweed is washed in seawater and then in a tube well water nearby and placed in a rack for drying. Seaweed's dry period depends on sunlight intensity. Basically, on a sunny day, it required 4 to 5 hours to completely dry. Then, dried seaweed is packed in a poly beg store in-house and ready for selling. 65% of farmers and natural production harvesters needed 8 kg of wet seaweed for 1 kg of dry seaweed production.

Most of the seaweed farmers were habituated to seaweed consumption along with family members. 92.5% of seaweed farmers and wild stock harvesters claimed they

were consuming seaweed in very minute amounts with a combination of other food items.

4.2 Value chain mapping of seaweed

A value chain map shows every part of the product and its route from raw materials to the final consumer. It also measures the processes the product goes through and provides an explanation of how the business works (Taylor, 2005). It addresses the key issues at the individual supply chain level rather than the group or location level. Figure 4 shows the seaweed value chain map as it currently exists. It detailed how the seaweed value chain works, who are the main and supporting actors in it, and how it is connected to others.

4.2.1. Primary actors

Primary actors in the value chain were recognized including input suppliers, farmers, naturally generated stock harvesters, local market sellers, wholesalers, and retailers. Certain roles were shared by multiple performers, while some actors took on multiple roles. In value chain analysis, the input supply level is the first place to look from which production starts. In the agricultural value chain, input suppliers are seed, fertilizer, pesticides etc. manufacturers. In seaweed farming, there is no need for fertilizers, pesticides and seeds but bamboo, float, plastic drums, ropes etc. as culture set-up materials. So, culture set-up materials manufacturers are known to be input suppliers. The primary actors in input supply networks are small wholesalers and even small stores that supply seaweed farmers in villages with small quantities of floats, net, rope, bamboo, and plastic drums. Besides, seaweed farmers got seaweed farming input support from several NGOs and this is the main source of input supply.

The key component of the value chain for seaweed was farmers and naturally produced stock harvesters. Taking into consideration the available resources, farmers decide which inputs to use, where to buy them, when to begin growing and harvesting them, and how much to sell. Seaweed farmers carry out several key-value chain tasks, including site selection, culture setup preparation, routine monitoring and cleaning, harvesting, post-harvest handling, and marketing. Farmers and natural production harvesters of seaweed often marketed their produce to farmgate wholesalers, wholesalers in distant markets, consumers (local ethnic community), and a tiny

percentage of them sold to local market sellers. As a result, they developed a connection or link in the chain.

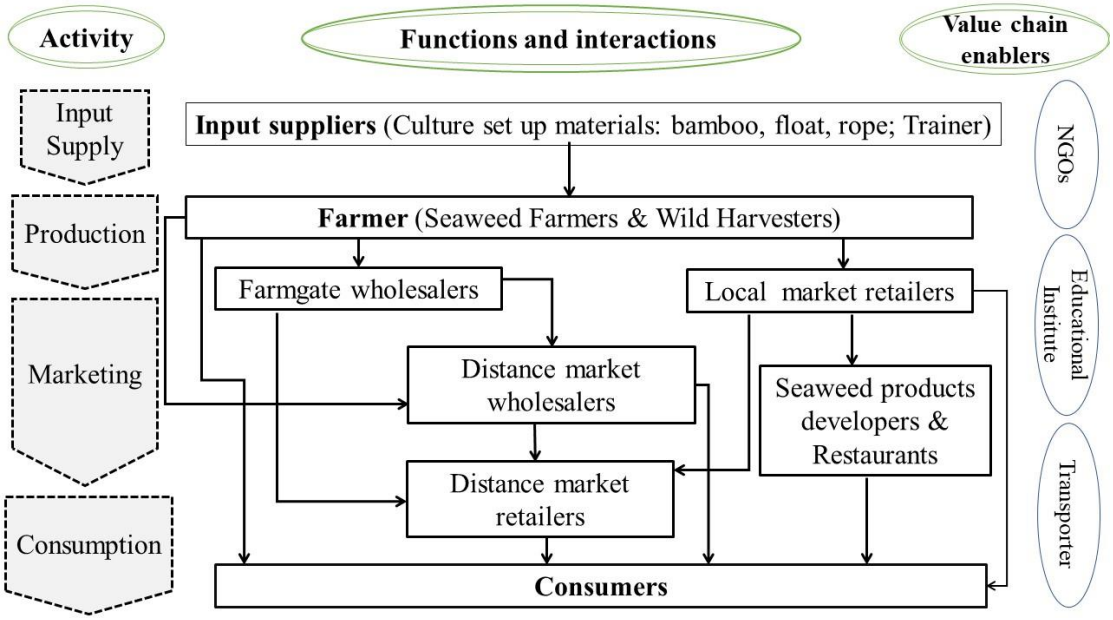

Figure 4: Seaweed value chain map in Bangladesh

Another important market participant known as wholesalers purchase seaweed in bulk from farmers and then resell it to other dealers. In the study area, a large amount of seaweed was bought at the farm gate by farmgate wholesalers than any other actor and sold to wholesalers and retailers of the distance market. As only a few farmers had good connections and relations with distance market wholesalers, most of the farmers brought seaweed to sell it to the farmgate wholesalers. Thus, farmgate wholesalers have a major impact on the formation of local prices. Though farmgate wholesalers were self-financed and independently arranged, they did not own any permanent shops, and they mostly conducted their business from their homes.

Distance market wholesalers and retailers sold seaweed in Alikodom, Lama, Bandarban Sadar and other Upazilas bazaars of Bandarban districts. Like farmgate wholesalers, distance market wholesalers were self-financed and independently arranged but the difference is that they had permanent stores in the marketplace and employees that handled selling tasks. They sold their large portion to distance market retailers and also performed retail selling activity directly to consumers in their shop. In Bandarban districts, 9 to 10 different tribal communities live, where 2 communities (Marma and Murang) are the main consumers of seaweed and are habituated to consuming seaweed from an early age after being born with family members.

Retailers are experienced sellers that sell small quantities of seaweed to consumers directly. Distance market retailers bought seaweed from farmgate wholesalers and distance market wholesalers as well as sometimes from local market retailers, before selling it to consumers. The majority of them are independently well-financed but the majority of them don't have any permanent stores, and they often sell their seaweed in open markets places during the weekly local hat (bazar) day. So, distance market wholesalers sold seaweed every day from their shop whereas distance market retailers sold one to two days a week on the weekly hat (bazar) day. On every weekly hat day an average of 3 to 4 seaweed retailers came to hat (bazar) and every distance market seller was able to deal with 35 to 40 seaweed consumers to sell 20 to 25 kg of dry seaweed. Distance market sellers (both retailers and wholesalers) were operating the seaweed business with their main business of dry fish selling.

Some seaweed farmers and naturally produced stock harvesters did not sell seaweed to farmgate wholesalers and usually came to the local market in Barmiz market, Cox's Bazar Sadar town to get a higher price. They often dealt with small quantities, had no permanent stores, and sat adjacent to the road 2 days a week. Those local market sellers mainly performed their activities in retail selling to consumers. Though they sold their harvested seaweed in local markets sometimes bought seaweed from farmers considering market demand and return possibility as those market actors are not financially arranged for seaweed business. Local tribal Rakhine communities were the main target customers of local market retailers but sometimes sold to distance market retailers of Bandarban districts as well as to restaurants, and seaweed products developers of Cox's Bazar in very tiny amounts. According to Jahanara Green Argo (a commercial basis seaweed-based products developer & who has a shop in Cox's Bazar) manufactures 132 products such as seaweed chocolate, seaweed extracts, seaweed oil, seaweed sheets etc. and sold in the whole country through online orders. In weekly Bazar day, 3 to 4 local market seaweed retailers come in Barmiz market, Cox's Bazar can deal with 22 to 25 seaweed consumers who sell seaweed. Sometimes, those local market sellers also sold mussels and clams with seaweed which they harvest from the wild.

Customers are the final users and the main actors in the value chain of seaweed. Domestic households, seaweed product developers, and restaurants were among the study's customers. Domestic household consumers bought seaweed directly from

farmers, local market retailers, distance market retailers and wholesalers. However, institutional consumers (i.e., product developers and restaurants) generally bought seaweed from local traders.

4.2.2 Supporting actors

Although they could not have been directly involved in the value chain, supporting actors deliver a wide variety of services to the chain actors. They supported the chain's stakeholders by providing knowledge, training, transportation, market data, infrastructure development, standard maintenance, and technical support, among other things. Many NGOs (Non-government organizations) variously supported seaweed farmers. Among the several NGOs, WorldFish is one of the primary organizations that provide training on improved production methods, standard maintenance, obtaining inputs easily from nearby sources, post-harvest handling, relevant information regarding customers and markets etc. to seaweed farmers. WorldFish also introduce and investigates improved and new culture methods in the field and assists farmers in determining market prices. In order to encourage seaweed farming, NGOs often provided free input support to some selected energetic seaweed farmers after training. The educational institution collaborates with non-governmental organizations (NGOs) to research various aspects of seaweed culture. As a result, the educational institution provides farmers with technological support on improved farming methods. However, value chain actors obtained about the supply and demand for seaweed, prices and other details from them and other traders. When traders transported their goods, they frequently had to pay a lot of money via motor vehicle, van, or pickup. To advance the seaweed value chain, these support initiatives must be on time and consistent.

