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PRESENT STATUS OF NATURALLY OCCURRING SEAWEED FLORA AND THEIR UTILIZATION IN BANGLADESH

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ABSTRACT

A survey was conducted to know the present status of naturally occurring seaweed flora and their utilization in Bangladesh by interviews of scientific officers of MFTS (Marine Fisheries and Technology Station, Bangladesh Fisheries Research Institute, Cox's Bazar), NGO officials associated with seaweed research project, local seaweed food products manufacturer, seaweed collectors and Mog or Rakhyine tribal community of Cox's Bazar and St. Martin Island. Lack of knowledge on availability, distribution, seasonal variation, utilization status is causing impediment on utilization (e.g. seaweeds as human food, hydrocolloids, animal feed, fertilizer, cosmetic products, etc.) of available seaweeds naturally occurring in Bangladesh. Seaweeds are available along the whole Bangladeshi coast, mostly in St. Martin Island, Cox's Bazar and Sundarbans Mangrove forest. Total 193seaweed species including 19 commercially important species, belonging to 94 genera are found. Approximately, 5,000 metric ton of seaweed biomass is available. Due to seasonal variation in water quality parameters, generally seaweeds are available from October to April, but highest abundance occurs from January to March. Seaweed salad and sauce has been utilizing by Mog people as food. About 400 seaweed collectors at St. Martin Island annually harvested 6-9 metric tons of wet seaweeds (*Hypnea* spp.) for smuggling to Myanmar. Different value added food, functional food and personal care products have prepared by Govt. institution, NGO and in private sector. Considering the economic importance and potentials of seaweeds, for effective and environmentally sustainable utilization, special concern is required by both government and private organizations.

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INTRODUCTION

"Seaweed", is a colloquial term for the common name of countless species of microscopic and mostly macroscopic, multicellular algae which do not have root systems or flowers, leaves, stems, fruits and seeds and generally grow and live attached to rock or other hard substrata below the high-water mark or remain drifted in the oceans (Chapman,1973; Santhanam *et al*., 1990; Okazaki, 1971; Round,1970; McHugh, 2003, National Ocean Service, 2015). Seaweeds are found in the coastal climatic zones throughout the world i.e. from the warm tropics to the icy Polar Regions. Seaweeds have been reported to be used for various purposes by the Romans, Egyptians, Japanese, and Chinese in the ancient time (Drugs.com, 2015, National Ocean Service, 2015, Dillehay et al., 2008). The extent and scope of seaweeds utilization in this modern world is increasing (McHugh, 2003).

Utilization of seaweed as human food was once confined only in Japan, China and Republic of Korea but now spread to mass people of North America, South America Europe and Australia (McHugh, 2003, Kılınç et al., 2013). Apart from conventional seaweed food products like Japanese Nori or Purple Laver and Korean Wakame, seaweed food products like burger, juice, sandwich, chocolate, ice-cream, cake, salad, biscuit, chips etc. are producing on commercial basis (Sarkar, 2015). The most remarkable utilization of seaweed is found in phycocolloid or hydrocolloid industry and cosmetic industry, biofuel industry, pharmaceutical industry for the development of drugs for Alzheimers' disease, cancer and gastric ulcer, waste water treatment industry, bio-plastic industry (De Roeck-Holtzhauer, 1991; McHugh, 2003; Wargacki et al., 2012; Burtin, 2003, National Ocean Service, 2015; Gade et al., 2013).

The scenario of utilization of seaweed in different economically valuable ways is quite opposite in Bangladesh except utilization by Mog or Rakhyine tribal community and seaweed collectors of St. Martin's Island (Majumder, 2010, Sarkar, 2015). Recently some recent experimental approaches on seaweeds' utilization were reported (DoF, 2014, COAST Trust, 2013). The seacoast of Bangladesh is one of the unreached areas of the world in the field of phycology. There is lack of very fundamental information and statistics regarding seaweeds distribution, total seaweeds and commercially important species available, abundance, seasonal availability, status and approaches for utilization in Bangladesh (Majumder, 2010; Khan, 1990).Without these information and statistics, it would be impossible to figure out feasible seaweed spp. for commercial utilization. Identification of just only one species; *Gracilaria* sp. from Penang leaded Malaysia toward agar production and utilization through *Gracilaria* sp. farming (Doty and Fisher, 1987). This study was designed to know the present status of naturally occurring seaweeds flora and its utilization pattern in Bangladesh

MATERIALS AND METHODS

Natural seaweeds in Bangladesh are available from October to April throughout the whole southern coast (Majumder, 2010; Islam 1976, 1998; Islam and Aziz 1987). Extensive water sampling and collection of seaweed specimen from exposed rock surface during low tide could be conducted to determine the present status of naturally available seaweeds in Bangladesh (Majumder, 2010) which will be very difficult due to large expanse, long time and very hard labor. So, to acquire information on present status of naturally occurring seaweeds a survey work was conducted.

Study area

Although seaweeds are available throughout the southern coast but most of the available seaweed species are found to grow naturally at Cox's Bazar. Great abundance of natural seaweed resource is reported at St. Martins' Island (DoF, 2014). Considering these points, Cox's Bazar and St. Martins Island was identified as the study area for data collection on seaweeds and their utilization (Figure 1).

Identification of target groups for data collection

Scientific officers of MFTS and NGO officials of COAST Trust, Jahanara Islam (renowned entrepreneur of Cox's Bazar, Bangladesh), Mog or Rakhyine tribal community of Cox's Bazar and seaweed collectors of St. Martin's Island were identified as target group.