4.2.3 Marketing channel of seaweed

A marketing channel is a system of intermediaries utilized to move grains for consumption from producers to final consumers (Acharya, 2004). In the case of seaweed marketing, **nine** different ways to market were found.

(a) Farmer → Consumer
(b) Farmer → Distance Market Wholesaler→ Distance Market Retailer→ Consumer
(c) Farmer → Distance Market Wholesaler→ Consumer

(d) Farmer → Farmgate Wholesaler → Distance Market Retailer→ Consumer

(e) Farmer → Farmgate Wholesaler → Distance Market Wholesaler→ Distance Market Retailer→ Consumer

(f) Farmer → Farmgate Wholesaler → Distance Market Wholesaler → Consumer

(g) Farmer → Local Market Retailer → Distance Market Retailer→ Consumer

(h) Farmer → Local Market Retailer → Seaweed Products Developer and Restaurant→ Consumer

(i) Farmer → Local Market Retailer → Consumer

Farmers and natural production harvesters sold the greatest quantity of seaweed (67%) through farmgate wholesalers out of the total amount. However, marketing by some farmers as local market retailers accounted for the lowest amount of seaweed (1%). Though directly marketing to consumers accounted for a significant volume of seaweed (27%) out of total production (Figure 5).

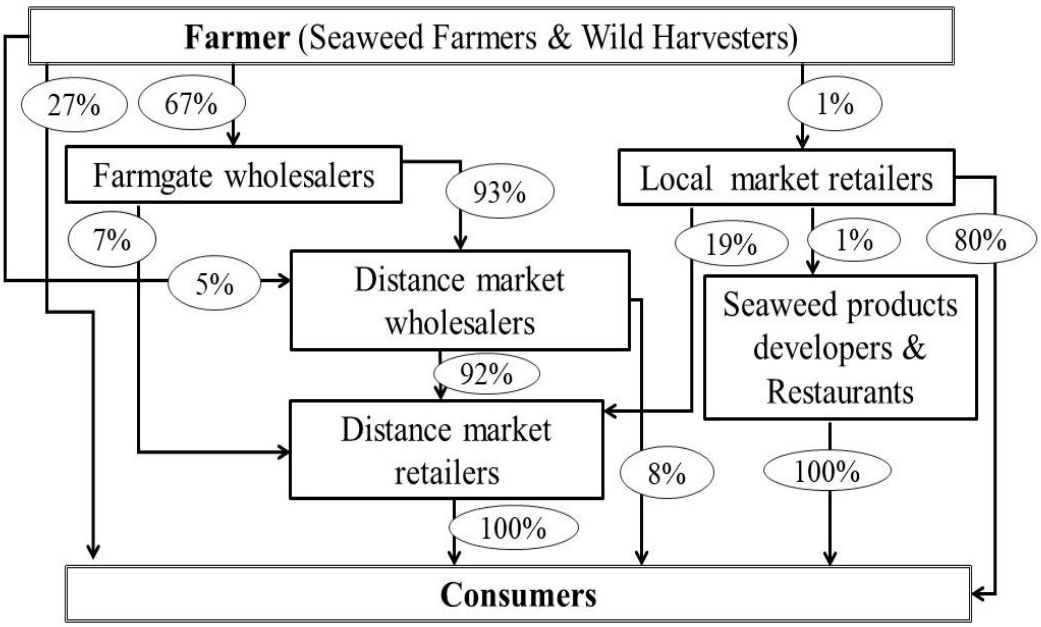

Figure 5: Seaweed marketing channels in Bangladesh

4.3 Cost and Margin analysis of the farmers

Cost is an important consideration that farmers consider in their decisions. To cultivate and market their produce, farmers had to pay both the production and

marketing costs. Fixed and variable costs are both included in culture costs but in seaweed farming, farmers had no fixed cost. Fixed cost incurred by farmers for land use cost. Due to seaweed farming operating in the intertidal zone of the sea, farmers did not bear any land use cost. Marketing costs are the expenses associated with the business operations required to carry out different marketing-related activities.

Table 2: Culture and marketing costs of seaweed farmers.

Cost Types	Cost Items	Cost (Tk./ 24m^2)
Culture cost	Material	3378.38 (63.65%)
	Labour	1702.71 (32.08%)
	other	226.32 (4.27%)
a) Total Culture cost		**5307.40**
Marketing cost	Transportation	291.3 (59.34%)
	Packaging	177.95 (36.26%)
	Others	21.6 (4.40%)
b) Total Marketing cost		**490.85**
Total cost (a + b)		**5798.247**

Among the three culture methods, on average total cost for culture and marketing of seaweed for single plot (24m^2) cultivation was 5798.247 Tk./ 24m^2, while the total fixed expense was 0 Tk./ 24m^2, total variable cost was 5307.40 Tk./ 24m^2 and marketing cost was 490.85 Tk./ 24m^2. The majority of the seaweed cultivation expenses, totaling around 63.65%, were incurred by materials for set-up preparations. Besides, 32.8% of the total culture cost accounted for labour payments to make culture structures. Seaweed farmers had to pay about 59.34% of the total marketing expenses for transportation, while they invested 36.26% of the total marketing costs on packaging (Table 2).

Table 3: Gross margin and net return of seaweed farmers.

Particulars	Seaweed (Tk./ 24m^2)
a. Gross return	11862.9
b. Fixed cost (Land use cost)	0
c. Variable cost	5307.40
d. Marketing cost	490.85
e. Total cost (b + c + d)	5798.247
f. Gross margin (a − c)	6555.5
g. Net return (a − e)	6064.66
h. Return on Investment (ROI) %	104.59%

With 5 months of active seaweed cultivation considering environmental factors fluctuations, seaweed yielded 63.06 kg (in dry weight, calculated 7 kg wet needed for 1 kg dry seaweed) on average per 24m^2, and farmers sold it in dry form for Tk.188.12 /kg on average. The average net return per 24m^2 seaweed cultivation was 6064.66 Tk. and the Return on Investment (ROI)% was found to be 104.59% (Table 3).

4.4 Value addition of the different market actors of seaweed

The largest amount of marketing expenses incurred by the distance market wholesalers and the distance market retailers was 78.45% and 70.09%, respectively, for transportation, loading and unloading costs. For farmgate wholesalers, cleaning, grading, and wastage costs accounted for the largest portion of seaweed marketing expenses (50%). The minimum marketing cost incurred by local market retailers for per kg seaweed marketing was 3.6 Tk where packaging cost expenditures accounted for about 50% of their total marketing expenses. Though local market retailers and farmgate wholesalers had no marketing cost for shop rent and miscellaneous costs, around 9.23% and 9.12% costs were incurred for distance market wholesalers and distance market retailers respectively (Table 4).

Table 4: Marketing cost of traders in the Seaweed value chain (Tk./kg); (Note: Figures within parentheses indicate the percentage)

Cost Items	**Trader's Type**			
	Local market retailers	**Farmgate wholesalers**	**Distance market wholesalers**	**Distance market retailers**
Transportation, Loading and unloading cost	1.8(50%)	1(25%)	17 (78.45%)	9 (70.09%)
Cleaning and grading, Wastage cost	-	2(50%)	1 (7.71%)	1.5 (9.12%)
Packaging cost	1.8(50%)	1(25%)	1.67 (4.62%)	1.17 (11.69%)
Shop rent and Miscellaneous cost	-	-	2 (9.23%)	1.17 (9.12%)
Total	3.6	4	21.67	12.84

Local market retailers had a minimum buying function as they sold the maximum portion from their harvest but the amount they contributed of the total value addition was around 10.79%. Distance market wholesalers invested the highest amount on marketing of all the traders, making up 51.46% of the total costs. Around 42.73% of

the total gross marketing margin was added by distance market retailers, which is the largest amount. Besides, the second highest value added by distance market wholesalers was 37.47%. The total net marketing margin per kilogram of seaweed was determined to be Tk. 69.05, while distance market retailers earned the largest portion at 50.19% (Table 5).

Table 5: Value addition, marketing cost, and net marketing margin of traders (Tk./kg); (Note: Figures within parentheses indicate the percentage)

Traders	Purchase Price (Tk.)	Selling Price (Tk.)	Gross Marketing Margin/ Value Addition (Tk.)	Marketing Cost (Tk.)	Net Marketing Margi (Tk.)	ROI (%)	Farmer's share in the sales price (%)
Local market retailers	198	210	12 (10.79%)	3.6 (8.54%)	8.4 (12.16%)	4.17	89.58
Farmgate wholesalers	200	210	10 (8.99%)	4 (9.49%)	6 (8.68%)	2.95	89.58
Distance market wholesalers	208.34	250	41.66 (37.47%)	21.67 (51.46%)	19.99 (28.95%)	8.70	75.26
Distance market retailers	245.84	293.34	47.5 (42.73%)	12.84 (30.49%)	34.66 (50.19%)	13.39	64.14
Total (Tk.)	--	--	**111.16**	**42.11**	**69.05**		

Among the seaweed market actors, with a return on investment of 13.39%, distance market retailers had the highest ROI. Besides, the lowest amount of ROI was achieved by Farmgate wholesalers, which was 2.95%. Comparing the price paid by consumers to the price received by farmers, the difference is huge which is investigated by farmer's share analysis. The farmer's share in the consumer's price at distance market retailers was about 64.14 percent (Figure 6).

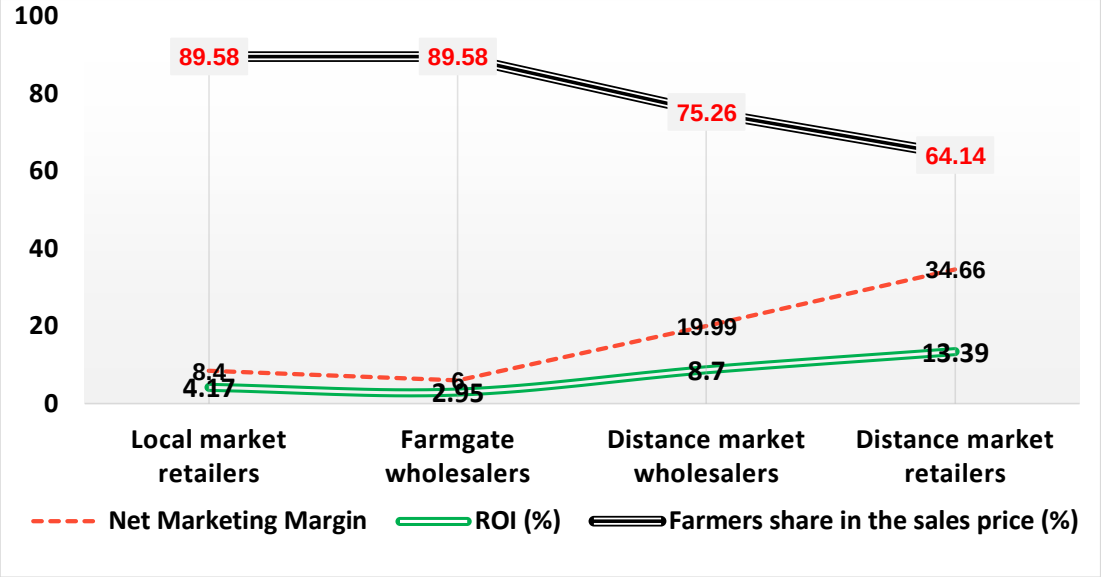

Figure 6: Net marketing margin, Return on investment (%) and farmers' shares (%) at different market actors of seaweed.

The increase of middlemen in the marketing channel decreased the farmer's net share. It was discovered that the intermediaries took advantage of the situation and set the price for seaweed for an excessively large margin. Though farmer's share was 89.58%, which was the same at local market retailers and farmgate wholesalers.

4.5 Observations and perceptions of seaweed value chain actors regarding farming, marketing as well as strategies to improve market demand

4.5.1 Farmers and wild stock harvester's observations and perceptions

During questionnaire interviews with seaweed farmers, they explained observations of an increase in seaweed farming, wild harvest production and market conditions by addressing some relevant statements. According to the farmers' observations, the highest percentage received for the category "moderately increase" of perceptions for the 'people involvement in seaweed farming/collection increase' (40%), 'natural harvest increase' (50%), 'farm production increase' (42.5%), 'local people's involvement in seaweed business' (50%) and 'market price for seaweed' (52.5%). Whereas 'demand increased in local market' (47.5%) and 'people eagerly come forward to farming & business increase' (52.5%) perceptions were the highest percentage in the "slightly increase" category. The remaining perception of 'government encourage & provide support increase' (95%) received the highest percentage in the "no increase" category (Table 6).

Table 6: Framers' observation in increase of seaweed farming and market condition (SD=Standard deviation)

Topics	**Degree of increase**		**Percentages of scores according to seaweed farmer's perceptions**				
	(Mean±SD)	**Degree of increase**	No (00)	Very little increase (01)	Slightly increase (02)	moderately increase (03)	Highly increase (04)
People involved in seaweed farming/collection	(3.13±0.83)	Highly increase	0%	2.5%	20%	40%	37.5%
Natural harvest	(2.60±1.19)	Moderately increase	7.5%	15%	7.5%	50%	20%
Farm production	(2.78±0.74)	Moderately increase	0%	0%	40%	42.5%	17.5%
Local people's involvement in seaweed business	(2.48±0.99)	Moderately increase	2.5%	17.5%	20%	50%	10%
Demand increased in local market	(2.56±0.79)	Moderately increase	0%	5%	47.5%	35%	12.5%
The market price for seaweed	(2.55±0.91)	Moderately increase	0%	17.5%	20%	52.5%	10%
People eagerly come to farming & business	(2.20±0.73)	Moderately increase	0%	15%	52.5%	30%	2.5%
Govt. encourage & provide support	(0.05±0.23)	Very little increase	95%	5%	0%	0%	0%

Another important survey question that was discussed during the interview was how seaweed farmers thought about various issues regarding strategies to enhance or boost seaweed production in Bangladesh. Regarding this issue, 50% of farmers did not agree with the perception of 'providing adequate training facilities on seaweed farming'. However, 70% and 57.1% of farmers highly agree on the perception of 'through technical & input support for culture' and 'declaration of specific land by government for cultivation', respectively. The highest percentage received for the category "moderately agreed" on perceptions for the 'increasing market demand and price of seaweed through different approaches' (45%), 'integrated aquaculture development' (47.5%) and 'involvement of local women and youth' (55%) (Table 7).

Table 7: Farmer's perceptions on strategies that can increase seaweed farming (SD=Standard deviation)

Topics	**Degree of agree**		**Percentages of scores according to seaweed farmer's perceptions**				
	(Mean±SD)	**Degree of agree**	00	01	02	03	04
Providing adequate training facilities on seaweed farming	(0.84±1.11)	very little agree	50%	32.5%	7.5%	5%	5%
Through technical & input support for culture	(3.64±0.63)	Highly agree	0%	0%	7.5%	22.5%	70%
Ensuring loan facilities	(2.89±0.86)	Moderately agree	0%	2.5%	35%	35%	27.5%
Increasing market demand and price of seaweed through different approaches	(3.16±0.84)	Highly agree	0%	5%	12.5%	45%	37.5%
Integrated aquaculture development	(2.56±0.75)	Moderately agree	%0	7.5%	37.5%	47.5%	7.5%
Involvement of local women and youth	(3.35±0.59)	Highly agree	0%	0%	5%	55%	40%
Declaration of specific land by govt. for cultivation	(3.5±0.65)	Highly agree	0%	0%	7.1%	35.8%	57.1%

In the survey another question that was discussed during the questionnaire interview with farmers on how seaweed farmers considered different perceptions regarding strategies that can improve/increase market demand and price in Bangladesh. According to the farmers, the highest percentage received for the category "moderately increase" of perceptions for the 'awareness creation among the general people' (50%), 'ensuring seaweed food safety and quality aspects' (60%) and 'setting up of seaweed-based industries' (55%). Whereas the highest percentages of the seaweed farmers and natural stock harvesters highly agreed on perceptions for, 'improving packaging, branding, storage system' (50%), 'creating export market' (85%), 'strong market channel' (77.5%) (Table 8).

Table 8: Farmer's perceptions on strategies that strategies can improve/increase market demand and price (SD=Standard deviation).

Topics	Degree of agree		Percentages of scores according to seaweed farmers perceptions				
	(Mean±SD)	Degree of agree	00	01	02	03	04
Awareness creation among the general people	(2.95±0.72)	Moderately agree	0%	0%	27.5%	50%	22.5%
Ensuring seaweed food safety and quality aspects	(2.95±0.64)	Moderately agree	0%	0%	22.5%	60%	17.5%
Improving packaging, branding, storage system	(3.48±0.56)	Highly agree	0%	0%	2.5%	47.5%	50%
Seaweed-based product diversification	(2.23±0.62)	Moderately agree	0%	7.5%	65%	25%	2.5%
Setting up of seaweed-based industries	(2.63±0.75)	Moderately agree	0%	7.5%	30%	55%	7.5%
Creating export market	(3.83±0.45)	Highly agree	0%	0%	2.5%	12.5%	85%
Strong market channel	(3.78±0.43)	Highly agree	0%	0%	0%	22.5%	77.5%

4.5.2 Seaweed seller's observations and perceptions

In the context of conducting questionnaire interviews, seaweed sellers provided insights into the expansion of seaweed cultivation, the production of wild harvests, and the state of the market by addressing relevant statements. According to the seaweed sellers thought, the highest percentage received for the category "moderately increase" of perceptions for the 'people involved in seaweed farming/collection increase' (56.8%), 'total production increase' (76.5%), 'seaweed market price increase' (82.4%), 'seaweed supply increase than previous year' (64.7%) and 'local market demand increase' (52.9%). Though, 100% of sellers were in the category "no increase" in perception for the 'government encourage & provide support' (Figure 7).