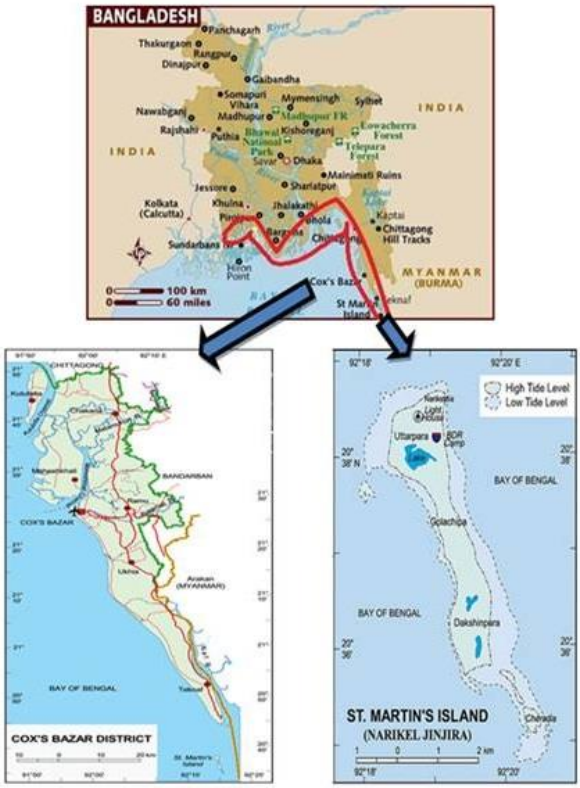

Figure 1. Selection of Cox's Bazar and St. Martians Island as study area from red marked Bangladeshi coast where seaweeds are naturally available every year from October to April.

Figure 2. Seaweed processing laboratory in MFTS (Marine Fisheries and Technology Station, BFRI, Cox's Bazar

Data collection approaches

Data mining from previous reports on seaweeds of Bangladesh. PRA tools: questionnaire interviewing, group discussion, cross check interviewing, transect walking were employed for scientific officers of MFTS, NGO officials of COAST Trust and Jahanara Islam. Seaweed collectors were interviewed by a semi-rigid questionnaire.

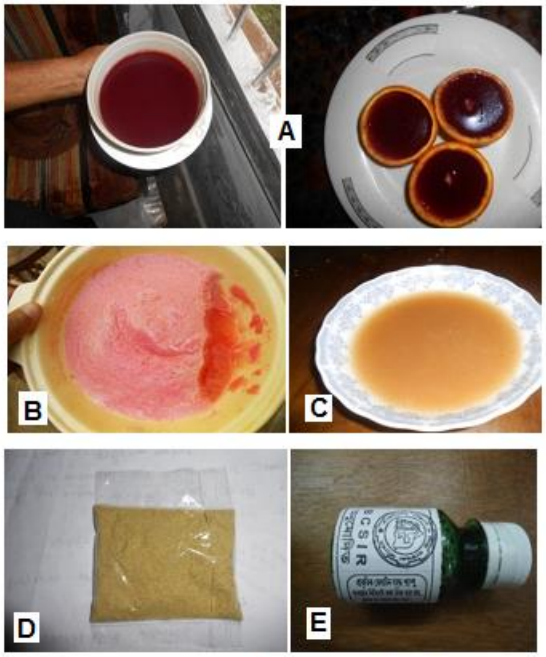

Figure 3. Different seaweed products: A: Seaweed jelly; B: Seaweed ice-cream; C: Seaweed soup; D: Seaweed Face pack; E: Seaweed Shampoo

RESULT

Data mining on Present status of naturally occurring seaweed flora in Bangladesh

Distribution of seaweeds

Favorable climatic, environmental conditions and interconnected network of waterways make natural availability of seaweeds throughout whole Sundarbans mangrove forest wherebenthic forms of seaweeds naturally grow in inter-tidal areas on pneumatophores of mangrove tree, other wooden logs and barks of trees.Around 60 seaweed species are found from Sundarbans and amongthose, *Boodliopsissun darbanensis*, *Ulvalactuca* and *U. intestinalis, Catenellarepen, C. nipae, Gelidium*, *Polysiphonia*, *Ceramium*, *Bostrychia, Compsopogon*etc.are available.

About 155 seaweed species are found in Cox's Bazar. In Cox's Bazar region, seaweeds are very abundant at Shilkhali/Shaplapur coast, Jaillapara, Shahparirdip area of Teknaf, Nuniarchara,Nazirartek of Bakkhali-Moheshkhali river estuary, MoheshkhaliIsl and and at planted mangrove forest or Parabon region. In Cox's Bazar, natural seaweed beds are found atNuniarchara to Nazirartek areas of Bakkhali River and Moheshkhali Channel estuary and in Moheshkhali Island. *Hypnea musciformis and Enteromorpha intestinalis* are the main seaweed species of seaweed beds.

About 140 seaweed species are found at St. Martin's Island. The St. Martin's island has four coasts: Western, Eastern, Southern and Northern coast. Seaweeds are not available at northern coast. *Sargassum coriifolium, Chaetomorpha moniligera, Gracilaria verrucosa, Colpomenia sinuosa* etc. seaweed species are found from southern coast. In eastern coast, *Sargassum coriifolium, Hypnea musciformis, H. pannosa*, *Hydroclathrus clathratus, Colpomenia sinuosa, Padina arborescens, Chaetomorpha moniligera, Gracilaria verrucosa* etc. seaweed species are found, whereas in western coast, *Gracilaria textorii, Hypnea musciformis, H. pannosa, Petalonia fascia, Dictyopteris divaricatum, Sargassum coriifolium, Enteromorpha compressa, Colpomenia sinuosa, Gracilaria verrucosa, Chaetomorpha moniligera, Hydroclathrus clathratus* etc. species are found. Seaweeds are more abundant in western coast of St. Martin Island than eastern coast.

Available seaweed species

About 193 seaweed species of 94 genera belonging to only three major divisions i.e. Chlorophyta-green algae, Phaeophyta-brown algae, Rhodophyta-red algae are available in Bangladesh (Table 1).