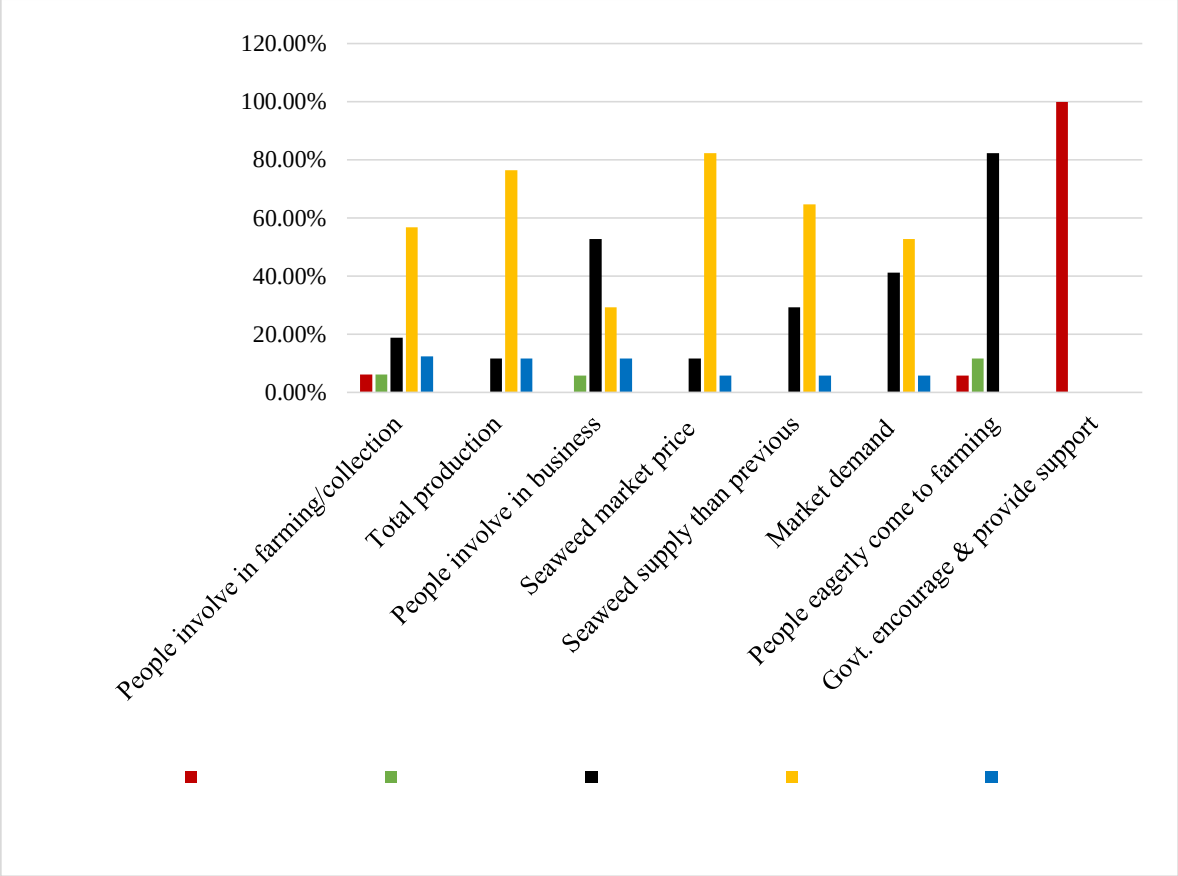

Figure 7: Seaweed seller's observation in increase of seaweed farming and market condition.

Further discussed with seaweed sellers' different perceptions regarding strategies that can improve/increase market demand and price in Bangladesh. As per the sellers of seaweed, the category with the largest percentage received was "moderately agreed" on the statements were 'awareness creation among the general people' (47.1%), 'ensuring seaweed food safety and quality aspects' (41.2%), 'seaweed-based product diversification' (52.9%), 'setting up of seaweed-based industries' (35.4%) and 'strong market channel' (52.9%). Besides, the highest percentage was obtained 47.1% and 62.5% on the statement 'improving packaging, branding, storage system' and 'creating export market', respectively (Table 9).

Table 9: Seaweed seller's perceptions on strategies can improve/increase seaweed market demand and price. (SD=Standard deviation)

Topics	Degree of agree		Percentages of scores according to seaweed farmers perceptions				
	(Mean±SD)	Degree of agree	00	01	02	03	04
Awareness creation among the general people	(3.18±0.72)	Highly agree	0%	0%	17.6%	47.1%	35.3%
Ensuring seaweed food safety and quality aspects	(3.06±0.89)	Highly agree	0%	5.9%	17.6%	41.2%	35.3%
Improving packaging, branding, storage system	(3.35±0.70)	Highly agree	0%	0%	11.8%	41.2%	47.1%
Seaweed based product diversification	(2.76±0.67)	Moderately agree	0%	0%	35.3%	52.9%	11.8%
Setting up of seaweed-based industries	(2.94±0.82)	Moderately agree	0%	0%	35.2%	35.4%	29.4%
Creating export market	(3.50±0.81)	Highly agree	0%	6.3%	0%	31.3%	62.5%
Strong market channel	(2.88±0.69)	Moderately agree	0%	0%	29.4%	52.9%	17.6%

4.5.3 Consumers perceptions

According to seaweed consumers' observations on seaweed price, supply and quality aspects, the highest 36.1% percentage was found in the very "little increase" category for seaweed price increase than previous year, 58.3% found in the "moderately increase" category for seaweed supply increased than previous. Besides, 58.3% of consumers claimed community people consumption increased slightly and 50% thought very little improved in packaging and branding. In perception of improvement in hygiene condition, the highest 36.1% of consumers observed slightly improved (Table 10).

Table 10: Consumers' observation in seaweed supply, price, and quality of seaweed. (SD=Standard deviation)

Topics	**Degree of increase/ improve**		**Percentages of scores according to seaweed farmers perceptions**				
	(Mean ±SD)	**Degree of increase/ improve**	No change (00)	Very little increase (01)	Slightly increase (02)	Moderately increase (03)	Highly increase (04)
Seaweed price increased	(1.78±0.99)	Slightly increase	8.3%	36.1%	25%	30.6%	0%
Seaweed supply increase	(2.58±0.649)	Moderately increase	0%	5.6%	33.3%	58.3%	2.8%
Community people consumption increased	(2.42±0.50)	Moderately increase	0%	0%	58.3%	41.7%	0%
Improvement in packaging and branding	(0.69±0.79)	Very little improve	50%	30.6%	19.4%	0%	0%
Improvement in hygiene condition	(1.86±0.89)	Slightly improve	5.6%	30.6%	36.1%	27.8%	0%

Chapter 5: Discussion

5.1 Socio-demographic characteristics of farmers (seaweed farmers and wild harvesters)

In this study, the average age of seaweed farmers and wild stock harvesters was 39.15 years, and the age range was 18 to 70 years, with the 31 to 45 years age group dominating the group which consisted of 42.8%. Akhtar et al. (2022) found in their study, the age range of seaweed farmers was 24 to 60, the average age was 38 years and between the ages of 30 and 39 respondents made up the majority (46%). The seaweed farmers' age demography of the present study is more similar to the above-mentioned research. Among the seaweed farmers in the study, the majority of seaweed farmers (52.5%) were illiterate, and none of them completed even one year of formal schooling. Despite this, 47.5% of the farmers completed many years of formal education. Akhtar et al. (2022) study also showed that 58% of respondents had never attended school or farmers had no formal education, which closely matched current research. So, it is necessary to upgrade the facilities and infrastructure for schooling in Bangladesh's rural coastal regions. In terms of phone use, 82.5% of the participants in the group that harvested wild stocks and farmed seaweed had phones. Farmers are using various technological devices such as Android phones and have the ability, and confidence to use them as assets for living explained by Farhaduzzaman et al. (2023). Among the participants in this study, the majority were (70%) female and the remaining 30% were male and this gender ratio is almost similar to an experiment. Approximately 20% of the seaweed farmers surveyed were male, and the majority of respondents (80%) were female found (Farhaduzzaman et al., 2023). So, it has been observed that female seaweed farmers are more attentive and energetic in all aspects of farming.

The majority of men and female farmers' primary occupations were fishing and housewife, respectively, whereas seaweed farming is their secondary occupation as seaweed farming is seasonal. Among the participants, the primary occupation of 67.5% of seaweed farmers was housekeeping, followed by fishermen (20%) and other service providers (10%), including daily labour, business, and schooling. In this regard, Akhtar et al. (2022) explained the majority of seaweed farmers in Bangladesh's coastal regions were involved in a variety of other occupations or sources of income such as seashell crafting, fish trading, daily labour etc. because

seaweed cultivation and related activities are seasonal. The majority of farmers (81.6%) claimed to have two to five years of experience, while the remainder 18.4% stated having six to ten years of farming experience. According to Hossain et al. (2020) the seaweed production field demonstration and exhibit in the coastal zones of Teknaf, Cox's Bazar, and St. Martin's Island has been promoted by the Bangladesh Fisheries Research Forum in 2011. Probably after this demonstration on seaweed farming people learned about seaweed farming. Among the people who harvested wild stock, 59.3% had been doing this for the last one to five years, 25.9% for the last six to ten years, and 14.8% for the last eleven to fifteen years. The Department of Fisheries in 2010 reported 140 species of seaweed from St. Martin's Island, 10 from the planted mangrove zone, 5 from the Backkhali-Moheshkhali channel estuary of Cox's Bazar and naturally occurring seaweed traditional used by the tribal community, which collected by coastal people (Sarkar et al., 2016).

In the study in terms of cultivation methods of the seaweed farmers, 59.5% used the long line (bottom) method, 24.3% used the horizontal net method (off-bottom net) in the intertidal zone, and the remaining 16.2% used the floating long line (raft) method in the subtidal zone. In a previous study, respondents practiced seaweed aquaculture with the highest scores (44%), using the long line approach that dominates Bangladesh's coastal waters in the intertidal zone. As per the respondent's scores of 27% and 22%, respectively, the bottom net and raft/hanging line methods are effectively utilized in lower intertidal and subtidal zones (Hossain et al., 2020). Though there is a difference in farming percentages with the previous study, there is a similarity in the sequence of dominating farming methods. The average distance between the homes of farmers and wild stock harvesters and the culture area was 1.40 km, with 55% of farmers residing at a distance of 1.5 km and 35% at a distance of 1 km. So, the culture area from home is not very far and they easily visit their culture plot daily. But, during natural disasters, those coastal seaweed farmers faced a challenging situation as they live very close to sea beach. The majority portion, around 75%, of farmers and wild stock harvesters resided 2 to 9 kilometres away from the closest local market where seaweed is sold by seaweed sellers. In a study on value chain analysis of cauliflower and tomato in Bangladesh, the closest market was approximately 6 to 10 kilometers away for 48% of farmers (Sharma et al., 2023). So, a good number of farmers lived in the nearest market to the study mentioned above

and this close distance to the market helps in marketing easily. From October to March, the majority of farmers (91.9%) stated that they actively engaged in seaweed farming for six months and the remaining were farmed for five months. A previous study on existing culture methods of seaweed found that the culture period for *Gracilaria sp.* takes place from September to March, October to March for *Gelidium* and most of the species' culture suitability were within 4-6 months from October to March along Bangladesh's southeast coast (Ahmed et al., 2022). Besides, seaweed farming activities are seasonal (Akhtar et al., 2022). Moreover, another study found, depending on the impacts of the southeast monsoon in the Cox's Bazar coastal region, seaweed cultivation can last four to six months from November to April (Hossain et al., 2020; Farhaduzzaman et al., 2023). In this current study, majority of seaweed farmers, about 81.1%, had two harvests every 15 days, while the remaining 18.9% received three harvests every month. This finding is quite similar to the previous experiment of Akhtar et al. (2022) and Hossain et al. (2020) which stated, seaweeds are harvested 15 to 30 days intervals during the production season, depending on species diversity and mass growth.

After harvest, seaweeds were cleaned in salt water, then in nearby tube well water, and then put in a rack to dry. Sunlight intensity determines how long seaweed takes to dry. Basically, it took four to five hours on a bright day to completely dry and 7 to 8 kg of wet seaweed is needed for 1 kg of dry seaweed production. In this context Ahmed et al., (2022) found, that after harvesting, 95% of farmers wash the seaweed with saline water then fresh water and seaweeds are sun-dried and do not use the air-dry procedure because of its high cost. Along with their family members, the majority of seaweed farmers (92.5%) were accustomed to consuming seaweed in very minute amounts in combination with food such as salad, sauce, vegetables and noodles as they knew about the food value of seaweed through attending training. Though in the study of Farhaduzzaman et al. (2023) found, seaweed's health benefits are becoming more well-understood to farmers and the majority of farmers treated stomach problems (80%), diabetes (5%), high blood pressure (3%), and cancer (2%) with raw seaweed as a kind of traditional medicine but did not found about regular basis consumption with family members.

5.2 Value chains mapping and marketing channel of seaweed

In the seaweed value chain two types of value chain actors were found are: primary actors and supporting actors. A total of seven active actors found in the primary actor category were farmers/ wild stock harvesters, local market retailers, farmgate wholesalers, distance market wholesalers, distance market retailers, seaweed products developers and consumers. According to Hossain et al. (2020) study, in Bangladesh, fresh and dried seaweed are distributed through two to five channel members, as per the survey participants (farmers). Through field investigation, this study found around six market actors present in marketing channels and working to supply seaweed to final consumers. The majority of seaweed is supplied from three major sources: 1) seaweed collected from wild production, 2) small commercial farming through farmers who get input support from NGOs, or 3) farmers' involvement in project-based farming. Therefore, in the study area, 3 to 4 supporting actors are available who are working in NGOs and transportation activity in the seaweed value chain. Akhtar et al. (2022) study on a baseline survey on seaweed cultivation in Cox's Bazar stated that seaweed farmers are involved in project-based cultivation and or small commercial basis type farming.

In the seaweed market channel, nine different channels were noticed. Though, in Hossain et al. (2020) study mentions 3 to 4 market channels of seaweed existence in Bangladesh. Among those nine market channels "Farmer → Consumers" is the shortest one through which a significant amount (27%) of the total harvest reached final consumers. Seaweed farmers did not know properly about who the actual target customers of seaweed are and sell seaweed to the local Rakhain tribal community in Cox's Bazar. Moreover, seaweed farmers of Reju khal sometimes go to Rakhain para to sell their harvest. Therefore, seaweed farmers and wild collectors sometimes transit to as sellers in the local market, which is also found in a study by Farhaduzzaman et al. (2023). Farmers can't sell their whole production in the local market of Cox's Bazar and to meet up financial crisis, immediately sold to nearby farmgate wholesalers. Among the market channels, through this channel "Farmer → Farmgate Wholesaler → Distance Market Wholesaler→ Distance Market Retailer→ Consumers" supply the majority of total production (67%) from farmers to consumers and the longest channel in the value chain. As seaweed farmers had no linkage among distance market traders, most of the farmers unintentionally sold to farmgate wholesalers at lower prices. According to Farhaduzzaman et al. (2023) study,

approximately 80% of seaweed farmers sell to merchants. Those farmgate wholesalers sold 100% of their seaweed to distance market sellers of several upazila Bazar in Bandarban districts. Farhaduzzaman et al. (2023) study found that harvested seaweed was marketed to Bandarban (40%), Rangamati (10%) and Khagrachari (10%), but in the current study only found the distance market in Bandarban district. According to distance market sellers and consumer interviews, only 2 tribal communities (Marma and Murang) consume seaweed and live with a larger population than others in Bandarban districts. A study on the value chain of seaweed in Amal Coast, Tarakan Island (Indonesia) found two market channels exist there (Wahyularassati et al., 2019). In another study in Viet Nam two major market channels were investigated for seaweed marketing (Anh and Hanh, 2021).

5.3 Cost and margin analysis of the farmers

The average total cost of the three cultural methods for the production and marketing of seaweed for a single plot ($24m^2$) was 5798.247 Tk. / 24 m^2 while, total farming cost was 5307.40 Tk./ $24m^2$ and marketing cost was 490.85 Tk./ $24m^2$. The majority of the seaweed cultivation expenses, around 63.65% and 32.8% of total culture cost had accounted for materials and labour payments to make culture structures, respectively. Ahmed et al. (2022) estimate that the bottom net technique costs 2000 Tk. while the line method costs 1420 Tk. for $20m^2$ area cultivations. Probable reasons for higher culture cost in the study are: differences in experimental time and differences in culture area. Moreover, the most possible reason is high-cost raft/ floating long line method was included in the average cost calculation of the study. Another study on seaweed culture found the cost for the bottom net method was 1,940 Tk./ $25m^2$ area and 4,200Tk. for long line with 30m long, 10 ropes (Hossain et al., 2020). The cultivation cost of the current study was higher than Hossain et al. (2020) study, probably due to an increase in labour cost and material price over time.

Farmers received, on average, 188.12 Tk per kilogram for mainly *Gracilaria* sp., when they sold it in dried form. Seaweed cultivation on a 24 m^2 area yielded an average net return of 6064.66 Tk. This result was matched with Farhaduzzaman et al. (2023) study where the average price of dried *Gracilaria sp*. seaweed/kg sold by farmers was 183.7 Tk. Besides, according to another study investigation, the highest and lowest amounts of money earned from seaweed farming were 3,000.00 Tk. and

1,500.00 Tk. respectively (Akhtar et al., 2022). So, farmers' monthly income during the seaweed cultivation period is almost similar to the Akhtar et al. (2022) study.

5.4 Value addition of the different market actors of seaweed

Transportation, loading and unloading costs were the major marketing costs among the cost items of four intermediaries in seaweed value chains while distance market wholesalers have to count about 78.45% of the marketing cost for it. Besides, distance market retailers of Bandarban districts also account for around 70% of marketing costs in transportation. This high marketing cost was logical as the far distance from Cox's Bazar and there was not available any goods transportation service or transport agency from Cox's Bazar to Bandarban. According to Akhtar et al. (2022), transportation costs limit the process of selling which was addressed in the constraints of seaweed sellers. Distance market wholesalers invested the biggest amount in the marketing of all the traders, accounting for 51.46% of the total costs, but distance market retailers added the greatest amount, around 42.73% of the total gross marketing margin. In the price formation of seaweed in the value chain, intermediaries fix the price as they wish and there is no monitoring by the government on price formations. Therefore, the highest gross marketing margin and more than 50% of total net return are achieved by distance market retailers.