Table 1. Seaweed species available in Bangladesh

Sl. No.	Species Name	Family Name	Habit	Habitat		National Status
				Macro	Micro	
1	*Acrochaetium bengalicum*	Rhodophyceae	F		E	VU
2	*A. crassipes*	Rhodophyceae	F		E	VU
3	*A. nurulislamii*	Rhodophyceae	F			VU
4	*A. polysporum*	Rhodophyceae	F			VU
5	*A. sagraeanum*	Rhodophyceae	F			VU
6	*A. zosterae*	Rhodophyceae	F			VU
7	*Goniotrichum alsidii*	Rhodophyceae	F		E	VU
8	*Erythrocladia subintegra*	Rhodophyceae	TH		E	VU
9	*Erythrotrichia carnea*	Rhodophyceae	TH		E	VU
10	*Liagora ceranoides*	Rhodophyceae	TH	R		VU
11	*L. harveyiana*	Rhodophyceae	TH	R		VU
12	*L. ferinosa*	Rhodophyceae	TH	R		VU
13	*Actinotrichia fragilis*	Rhodophyceae	TH	R		VU
14	*Scinaia complanate*	Rhodophyceae	TH	R		VU
15	*Gellidium amansii*	Rhodophyceae	TH	R		
16	*Galaxaura fastigiata*	Rhodophyceae	TH	R		VU
17	*Gelidiella tenuissima*	Rhodophyceae	TH	R		VU
18	*G. tenera*	Rhodophyceae	TH	R		VU
19	*Gelidium pusillum*	Rhodophyceae	TH	R		VU
20	*Jania adhaerens*	Rhodophyceae	TH	R		VU
21	*J. ungulata*	Rhodophyceae	TH	R		VU
22	*Amphiroa fragilissima*	Rhodophyceae	TH	R		VU
23	*A. anceps*	Rhodophyceae	TH	R		VU
24	*Euchema* sp.	Rhodophyceae	TH	R		VU
25	*Melobesia confervicola*	Rhodophyceae	TH	R	E	VU
26	*Hypnea musciformis*	Rhodophyceae	TH	R	E	VU
27	*H. pannosa*	Rhodophyceae	TH	R	E	VU
28	*H. boergesenii*	Rhodophyceae	TH	R	E	VU
29	*H. cornuta*	Rhodophyceae	TH	R	E	VU
30	*H. valentiae*	Rhodophyceae	TH	R	E	VU
31	*Sarconema jurcellatum*	Rhodophyceae	TH	R	E	VU
32	*Catenella impudica*	Rhodophyceae	TH		E	VU
33	*C. nipae*	Rhodophyceae	TH		E	VU
34	*C. repens*	Rhodophyceae	TH		E	VU
35	*Champia parvula*	Rhodophyceae				VU
36	*Chrysymenia okamura*	Rhodophyceae	TH			VU
37	*C. enteromorpha*	Rhodophyceae	TH			VU
38	*C. agardhii*	Rhodophyceae	TH			VU
39	*Halymenia duchassaignii*	Rhodophyceae				VU
40	*Laurrencia* sp.	Rhodophyceae	TH	R		
41	*Asparagopsis taxiformis*	Rhodophyceae	TH	R		VU
42	*Scinaia japonica*	Rhodophyceae	TH	R		
43	*Antithamnion* sp.	Rhodophyceae	TH		E	VU
44	*Callithamnion* sp.	Rhodophyceae	TH	R	E	VU
45	*Callophyllis rangiferina*	Rhodophyceae	TH	R		
46	*Centroceras clavulatum*	Rhodophyceae	TH	R		VU
47	*Ceramium fastigiatum*	Rhodophyceae	TH		E	VU
48	*C. gracillimum*	Rhodophyceae	TH		E	VU

Table 1. Seaweed species available in Bangladesh (contd.)

49	*C. tenerrimum*	Rhodophyceae	TH		E	VU
50	*C. brevizonatum*	Rhodophyceae	TH		E	VU
51	*Dasya corymbifera*	Rhodophyceae	TH	R		VU
52	*D. pedicillata*	Rhodophyceae	TH	R		VU
53	*Gracilaria textorii*	Rhodophyceae	TH	R		
54	*G.verrucosa*	Rhodophyceae	TH	R		
55	*Calliblepharis* sp.	Rhodophyceae	TH	R		VU
56	*Halymenia floresia*	Rhodophyceae	TH	R		
57	*Heterosiphonia* sp.	Rhodophyceae	TH	R		VU
58	*Messophyllum* sp.	Rhodophyceae	TH		E	
59	*Caloglossa leprieuri*	Rhodophyceae	TH	R		VU
60	*Vanvoorstia coccinea*	Rhodophyceae	TH	R		VU
61	*Dudresnaya hawaiiensis*	Rhodophyceae	TH	R		
62	*Cottoniella filamentosa*	Rhodophyceae	TH	R	E	VU
63	*Polysiphonia denudata*	Rhodophyceae	TH		E	VU
64	*P. mollis*	Rhodophyceae	TH			VU
65	*P. harveyi*	Rhodophyceae	TH			VU
66	*Peyssonellia* sp.	Rhodophyceae	TH	R		
67	*Tolypiocladia glomerulata*	Rhodophyceae	TH	R		VU
68	*Cthonoplastis* sp.	Rhodophyceae				
69	*Acanthophora specifera*	Rhodophyceae	TH	R		VU
70	*Gigartina intermedia*	Rhodophyceae	TH	R		
71	*Bostrychia radicans*	Rhodophyceae	TH	R		VU
72	*B. tenella*	Rhodophyceae	TH	R		VU
73	*Callophyllis* sp.	Rhodophyceae	TH	R		
74	*Halymenia discoidea*	Rhodophyceae	TH	R		
75	*H. floridana*	Rhodophyceae	TH	R		
76	*Porphyra* sp	Rhodophyceae	TH	R		
77	*Herposiphonia dendroidea var. minor*	Rhodophyceae	TH	R		VU
78	*Herposiphonia tenella fa. Secumda*	Rhodophyceae	TH	R		VU
79	*Pterosiphonia pennata*	Rhodophyceae	TH	R		
80	*Laurencia obtusa*	Rhodophyceae	TH	R		VU
81	*Lithothamnion* sp.	Rhodophyceae	TH	R		VU
82	*Crouania attenuata*	Rhodophyceae	TH	R		VU
83	*Kallymenia cribrosa*	Rhodophyceae	TH	R		
84	*K. tasmanica*	Rhodophyceae	TH	R		
85	*K. rosea*	Rhodophyceae	TH	R		
86	*K. rubra*	Rhodophyceae	TH	R		
87	*Lophocladia trichociados*	Rhodophyceae	TH	R		VU
88	*Falkenbergia hillebrandii*	Rhodophyceae				
89	*Ectocarpus breviarticulatus*	Phaeophyceae	TH		E	VU
90	*E. rhodochortonoides*	Phaeophyceae	TH		E	VU
91	*Giffordia conifera*	Phaeophyceae	TH		E	VU
92	*G. irregularis*	Phaeophyceae	TH		E	VU
93	*G. mitchellae*	Phaeophyceae	TH		E	VU
94	*G. rallsae*	Phaeophyceae	TH		E	VU
95	*G. thyrsoideus*	Phaeophyceae	TH		E	VU
96	*Feldmannia columellaris*	Phaeophyceae	TH		E	VU
97	*F. elachistaeformis*	Phaeophyceae	TH		E	VU
98	*F. indica*	Phaeophyceae	TH		E	VU
99	*F. vaughani*	Phaeophyceae	TH		E	VU
100	*Sphacelaria tribuloides*	Phaeophyceae	TH		E	VU
101	*S. novae-hollandiae*	Phaeophyceae	TH		E	VU