Return on investment (ROI) of distance market retailers had gained the highest (13.39%) among the intermediaries in marketing channels. Distance market retailers purchased a larger volume of seaweed than they sold from distance market wholesalers thus resulting in lower marketing cost and higher net return. Therefore, the return-on-investment ratio was found highest in distance market retailer levels. This result was similar to a study on value chain analysis of cauliflower and tomato by Sharma et al. (2023), where wholesalers received a higher return on investment (ROI) than others for a large amount of net return. In the case of farmer's share in the consumer purchase price, the present study shows that farmers get 64.14% of the consumer purchase price at the retailer level. The shorter the marketing chain, the more the farmer's share of consumers' pricing (Shrivastava and Ranadhir, 1995). A study on the value chain of seaweed in Amal Coast, Tarakan Island (Indonesia) found

farmer’s share of seaweed on end customer prices in 2 market channels were 42.80% and 45% (Wahyularassati et al., 2019). As there is limited article on the farmer’s share of seaweed calculated but can relate to some marine fish value chain-related research work with this study. In the marketing of some marine fish, the average share that fishermen received was 68% of the consumer purchase price (Islam et al., 2006). In the Cox's Bazar region, fishermen's share of the consumer market for ribbon fish and Bombay duck was less than 74% (Ahsan et al., 2016).

5.5 Observations and perceptions of seaweed value chain actors regarding farming, marketing as well as strategies to improve market demand

According to farmers' and sellers’ observations of an increase in seaweed farming and market condition, most perceptions on total production, local people’s involvement in seaweed business, demand increased in the local market, the market price for seaweed was in “moderately increased” based on average score. Moreover, people involved in seaweed farming/collection were “highly increased” from the perceptions of farmers and wild harvesters. During focus group discussions and kay informants’ meetings mentioned in this regard, a large number of females were involved in the last few years as they can support household expenses by selling seaweed an affordable task for them to operate. In Tanzania, seaweed farming has raised the income of farmers who have been farming seaweed for four to twenty years, and as a result, the number of seaweed farmers has increased (Matoju et al., 2022). According to Shafitri et al. (2019), seaweed farming in Nunukan Island, Indonesia improves the livelihood situation of the coastal people, which is supported by the current study. Government encouragement & support for seaweed farmers was very poor for developing this sector according to perceptions of value chain actors. As seaweed farming and business is a growing income source for poor coastal people, the government along with other organizations should focus on a long-term development plan.

Farmers “highly agreed” on the perceptions regarding strategies that can improve/increase seaweed farming(production) in Bangladesh were technical & input support for culture and declaration of designated land by govt. for seaweed cultivation. Farmers explained that through technical & input support for culture from NGOs and participatory project-based cultivation, seaweed farming and production increased in the last few years. Besides, airport runway expansion work reduced the

culture sites in Nuniarchora, Cox's Bazar and boat navigation hamper the culture structure. Therefore, specific cultivation site declarations urge the need for seaweed farmers. Land/water use conflict obtained the highest scores regarding social challenges for seaweed production found from the Hossain et al. (2020) study in Bangladesh which supported the study.

Perceptions regarding strategies that can improve/increase seaweed market demand and price in Bangladesh, most of them were moderately agreeing to highly agree on average scores of seaweed farmers and sellers. Seaweed sellers' perceptions were highly agreed on creating awareness among the general people as tribal consumers were the only customers. So, awareness creation among people on seaweed through various ways such as food value, advertising etc. can increase seaweed market demand. An awareness campaign that got the highest scores among the major techniques for promoting seaweed was reported in Hossain et al. (2020) experiment. For mass people's acceptance of seaweed, improved packaging, and branding in marketing was a highly agreed strategy of both farmers and sellers. Because seaweed marketing conditions were very poor as sellers used normal polythene bags. Key informants thought that using an airtight and properly labeled bag in seaweed marketing could increase demand and acceptance by mass people. Seaweed farmers and sellers highly agreed with the perception of the creation of exporting facilities as a strategy for improving market demand. As farmers and sellers depend only on tribal consumer markets to sell seaweed, exporting to outside countries could be a significant option for them. Ahmed et al. (2022) study reported that seaweed was exported by local entrepreneurs outside of Bangladesh but, during data collection, no exporter was found. Strong market channel linkage development was highly agreed on perceptions of farmers to get a sufficient price as they had to depend on farmgate intermediaries to sell seaweed. Farmer's share of consumers' purchase price could increase through linkage with retailers and shortening marketing channels. Seaweed cultivation and marketing are threatened by unstable and unfair farm gate prices as well as a small number of buyers (Akhtar et al., 2022).

As per seaweed consumers' perceptions, community people consumption and seaweed supply increased moderately, which is a good sign for seaweed value actors to utilize this sector efficiently. So, to expand the domestic market demand must be improved in packaging, branding and hygiene conditions from the current state of very little

improved and slightly improved respectively. Thus, mass people acceptance will increase with present tribal consumers subsequently.

Chapter 6: Conclusion

Following the study's findings, seaweed farming has a huge potential in Bangladesh, because an increasing number of coastal people, especially women, are dedicated to farming and natural stock harvesting for earning, as they have a limited income source than urban people. In the value chain of seaweed, seven active primary actors found to include supplying seaweed were farmers, local market sellers, farmgate wholesalers, distance market wholesalers, distance market retailers, seaweed products developers and consumers. There are nine seaweed marketing channels identified and one channel includes farmers, farmgate wholesalers, distance market wholesalers, distance market retailers, and consumers who carry the maximum quantity (67%) of seaweed flow. Direct marketing to consumers accounted for a significant volume of seaweed (27%) out of total production. Due to selected consumers of seaweed being tribal communities in the domestic market and poor linkage with distance market actors, farmers sold a large portion of the total harvest at lower prices to farmgate wholesalers. Therefore, the farmer’s share in the consumer’s price at the distance market retailer level was about 64.14% and the remaining more than 35% share went to market intermediaries. The highest marketing cost incurred by transportation costs and distance market wholesalers accounted for the highest total marketing cost among market actors, but distance market retailers secured the maximum net return as well as ROI (%). The study identified that local people involved in seaweed farming and or wild stock collection highly increased, the market demand and price for seaweed moderately increased and consumers' community consumption also increased moderately. A few recommendations are put forward to enhance the entire value chain of seaweed. Strong market channel linkage with farmers should be established so that farmers get proper prices. Should create facilities for export to the outside country as the domestic market is very limited. To expand domestic market demand, public awareness creation in various ways with the support of the government and NGOs must be implemented. Moreover, seaweed-based product diversification and

improved packaging, hygiene maintenance, branding etc. can increase mass people acceptance in the domestic market. Lastly, the declaration of a designated seaweed farming zone by resolving land/water use conflict for smooth seaweed supply in the seaweed value chain can contribute to securing the nation's blue economy goal.

Chapter 7: References

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Chapter 8: Appendix

8.1 "Questionnaire for Market & Value Chain Analysis of Seaweed"

1. Questionnaire for Seaweed Farmer/Collector

1.1) General Information:

Interview No.: Date:

1. Interviewer Name:

2. Address:

Village	
Upazila	
District	

3. Gender:

Male	
Female	

4. Age:

5. Year of education:

6. Mobile: 7. Occupation: (primary) _ _ _ _ _ _ _ _ _ _Secondary: _ _ _ _ _

*Do you involve in seaweed farming/collecting from the wild?
Yes/ No

If, yes…

1.2) Seaweed production/collection related information:

1. Are you a seaweed collector/farmer/both collector & farmer?

Seaweed farmer (Own farm/ beneficiaries)	
Collector from wild	
Both farmer & collector	

2. How many years have you been involved in seaweed farming/collecting?

Seaweed farming: ………..(Years) and collecting ………..(Years)

3. Where do you culture/harvest? _ _ _ _ _ _ _ _ _ _ _ _ _ _ __ _ _ _ _ _ _ _ _ _ _ _ _ _ _ _ _

4. How far the culture area and harvesting location from your village:…..KM and…………..(KM)

5. Which species of seaweed do you collect from wild/harvest?

Scientific Name	**Scientific Name**	**Scientific Name**	**Scientific Name**
Gracilaria sp	*Caulerpa racemosa*	*Hypnea pannosa*	*Porphyra*
Ulva lactuca	*Enteromorpha*	*Sargassum*	*Codium fragile*
Gelidium pusillum			*Padina tetrastromatica*

6. If you collect seaweed from a natural source, how many days in a week/month do you collect seaweed? __ _ _ _ _ _ _ _

7. How many months in a year do you collect seaweed from natural sources? _ _ _ _ _ _ _ _ _

8. On average, how much volume of seaweed you can collect from the wild source per month_ _ _ _ _ _ _ _

9. Could you give an idea about how many peoples are involved in collecting/farming seaweed

from the same area you collect/farming_ _ _ _ _ _ _ _ _ _ _ _ _ _ _ _ _ Men_ _ _ _ _ _ _ _ __

Women__ _ _ _ _ _ _ _ _ _ _

10. Tentatively how much volume do all of you collect seaweed in a month from the same place_ __ _ _ _ _ _ _ _ _ _ _ _ _ _

11. What was total production in the last year/season? Fresh weight …………. (kg); Dried weight…..………(kg)

12. If you are a seaweed culture farmer, which method do you use in seaweed farming? _and which species do you culture _

13. Your total culture area/plot size _

14. When did you start culture/collecting of seaweed (year of experience) _ _ _ _ _ _ _ _ _ _ _ _

15. Do you collect seeds from the wild? Yes/ No; If no, from where? _ _ _ _ _ _ _ _ _ _ _ _ _

16. Total culture duration (months) in a year _

17. How many times do you harvest seaweed per month from your culture plots? _ _ _ _ _ _ _

18. Average production in wet weight (kg) in a single harvest from your culture plots? _ _ _ _

19. Total production in wet weight (kg) for a full season/year from your culture plots _ _ _ _ _

20. In which form do you sell your seaweed? Wet/ dry/ both

21. How much wet/fresh(kg) of your culture seaweed species need for 1 kg dry seaweed production_ _

22. What were the input cost for seaweed culture in you practiced? Material cost………..Labour cost…………& others……………(Total……………..)