Table 1. Seaweed species available in Bangladesh (contd.)

102	*Dectyota bratayresii*	Phaeophyceae	TH	R		VU
103	*D. dechotoma*	Phaeophyceae	TH	R		VU
104	*D. divaricata*	Phaeophyceae	TH	R		VU
105	*D. friabilis*	Phaeophyceae	TH	R		VU
106	*D. patens*	Phaeophyceae	TH	R		VU
107	*Dictyota ciliolate*	Phaeophyceae	TH	R		VU
108	*Dictyopteris australis*	Phaeophyceae	TH	R		VU
109	*D. divarcatum*	Phaeophyceae	TH	R		VU
110	*Eisenia bicyclis*	Phaeophyceae	TH	R		
111	*Lobophora variegata*	Phaeophyceae	TH	R		VU
112	*Padina australis*	Phaeophyceae	TH	R		VU
113	*P. tenuis*	Phaeophyceae	TH	R		VU
114	*P. gymnospora*	Phaeophyceae	TH	R		VU
115	*P. pavonica*	Phaeophyceae	TH	R		VU
116	*P. sanctae-crucis*	Phaeophyceae	TH	R		VU
117	*P. tetrastromatica*	Phaeophyceae	TH	R		VU
118	*P. vickersiae*	Phaeophyceae	TH	R		VU
119	*P. arborescens*	Phaeophyceae	TH	R		VU
120	*P. fraseri*	Phaeophyceae	TH	R		VU
121	*Ishigae okamurae*	Phaeophyceae	TH	R		
122	*Myriactula arabica*	Phaeophyceae	TH	R		VU
123	*Chnoospora implexa*	Phaeophyceae	TH	R		VU
124	*Hydroclathara* sp.	Phaeophyceae				
125	*Colpomenia sinuosa*	Phaeophyceae	TH	R		VU
126	*C. perigrina*	Phaeophyceae	TH	R		VU
127	*Petalonia fascia*	Phaeophyceae	TH	R		
128	*Hydroclathrus clathratus*	Phaeophyceae	TH	R		VU
129	*Rosenvingea intricata*	Phaeophyceae	TH	R		VU
130	*R. orientalis*	Phaeophyceae	TH	R		VU
131	*R. sanctae-crucis*	Phaeophyceae	TH	R		VU
132	*Sargassum caryophyllum*	Phaeophyceae	TH	R		VU
133	*S. flavicans*	Phaeophyceae	TH	R		VU
134	*S. ilicifolium*	Phaeophyceae	TH	R		VU
135	*S.piluliferum*	Phaeophyceae	TH	R		VU
136	*S.vulgare*	Phaeophyceae	TH	R		VU
137	*S.wightii*	Phaeophyceae	TH	R		VU
138	*S.coriifolium*	Phaeophyceae	TH	R		VU
139	*S. crassifolium*	Phaeophyceae	TH	R		VU
140	*S. cristaerfolium*	Phaeophyceae	TH	R		VU
141	*S. oligocystum*	Phaeophyceae	TH	R		VU
142	*S.* spp. *(unidentified*	Phaeophyceae	TH	R		VU
143	*Enteromorpha clathrata*	Chlorophyceae	TH	R		VU
144	*E. compressa*	Chlorophyceae	TH	R		VU
145	*E. intestinalis*	Chlorophyceae	TH	R		VU
146	*E. prolifera*	Chlorophyceae	TH	R		VU
147	*E .moniligera*	Chlorophyceae	TH	R		VU
148	*Ulva lactuca*	Chlorophyceae	TH	R		VU
149	*U. Intestinalis*	Chlorophyceae	TH	R		VU
150	*Chaetomorpha aerea*	Chlorophyceae	TH		E	VU
151	*C. brachygona*	Chlorophyceae	TH		E	VU
152	*C. gracilis*	Chlorophyceae	TH		E	VU
153	*C. linum*	Chlorophyceae	TH		E	VU
154	*C. moniligera*	Chlorophyceae	TH		E	VU
155	*Lola capillaris*	Chlorophyceae	TH		E	VU
156	*L. implexa*	Chlorophyceae	TH			VU

Table 1. Seaweed species available in Bangladesh (contd.)

157	*L. tortuosa*	Chlorophyceae	TH			VU
158	*Rhizoclonium grande*	Chlorophyceae	TH			VU
159	*R. hookeri*	Chlorophyceae	TH			VU
160	*R. kerneri*	Chlorophyceae	TH			VU
161	*R. riparium*	Chlorophyceae	TH			VU
162	*Cladophora echinus*	Chlorophyceae	TH	R		VU
163	*C. patentiramea*	Chlorophyceae	TH	R		VU
164	*C. sakaii*	Chlorophyceae	TH	R		VU
165	*C. vagabunda*	Chlorophyceae	TH	R		VU
166	*C. crispula*	Chlorophyceae	TH	R		VU
167	*C. prolifera*	Chlorophyceae	TH	R		VU
168	*Phyllodictyon anastomosans*	Chlorophyceae	F		E	
169	*Dictyosphaeria cavernosa*	Chlorophyceae	TH	R		VU
170	*Boodlea composite*	Chlorophyceae	TH	R		VU
171	*Oedogonium inversum*	Chlorophyceae				
172	*Bryopsis indica*	Chlorophyceae	TH	R		VU
173	*Caulerpa cactoides*	Chlorophyceae	TH	R		VU
174	*C. peltata*	Chlorophyceae	TH	R		VU
175	*C. racemosa var. Clavifera*	Chlorophyceae	TH	R		VU
176	*C. racemosa var. Occidentalis*	Chlorophyceae	TH	R		VU
177	*C. racemosa var. Turbinate*	Chlorophyceae	TH	R		VU
178	*C. racemosa var. uvifera*	Chlorophyceae	TH	R		VU
179	*C. sealpelliformis*	Chlorophyceae	TH	R		VU
180	*C. sertularioides*	Chlorophyceae	TH	R		VU
181	*C. sertularioidesfa. Brevipes*	Chlorophyceae	TH	R		VU
182	*C. taxifolia*	Chlorophyceae	TH	R		VU
183	*C. okamurae*	Chlorophyceae	TH	R		VU
184	*C. microphysa*	Chlorophyceae	TH	R		VU
185	*Halimeda discoidea*	Chlorophyceae	TH	R		VU
186	*H. opuntia*	Chlorophyceae	TH	R		VU
187	*Acetabularia calyculus*	Chlorophyceae	TH	R		VU
188	*Codium geppei*	Chlorophyceae	TH	R		VU
189	*C. fragile*	Chlorophyceae	TH	R		VU
190	*C. extricatum*	Chlorophyceae	TH	R		VU
191	*Cladophorella calcicola*	Chlorophyceae	TH	R		
192	*Halodule univervis*	Chlorophyceae	TH	R		VU
193	*Boodliopsis sundarbanensis*					

Notes: Habit: TH= Thalloid/micro- or macro thailus; F = Filamentous, microscopic; Habit at: E = Epiphyte on other marine macro algae; R = On rocks/entangled with other seaweeds under sea water in the intertidal zone; National Status: VU = Vulnerable

Commercially important seaweed species:

Among the available seaweed species, 19 species of 14 genera are considered as economically important (Table 2)

Natural production of seaweeds:

Approximately, 5,000 metric ton seaweed biomass is annually available throughout the whole Bangladeshi coast from October to April.

Seasonal variation in seaweeds' availability:

Seaweeds in Bangladesh are available in winter, spring and summer seasons and unavailable in rainy or autumn season. On that basis, in Bangladesh generally seaweeds are available from October to April, but highest abundance occur from January to March.

Table 2. Commercially important seaweed species of Bangladesh

Sl. No.	Genus	Species	Type
1	*Caulerpa*	*Caulerpa racemosa*	Green Seaweed
		Caulerpa sertularioides	
2	*Enteromorpha*	*Enteromorpha intestinalis*	Green Seaweed
		Enteromorpha moniligera	
3	*Gelidiella*	*Gelidiella tenuissima*	Red Seaweed
4	*Halymenia*	*Halymenia discoidea*	Red Seaweed
5	*Hypnea*	*Hypnea pannosa*	Red Seaweed
		Hypnea valentiae	
		Hypnea musciformis	
6	*Hydroclathrus*	*Hydroclathrus clathratus*	Brown Seaweed
7	*Sargassum*	*Sargassum oligocystum*	Brown Seaweed
		Sargassum coriifolium	
8	*Gelidiella*	*Gelidiella tenuissima*	Red Seaweed
9	*Gelidium*	*Gelidium pusillum*	Red Seaweed
10	*Padina*	*Padina tetrastromatica*	Brown Seaweed
11	*Catenella*	*Catenella* spp.	Red Seaweed
12.	*Porphyra*	*Porphyra* spp.	Red Seaweed
13.	*Gelidium*	*Gelidium amansii*	Red Seaweed
14.	*Codium*	*Codium fragile*	Green Seaweed

Table 3. Micronutrients in normal salad and salad with seaweed

SL.	Treatment Type	Ca (ppm)	Fe (ppm)	K (ppm)	Na (ppm)	Zn (ppm)
1	Normal Salad	833.05	16.29	6507.82	17,663.24	4.93
2	Salad with seaweed	1,565.14	154.17	6031.64	15,636.07	8.85

Utilization of naturally occurring seaweed in Bangladesh

Conventional utilization

Seaweeds are almost unknown to Bangladeshi people. Seaweeds in Bangladesh have been utilized only by Mog or Rakhyine tribal community and people of St. Martins' Island.

Traditionally, as a marine plant, seaweeds are respected by Mog. Seaweeds are known to them as 'Hejla'. Like different non-conventional food items seaweeds are taken by them. Seaweed salad and sauce is prepared by Mog people. Seaweed species used by Mog people is black in color; resemble shape like a thin thread. Seaweeds are most significantly utilized in St. Martin's Island as seaweeds are only harvested and processed here for marketing to Myanmar. Beyond this type of utilization, seaweeds are sometimes used there as medicinal food for young ladies and post-pregnant females. Traditionally boiled seaweeds are taken sometimes by adult female for good health. Rotten seaweeds are used there as plant manure for vegetable production.