23. How much cost incurred for selling seaweed in a day/week/per kg? Transportation cost…….. Packaging cost……… & Bazar rent……….

24. Seaweed culture methods are practiced by farmers in this site are_ Please mention, which method having the best production with species_ _

25.Where do you sell your seaweed usually?

	Name of the market	How far the market(km)
Local market		
Other upazilla or districts		
On-site		

26. Who is the buyer?

	Quantity of sell to buyer	In which form (fresh/dry)
Local consumer/Tribal people		
Local agent/wholesaler		
Restaurants		
Processor/Exporter		
Distance market seller		

27. Which form is mostly preferred /demand in the market?

Wet /Fresh	
Dry	
Both	

28. What is the average price of your seaweed?

		On-spot		**Market**	
Scientific Name	**Local Name**	**Wet/Fresh**	**Dry**	**Wet/Fresh**	**Dry**
Gracilaria sp					
Ulva lactuca					
Other					
Other					

29. Do you sell seaweed for a whole year? Yes / No

30. If not, how many months do you sell in a year? _

31. Why you don't sell for a whole year? (Mark in the following)

Seaweed is not available throughout the year	
Don't know how to store & package to sell in the off-season	
Lower preference to consume by local people during offseason	
Only wet seaweed consumer/buyer come to market during peak season	
Others:	

32. Market demand and price of seaweed remain constant every month? Yes / No

33. In which months, prices of seaweed are lower_ _

34. Which months you can get a higher price_ _

35. To get the high price for your harvested seaweed, which strategies do you follow? _ _ _ _
_ _

36. Do you or the local people consume seaweed? Yes / No

37. If yes, which seaweed species are mostly consumed by you/local people? _ _ _ _ _ _ _ _ _
_ _

38. If yes, how much (kg) do you consume per month? _

39. What about your observation in increase of seaweed collection, production, and market condition….

People involved in seaweed farming/collection	0	1	2	3	4
Natural harvest/collection	0	1	2	3	4
Farm production of seaweed	0	1	2	3	4
Local people's involvement in seaweed business	0	1	2	3	4
Demand for seaweed in the local market	0	1	2	3	4
The market price for seaweed	0	1	2	3	4
People eagerly come for forward to seaweed farming & business	0	1	2	3	4
Govt. encourage & provide support to the business	0	1	2	3	4

40. What strategies can improve seaweed farming(production) in Bangladesh

Providing adequate training facilities on seaweed farming	0	1	2	3	4
Through technical & input support for culture	0	1	2	3	4
Ensuring loan facilities	0	1	2	3	4
Increasing market demand and price of seaweed through different approaches	0	1	2	3	4
Integrated aquaculture development	0	1	2	3	4
Involvement of local women and youth	0	1	2	3	4
	0	1	2	3	4

41. Are you satisfied with the market demand and price of the seaweed?

0	**1**	**2**	**3**	**4**

42. If you are not highly satisfied with the market demand and price of the seaweed, what are the possible strategies that can improve the seaweed market demand and price in Bangladesh?

Awareness among the general people about the food value of seaweed	0	1	2	3	4
Ensuring seaweed food safety and quality aspects	0	1	2	3	4
Improving packaging, branding, and storage system	0	1	2	3	4
Seaweed based product diversification	0	1	2	3	4
Setting up of seaweed-based industries for commercial products	0	1	2	3	4
Creating export market	0	1	2	3	4
Strong market chennel	0	1	2	3	4
	0	1	2	3	4
	0	1	2	3	4

*0= no change, *1= very little increase, *2= Slightly increase, *3= moderately increase, *4= highly increase.

43. Others…..

1.3 Other Questions (Producer)

1. Do you know maintaining hygiene and good packaging can increase seaweed value? Yes/ No

2. If yes, do you apply proper hygiene and packaging in harvest and post-harvest handling? Yes/ No

3. Do you follow any traceability system for the growing trust in your product to consumer/buyer? Yes/ No

4. Do you follow the supply chain management system for due-time delivery of the order? Yes/ No

5. Before selling, are you sorting fresh and quality seaweed from the total harvest? Yes/ No

If yes, have any use/demand of the low-grade seaweed after sorting?

6. Where are the major demands of seaweeds? Human feed…….(%); Animal feed…….(%);

Industrial (Pharmaceutical and cosmetics) ……. (%); Others……..(%)

7. What facilities are lacking in value addition of seaweed products? Please rank 5 challenges, 1 being most critical challenge…

*Lack of awareness (Rank……); *Seasonal production (Rank……); *Limited supply (Rank……); *Seaweed products are not available in local market and restaurant (Rank……) *Lower local demand (Rank……)

8. How does seaweed farming and business sustain income source for coastal community?

Designated zone for seaweed aquaculture	0	1	2	3	4
More economic and feasible culture techniques dissemination	0	1	2	3	4
Processing facilities and products diversification	0	1	2	3	4
Strong market channel development	0	1	2	3	4
Awareness of food value and medicinal importance	0	1	2	3	4
Local demand increases through different approach	0	1	2	3	4
Whole year availability					
Others	0	1	2	3	4

2. Questionnaire for Local Market

2.1) General Information:

Interview No.: Date:

1. Interviewer Name:

Village	
Upazila	
District	

2. Address:

3. Gender:

Male	
Female	

4. Age:

5. Mobile: 6. Occupation: (primary) _ _ _ _ _ _ _ _ _ _ Secondary: _ _ _ _ _

6. Year of education:

7. Do you involve in the seaweed business/farming? Yes/ No

If yes, how long are you involved in this business(years)? _

2.2) Seaweed Related Information

1. You are a farmer and those seaweeds come from your own cultural site? Yes/ No

2. If no, from where do you collect seaweed(source) and purchase price? _

3. How many days in a week do sellers come to sell seaweed in this market? _ __ _ _ _ _ _ _ _

4. How many days do you sell seaweed in a month here? _

5. How many customers you may sell in a day? _

6. How many seaweed sellers come per day in this market? _

7. In which form do you sell your seaweed? Wet/ dry/ both

8. On average how much(kg) wet and dried seaweed sell per day?

Wet/ Fresh seaweed	
Dried seaweed	

9. How much cost incurred for selling seaweed in in a day/week/per kg? Transportation cost……. Packaging cost…….

10. On average how much (kg) do you sell seaweed in a year in this market? _ _ _ _ _ _ _ _ _ _ _ _ _ _ _ _ _ _

11. Seaweed price range per kg.

Species		**Tk/kg**	
Scientific Name	**Local Name**	**Wet/Fresh**	**Dry**
Gracilaria sp			
Ulva lactuca			

12. Do you sell seaweed for whole year in this market? Yes/ No

13. If no, how many months you sell in a year? _

14. Why you don’t sell for whole year? (mark in the following)

Don’t know how to store & package	
Lower demand during offseason	
Low availability of seaweed in off season	
Lower preference to consume by local people	
During off-season lower market price of seaweed	
Only wet seaweed consumer/buyer come to this market during	

peak season	
Others	
Others	

15. Which month has the highest sales?

Jan	**Feb**	**Mar**	**Apr**	**May**	**Jun**	**Jul**	**Aug**	**Sep**	**Oct**	**Nov**	**Dec**

16. Which month has the lowest sell?

Jan	**Feb**	**Mar**	**Apr**	**May**	**Jun**	**Jul**	**Aug**	**Sep**	**Oct**	**Nov**	**Dec**

17. In this market seaweed supply is higher than market demand? Yes/ No

18. If no, how much (kg) seaweed can be sold in a day? _

19. Who are the target customer/buyer and percentage of total sell them?

Local consumer/Restaurant/ Super shop (Retailer Sell)	
Local wholesaler	
Exporter/ Processor	
Distance market seller	

20. Is the seaweed demand increasing than previous year? Yes/ No

If yes, mention the how much it increased…

0	**1**	**2**	**3**	**4**

*0= no change, *1= very little increase, *2= Slightly increase, *3= moderately increase, *4= highly increase.

21. What about your observation in increase of seaweed production, business and market condition….

Factors	**Rank**				
Local people involvement in farming/collecting	0	1	2	3	4
Total production	0	1	2	3	4
Local involvement in seaweed business	0	1	2	3	4
Seaweed market price	0	1	2	3	4
Seaweed supply than previous year	0	1	2	3	4
Local market demand	0	1	2	3	4
Farm production of seaweed	0	1	2	3	4
People eagerly come for forwarding to seaweed farming & business	0	1	2	3	4
Govt. encourage & provide support to the business	0	1	2	3	4
	0	1	2	3	4

22. Customer satisfied with the hygiene & packaging condition of seaweed?

0	1	2	3	4

23. Are you satisfied with the market demand and price of the seaweed?

0	1	2	3	4

24. If you are not highly satisfied with the market demand and price of the seaweed, what are the possible strategies that can improve the seaweed market demand and price in Bangladesh?