Approaches for seaweed utilization by government organization

In the approach of utilization, MFTS (Marine Fisheries and Technology Station, BFRI, Cox's Bazar) has established seaweed processing lab (Figure 2). Different types of seaweed food products such as salad, soup, pickle, cake, chanachur, jelly sauce etc. has manufactured by them. In this case, a comparative analysis of micronutrient content in seaweed salad and conventional salad is known (Table 3).

Approaches for seaweed utilization by private entrepreneur and non-government organization

Several seaweed foods, functional and personal care products have been developed by Jahanara Islam (Figure 3). The post-harvest handling procedure followed by that private entrepreneur is presented at Figure 4. A local NGO named COAST Trust also prepared different value added food and functional food products (Figure 5).

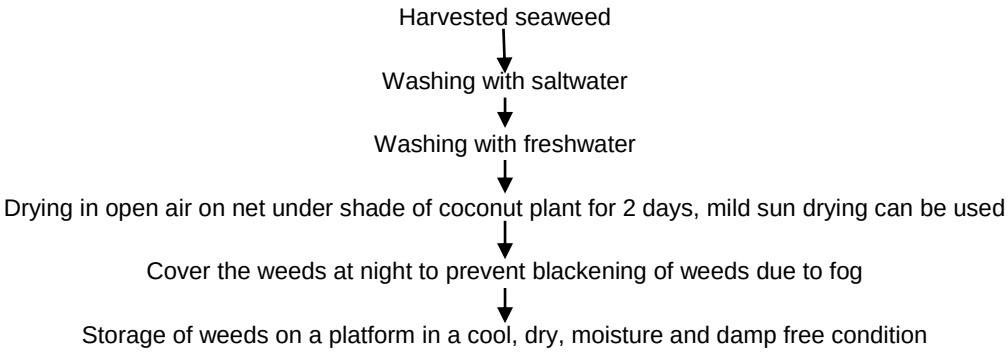

Figure 4. Post harvest management flow chart used by Jahanara Islam

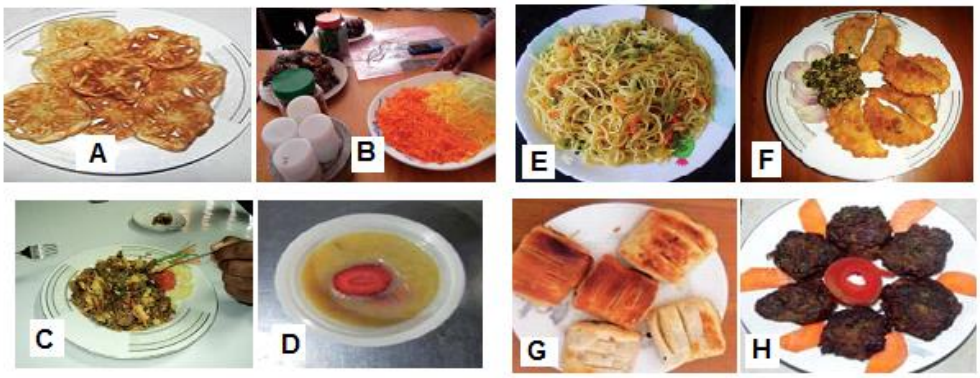

Figure 5. Different food products prepared by COAST Trust NGO (COAST Trust, 2013)

A: Seaweed cake; B: Seaweed salad; C: Seaweed and vegetable; D: Seaweed pudding E: Seaweed noodles F:Seaweed samucha; G: Seaweed Biscuit; H: Seaweed chop and piyaju

Figure 6. Saint Martin's Island; an ideal site for natural occurring seaweeds

Figure 7. Close proximity of eastern coast to Myanmar land mass makes less seaweeds abundance in eastern coast than western coast (Images taken from Google Earth, 2015)

DISCUSSION

Present status of naturally occurring seaweed flora in Bangladesh

Distribution of seaweeds

Seaweeds are generally seen in the littoral and sub-littoral zones of Sundarbans Mangrove Forestto St. Martin Island of Bangladesh (Islam, 1976; Islam and Aziz, 1987; Islam, 1998). Salinity of 2-34 ppt, P^H 7.5-8.5 and 20-30° C is required for seaweed growth and Sundarbans offer a favorable condition by fulfilling the criteria (Satpati*et al*., 2012; COAST Trust, 2013).Nine species of seaweeds were reported from the Indian Sundarbans mangrove forest namely *U. lactuca, U. intestinalis, Catenellarepens*and *C.nipae*followed by *Gelidium, Polysiphonia, Ceramium, Bostrychia* and *Compsopogon*(Satpati et al., 2012). McHugh, 2001 reported good growth for the edible red alga, *Catanella*, in the Sunbarbans mangrove forests, on the pneumatophores. These species were also found in the present study.Comparatively less seaweed species is expected in Sundarbans than other places where seaweeds are naturally available in Bangladesh due to the presence of suspended solids from tidal silt, rotten leaves etc. in water which hinder light penetration causes low growth of seaweeds in Sundarbans (Satpati et al., 2012). One hundred forty seaweeds species from St. Martin's Island, 10 species from planted mangrove region and 5 species from Backkhali-Moheshkhali channel estuary of Cox's Bazar was reported by DoF(2010). Seaweed species are abundant Shaplapur coast, Shahparirdip area of Teknaf, Nuniarchara, Nazirartek of Bakkhali-Moheshkhali river estuary Jaillapara of Teknaf and in planted mangrove forest or Parabon region (DoF, 2010; Haque, 2013).

Water quality parameters of the St. Martin's Island, which situated in the extreme South-eastern corner of Bangladesh, appear to be very positive for seasonal abundance (Khan, 1990; Tomascik, 1997; Zafar, 2005; Haque, 2013; COAST Trust, 2013).Rocky substrates, which are crucially required for seaweedhabitat are available around the St. Martin Islandexcept the north coast (FAO/NACA, 1996; Hossain, 2004). Therefore, St. Martin Island is an extraordinary place for natural availability of seaweeds (Figure 06).

Due to less violent wave action in eastern coast for close proximity to Myanmar territorial land mass , less deposit of drifted seaweeds is reported in eastern coast than western coast (Figure 07). Due to the absence of rocky substrates in the northern coast seaweeds are not available there. Therefore, presence of rocky substratum and Geographical position of St. Martin Island causes variation in distribution of seaweeds around St. Martin's Island (Majumder, 2010).

Available Seaweed species

Taxonomic identification of available seaweeds of Bangladesh is yet to be done **(**FAO/NACA, 1996). That's why; there is an argument about total number of seaweed species found in Bangladesh (Islam, 1976, Sharif, 1992, Hossain*et al.*, 2013, Ahmed and Taparhudee, 2005; Quader, 2010; Haque, 2013).

Commercially important seaweeds species

Ten seaweed species were documented as commercially important species by Khan(1990) and Majumder(2010), whereas,DoF (2014) assumed 20 seaweed species can be commercially important.

Natural production of seaweeds

Regular statistics on production of seaweed is yet to be developed. About 1,500 MT seaweed biomass was reported from the St. Martin Island (Sarkar, 1992).

Seasonal variation in seaweeds' availability

In seasonal variation in seaweeds availability are basically due to variation in water quality. Geographical and vertical distribution and growth of seaweed are governed by various factors like water temperature, salinity, pH, dissolved oxygen, water transparency, nutrients etc. (Luning, 1990).Specific water quality parameters are required for growth and propagation of seaweeds (Round, 1970) and that's whyseaweeds can only be found in those season or months of the year where water quality is favorable. Seaweeds in Bangladesh are available in winter, summer and spring seasons.As, the water quality parameters remain in peak in respect of favorable conditions of seaweeds, the highest abundance of seaweeds found from January to March. Similar finding was also reported by FAO/NACA, 1996. Salinity can be considered as an example of physical parameter of water. Heavy rainfall during the monsoon season lowers the salinity of coastal region than the other seasons of year. For growth and propagation 20-34 ppt salinity is required by seaweeds. This range or around this range is available only from October to April.

Abundance of seaweed is also influenced by pollution, disturbance etc. The present day populations of marine algal flora are very different from what they were in 1960s and even 1980s, and this degradation may be ascribed to continuous disturbance of inter-tidal rocks, particularly for construction and household use, is an impediment to growth of marine algae. The dragging of seine nets across the inter-tidal zone adversely affects seaweed settling. Pollution is also an issue: waste entrance to coastal waters may affect marine algae growth (MoEF, 2001; Thompson and Islam, 2010).

Utilization of seaweed in Bangladesh

Conventional utilization of seaweed

Utilization of seaweed by Mog or Rakhyine tribal community was reported by Majumder, 2010.Kamal, 1994; Zafar, 2005 Majumder, 2010 and COAST Trust, 2013 reported about utilization of dried seaweeds by illegal trading to Myanmar from St. Martin's Island. In St. Martin's island, about 100 people, mostly fishermen, children and women, were engaged in collecting seaweeds particularly *Hypnea*spp manually by hand or using nets like push net during low tide. About 40-80 kg seaweeds can be collected per day per person depending on the abundance. The weeds were dried in the sun on the open sandy beach and it took 3-4 days to dry. Price of seaweeds from seaweed collectors to wholesaler is reported as BDT 80-100, wholesaler to Myanmar trawler as BDT 400-500 and about 200 tons of seaweeds are annually smuggled to Myanmar (Figure 08) (Kamal, 1994; Zafar, 2005 Majumder, 2010).Medicinal use of seaweeds was also reported by Majumder,2010.

Utilization of seaweed by government organization

Seaweed salad, soup, pickle, cake, jelly etc. were manufactured by MFTS (DoF, 2014).

CONCLUSION

Seaweeds have potential to emerge as an individual export oriented industry in Bangladesh. More comprehensive studies on present status of naturally available seaweeds and their present status of utilization should be conducted and a long-term scheme for utilization of this resources required establishing.