Awareness among the general people about the food value of seaweed	**0**	**1**	**2**	**3**	**4**
Ensuring seaweed food safety and quality aspects	**0**	**1**	**2**	**3**	**4**
Improving packaging, branding, and storage system	**0**	**1**	**2**	**3**	**4**
Seaweed based product diversification	**0**	**1**	**2**	**3**	**4**
Setting up of seaweed-based industries for commercial products	**0**	**1**	**2**	**3**	**4**
Creating export market	**0**	**1**	**2**	**3**	**4**

25. Could you inform me of other places where seaweed sells? _

26. Others……

2.3) Other Questions (Local market)

1. Do you know maintaining hygiene and good packaging can increase seaweed value? Yes/ No

2. If yes, do you apply proper hygiene and packaging in harvest and post-harvest handling? Yes/ No

3. Do you follow any traceability system for the growing trust of your product to consumer/buyer? Yes/ No

4. Do you follow supply chain management system for due time delivery of order? Yes/ No

5. Before selling, are you sorting fresh and quality seaweed from the total collection? Yes/ No

If yes, have any use/demand of the lower-grade seaweed after sorting?

6. Where are the major demands of seaweeds? Human feed…….(%); Animal feed…….(%);

Industrial (Pharmaceutical and cosmetics) ……. (%); Others……..(%)

7. What facilities are lacking in value addition of seaweed products? Please rank 5 challenges, 1 being most critical challenge…

*Lack of awareness (Rank……); *Seasonal production (Rank……); *Limited supply (Rank……) *Seaweed products are not available in local market and restaurant (Rank……) *Lower local demand (Rank……)

8. How does seaweed farming and business sustain income source for coastal community?

Designated zone for seaweed aquaculture	0	1	2	3	4
More economic and feasible culture techniques dissemination	0	1	2	3	4
Processing facilities and products diversification	0	1	2	3	4
Strong market channel development	0	1	2	3	4
Awareness of food value and medicinal importance	0	1	2	3	4
Local demand increases through different approach	0	1	2	3	4
Whole year availability					
Others	0	1	2	3	4

3.Questionnaire for wholesale market/ Commission agent

3.1) General Information:

Interview No.: Date:

1. Trade Name:

3. Address:

Village	
Upazila	
District	

4. Respondent Name:

5. Position:

Owner	
accountant/manager	
employee	

6. Gender:

Male	
Female	

7. Age: 8. Mobile:

9. Year of schooling:

9.How many years you worked here: _

10.No. of workers work here:

11. Any female employee work here?
Yes/ No

12. Shop category?

Large	
Medium	
Small	

13. If commission agent, total number of farmers covered…….

14. Reasons behind the farmer sell to this shop are….

Good relation	
Farmers get comparatively high price	
Dadon	
Get technical support	
Others	

<u>3.2) Seaweed Related Information:</u>

1. Which months have the abundant supply of seaweed? (Peak season) _

2. From where you buy seaweed for sell and price, please? (Source) _

3. In which form do you sell your seaweed? Wet/ dry/ both

4. In average how much(kg) seaweed sell per week?

	Quantity of sell to buyer	In which form (fresh/dry)

Wet/ Fresh seaweed		
Dried seaweed		

5. Target customer/buyer…

	Quantity of sell to buyer	In which form (fresh/dry)
Local consumer / Super shop / Restaurant		
Wholesaler		
Exporter/ Processor		
Distance market seller		

6. Avg. seaweed sell (kg) in last year_ _ _ _ _ _ _ __ _ _ _ _ _ _ _ __ _ _ _ _ _ _ _ __ _ _ _ _ _ _ __ _ _ _ _ _ _ _ _

7. In this market seaweed supply is higher than market demand? Yes/ No

8. If no, how much (kg) seaweed can be sold in a day? _

9. How much cost incurred for selling seaweed in in a day/week/per kg ? Transportation cost……….. Packaging cost……….

10. What are the processing costs of exporter (BDT/MT)?

*Labor …………..*Packeging……………..*Storage……………………*Others………..

11.What is the price of seaweed in export market (BDT/ kg)?(Sell Price) __ _

12.What are the destinations of seaweed market? Country-1:………………. Country-2:………………. Country-3:………………. Country-4:………………. Country-5:……………….

13. Which seaweed species are having a lot of demand in the market? __ _ _

14. Do you think the market demand for seaweed increased than before? Yes / No

15. If yes, mention how much it increased…

0	**1**	**2**	**3**	**4**

16. What about your observation in increase of seaweed production, business and market condition….

Factors	**Rank**				
Local people involvement in farming/collecting	0	1	2	3	4
Total production	0	1	2	3	4
Local involvement in seaweed business	0	1	2	3	4
Seaweed market price	0	1	2	3	4
Seaweed supply than previous year	0	1	2	3	4
Local market demand	0	1	2	3	4
Farm production of seaweed					

People eagerly come for forwarding to seaweed farming & business					
Govt. encourage & provide support to the business					

*0= no change, *1= very little increase, *2= Slightly increase, *3= moderately increase, *4= highly increase.

17. Customer satisfied with the hygiene & packaging condition?

0	**1**	**2**	**3**	**4**

18. Are you satisfied with the market demand and price of the seaweed?

0	**1**	**2**	**3**	**4**

19. If you are not highly satisfied with the market demand and price of the seaweed, what are the possible strategies that can improve the seaweed market demand and price in Bangladesh?

Awareness among the general people about the food value of seaweed	**0**	**1**	**2**	**3**	**4**
Ensuring seaweed food safety and quality aspects	**0**	**1**	**2**	**3**	**4**
Improving packaging, branding, and storage system	**0**	**1**	**2**	**3**	**4**
Seaweed based product diversification	**0**	**1**	**2**	**3**	**4**
Setting up of seaweed-based industries for commercial products	**0**	**1**	**2**	**3**	**4**
Creating export market	**0**	**1**	**2**	**3**	**4**

20. Could you inform me other places where seaweed sell? _

21.Does Bangladesh import any import kind or form of seaweeds? Yes/No

If yes, please mention quantity and countries? …………MT, ……………….…………………………

22. Others……

<u>3.3) Others Questions (Whole seller/ Exporter/ Process)</u>

1. Do you follow any traceability system for the growing trust of your product to consumer/buyer? Yes/ No

2. Do you follow the supply chain management system for due-time delivery of the order? Yes/ No

3. Do you maintain communication with buyers about feedback on quality (moisture, plastics, contaminants, and heavy metal)?
Yes/ No

4. If yes, how do you maintain the quality of seaweed through feedback from buyers? _ _ _ _
_ _
_ _
_ _

5. Do you think that you have right information and knowledge of new technologies for extract (carrageenan) production?
Yes / No

If yes, how much you satisfied with using technologies…

0	**1**	**2**	**3**	**4**

6. What do you think about buyer's perception of Bangladeshi seaweed quality?

0	**1**	**2**	**3**	**4**

4.1. Questionnaire for Seaweed Consumers

Interview No.: Date:

2. Interviewer Name:
3. Address: *Village: _ _ _ _ _ _ _ _ _ _ _ * Upazila: _ _ _ _ _ _ _ _ _ _ _ _ *District: _ _ _ _ _ _ _ _ _ _ _

3. Age:
4. Gender:

Male	Female

5. Mobile:

4..2) Seaweed consumption related information:

1. Do you consume seaweed in your family? Yes/No

2.If yes, how many years you had started consuming seaweed regularly? _ _ __ _ _ _ _ years.

3. Which spices are do you consume usually _

4. In which form you buy from market? Wet / Dry / Both

5. How many months do you consume in a year? _ _ _ _ _ _ _ _ _ _ _ _ _ _ _ _ _ _ months.

6. How many members in your family are used to consuming seaweed? _ _ _ _ _ _ _ _ _ _ _ _

7. Approximately total amount of seaweed consume in our family per month: Dry_ _ _ _ _ _ _ kg; Wet _ _ _ _ _ _ _ kg. Most consuming species are_ _

8. Could you tell me, what about the process or uses of seaweed in your food item_ _

9. Is the supply of seaweed remain the constant whole round the year? Yes/No

10. If no, how many months seaweed available in local market_ _ _ _ _ _ _And please mention here, in which months seaweed are not available in market_ _ _ _ _ _ _ _ _ _ _ _

11. Per kg seaweed price in dry and wet form you buy…..

Species	Wet/kg	Dry/kg

12. Price of seaweed remain constant whole round the year? Yes/No

13. If no, you had to pay high price in months_ _ _ _ _ _ _ _ _ __ _ _lower price in months_ _ _

14. Do you satisfied with the hygiene and safety in post-harvest activities of seaweed? How is it….

0	1	2	3	4

*0= no change, *1= very little increase, *2= Slightly increase, *3= moderately increase, *4= highly increase.

15. What's about your observation in seaweed supply, price, demand, quality of seaweed…..

Factors	Ranks

Seaweed price increased/decreased than before	0	1	2	3	4
Seaweed supply increased/decreased than before	0	1	2	3	4
Community people consumption increased/decreased	0	1	2	3	4
Improvement in seaweed packaging and branding increased/decreased	0	1	2	3	4

16. Which initiatives may increase acceptance of seaweed to consumers or increase consumers in our country you may thought are _
_ _
_ _
_ _

8.2 Survey Photos:

Farmers Survey at Noniarchora, Cox's Bazar

Farmers Survey at Reju khal, Cox's Bazar

Seaweed Consumers Survey at Bandarban

Seaweed Sellers Survey at Bandarban

Local Market Sellers and Farmgate Wholesalers (Cox's Bazar)