REFERENCES

1. Ahmed N and W Taparhudee, 2005. Seaweed Cultivation in Bangladesh: Problems and Potentials. KASETSART UNIVERSITY FISHERIES RESEARCH BULLETIN, 28: 13-21.
2. Burtin P, 2003. Nutritional Value of Seaweeds. Electronic Journal of Environmental, Agricultural and Food Chemistry, 2(4).
3. Chapman JV, 1973. Seaweeds and their uses. Methuer and Co. Ltd., India. pp 299.
4. COAST Trust, 2013.Potentials of Seaweeds. COAST Trust, Shyamoli, Dhaka.48pp.
5. De Roeck-Holtzhauer Y, 1991. Uses of seaweeds in cosmetics. In: Guiry MD and G Blunden (Editors), Seaweed Resources in Europe: Uses and Potential. John Wiley & Sons, New York. pp. 83-94.
6. Dillehay TD, C Ramírez, M Pino, MB Collins, J Rossen, JD Pino-Navarro, 2008. Monte Verde: Seaweed, Food, Medicine, and the Peopling of South America. SCIENCE, 320: 784-786.
7. DoF, 2014: National Fish Week 2014 Compendium (In Bengali). Department of Fisheries, Ministry of Fisheries and Livestock, Bangladesh. pp 144.
8. Doty M and J Fisher, 1987.Experimental Culture of Seaweeds (*Gracilaria* sp.) in Penang, Malaysia. In: Bay of Bengal Programme: Development of Small-Scale Fisheries. Swedish International Development Authority and Food and Agricultural Organization.Pp-41.
9. Drugs.com (www.drugs.com), 2015.Seaweed, www.drugs.com/npc/seaweed.html (Accessed on 17.08.2015).
10. FAO/NACA, 1996. Regional Study and Workshop on the Taxonomy, Ecology and Processing of Economically Important Red Seaweeds (NACA Environment and Aquaculture Development Series No. 3.).Network of Aquaculture Centres in Asia-Pacific, Bangkok, Thailand.
11. Gade R, MS Tulasi and VA Bhai, 2013.Seaweeds: A Novel Biomaterial. International Journal of Pharmacy and Pharmaceutical Sciences, 5: 40-44.
12. Haque MA (Scientific Officer, Marine Fisheries and Technology Station, Bangladesh Fisheries research Institute, Cox's Bazar) 2013: Annual Research Progress Report of 2012-2013 on Development of culture technique and utilization of seaweed (Submitted to Bangladesh Fisheries research Institute).
13. Hossain MA, MSE Mahfuj, SMA Rashid, MI Miah, MN Ahsan, 2013. Present status of conservation and management of sea turtle in Cox's Bazar district, Bangladesh. Mesopotamian Journal of Marine Science, 28: 45 – 60.
14. Hossain MM, 2004. Sustainable Management of the Bay of Bengal Large Marine Ecosystem (BOBLME), National Report of BOBLME-Bangladesh (GCP/RAS/179/WBG/179). FAO, Rome.
15. Islam AKMN and A Aziz, 1987. Addition to the list of marine algae of St. Martin's Island, Bangladesh.III.Redalage (Rhodophyceae).Nova Hedwigia, 45: 21 1-222.
16. Islam AKMN, 1976. Contribution to the study of benthic marine algae of Bangladesh. Bibliotheca Phycologica, 19: 253-258.
17. Islam AKMN, 1998. The seaweed resources of Bangladesh. In: Critchley and Ohno (edited), Seaweed Resources of the World. Japan International Cooperation Agency, 5-25-1 Nagai, Yokosuka, Japan. pp. 106-109.
18. Kamal M, 1994. Assistance to Fisheries Research Institute - A Report Prepared for the "Assistance to Fisheries Research Institute". FAO, Rome.
19. Khan G, 1990. Status of production and utilization of seaweeds in Bangladesh. In: Report of the Regional Workshop on the Culture & Utilization of Seaweeds. FAO, Rome.
20. Kılınç B, S Cirik, G Turan, H Tekogul and E Koru, 2013. Seaweeds for Food and Industrial Applications. In: Muzzalupo I (Editor), Food Industry. In Tech (www.intechopen.com).
21. Luning K, 1990. Seaweeds: Their Environment, Biogeography and Eco-physiology. John Wiley and Sons, Inc., New York. Pp 544.
22. Majumder S, 2010. Development of value added products from seaweed available in the Bay of Bengal, Bangladesh coast. MS thesis. Department of Fisheries Technology. Bangladesh Agricultural University, Mymensingh, Bangladesh.
23. McHugh DJ, 2001. Prospects for seaweed production in developing countries (FAO Fisheries Circular No. 968 FIIU/C968 (En). FAO, Rome.

24. McHugh DJ, 2003. A Guide to Seaweed Industry.FAO, Rome, Italy. pp105.
25. MoEF (Ministry of Environment and Forests), 2001. Survey of Flora. National Conservation Strategy Implementation Project-1.Ministry of Environment and Forests, Dhaka.
26. National Ocean Service (oceanservice.noaa.gov) of NATIONAL OCEANIC AND ATMOSPHERIC ADMINISTRATION, 2015. What is seaweed? http://oceanservice.noaa.gov/facts/seaweed.html (Accessed on 30.08.2015).
27. Okazaki A, 1971.Seaweeds and Their Uses in Japan.Tokai University Press, Japan. pp 170.
28. Quader O, 2010.Coastal and marine biodiversity of Bangladesh (Bay of Bengal). In: Proceeding of International Conference on Environmental Aspects of Bangladesh (ICEAB10), Japan. pp. 83-86.
29. Round FE, 1970.The Biology of the Algae. Edward Arnold (Publisher) Ltd., UK. pp 269.
30. Santhanam R, N Ramanthan and GbJegatheesan, 1990. Coastal Aquaculture in India.CBS Publishers and Distributors, India. pp 180.
31. Sarkar MSI, 2015. Studies on Production, Culture Potential and Utilization of Seaweed Resources in Bangladesh.MS thesis.Department of Fisheries Technology. Bangladesh Agricultural University, Mymensingh, Bangladesh.
32. Sarker MN, 1992.Studies on the red sea weeds in Bangladesh. In: Regional workshop on the taxonomy, ecology and processing of commercially important red sea weeds, held at Kasetsart University in Bangkok, Thailand, Organized by FAO/NACA and France Govt.
33. Satpati GG, N Barman and R Pal, 2012. Morphotaxonomic account of some common seaweeds from Indian Sundarbans mangrove forest and inner island area. Journal of Algal Biomass Utilization, 3(4): 45– 51.
34. Sharif M, 1992. Studies on the siltation rate of the Karnaphuli estuary of the Bay of Bengal. A postgraduate dissertation, Institute of Marine Sciences, University of Chittagong, Bangladesh.pp 20.
35. Thompson PM and MA Islam, 2010. Environmental Profile of St. Martin's Island. United Nations Development Programme, Dhaka. Pp 151.
36. Tomascik T, 1997. Management Plan for Coral Resources of NarikelJinjira (St. Martin's Island).In: Final Report, National Conservation Strategy Implementation Project-1, Ministry of Environment and Forest, Government of Bangladesh. pp 125.
37. Wargacki AJ, E Leonard, MN Win, DD Regitsky, CNS Santos, PB Kim, SR Cooper, RM Raisner, A Herman, AB Sivitz, A Lakshmanaswamy, Y Kashiyama, D Baker and Y Yoshikuni, 2012. An Engineered Microbial Platform for Direct Biofuel Production from Brown Macroalgae. SCIENCE, 335: 308-313.
38. Zafar M, 2005. Seaweed culture in Bangladesh holds promise. INFOFISH International, 1: 18-10.