Central America and the Caribbean Region (Broad Region)

Preliminary Survey on Technologies in Japan for the Utilization of Sargassum along the Caribbean Coast

Final Report

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Japan International Cooperation Agency

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Abbreviations

Abbreviation	Official Name (English)
ACS	Association of Caribbean States
BHA	Bioplastic (poly-3-hydroxybutyrate)
CARDI	Caribbean Agricultural Research & Development Institute
CARICOM	Caribbean Community
CERMES	Centre for Resource Management and Environmental Studies
CRFM	Caribbean Regional Fisheries Mechanism
EU	European Union
HTL	Hydrothermal liquefaction
IDB	Inter-American Development Bank
JBE	Japan Blue Economy Association
JICA	Japan International Cooperation Agency
MOFA	Ministry of Foreign Affairs of Japan
NEDO	New Energy and Industrial Technology Development Organization
PHA	Polyhydroxyalkanoates
R&D	Research & Development
SATREPS	Science and Technology Research Partnership for Sustainable Development
SICA	Sistema de la Integracion Centroamericana
SMEs	Small and Medium-sized Enterprises
UNDP	United Nations Development Programme
UNEP	United Nations Environment Programme
UWI	The University of the West Indies

1. Survey Overview

1.1 Background and Circumstances

Sargassum is a brown macroalgae of the sargassum genus, and since 2011, explosive has been observed in the Sargasso Sea and from northeastern Brazil to the Gulf of Guinea. In June 2022, the drifting ashore of sargassum exceeding 24 million tons has been observed along the coastal regions of the entire Atlantic, which represents a 20% increase compared to the same period four years ago. Drifted sargassum is prone to decomposition and causes environmental pollution due to foul odor. It has also affected the tourism and fishing industries and has been confirmed to be having a damaging effect on the region's social economy. In addition, sargassum has been reported to contain arsenic and heavy metals, which are challenges in considering effective utilization and treatment methods.

JICA commissioned the Caribbean Regional Fisheries Mechanism (Caribbean Regional Fisheries Mechanism, CRFM) to conduct a “Fact-finding Survey Regarding the Influx and Impacts of sargassum Seaweed in the Caribbean Region” in 2018 to confirm its potential for utilization as animal food, fertilizer, bioplastic, biofuel, alginate, building insulation, and binding material. However, it was concluded that further investigation and research is needed to process the large amount of sargassum at low cost and in a short time, as well as to remove the hazardous substances contained. In addition, in FY2022, JICA's Central America and Caribbean Division, Latin America Department (hereinafter referred to as "Central America and Caribbean Division") conducted the "Study on human resources and infrastructure development for cocreation of resilient society under the with/post COVID-19 context in Central America and the Caribbean region" to investigate the status of efforts in the Caribbean region. The Ministry of Foreign Affairs of Japan (MOFA) has been cooperating with Caribbean countries in the collection (removal) of sargassum through the Grant Assistance since 2022, but no effective measures have been established for the utilization of the collected sargassum. Considering this situation, the Preliminary Survey on Tehchnologies in Japan for the Utilization of sargassum along the Caribbean Coast (hereinafter referred to as “the JICA survey”) was conducted to examine the possibility of cooperation for the utilization of sargassum, by reviewing the technologies and research possessed by Japanese private companies and research institutes.

1.2 Purpose of the JICA Survey

The purpose of the JICA Survey is to collect and organize information on technologies and products related to the utilization of sargassum and related research in order to mitigate the impact of sargassum on tourism, fisheries, etc. in areas where it drifts ashore, and to organize and survey the possibility of cooperation regarding the utilization of sargassum using these technologies.

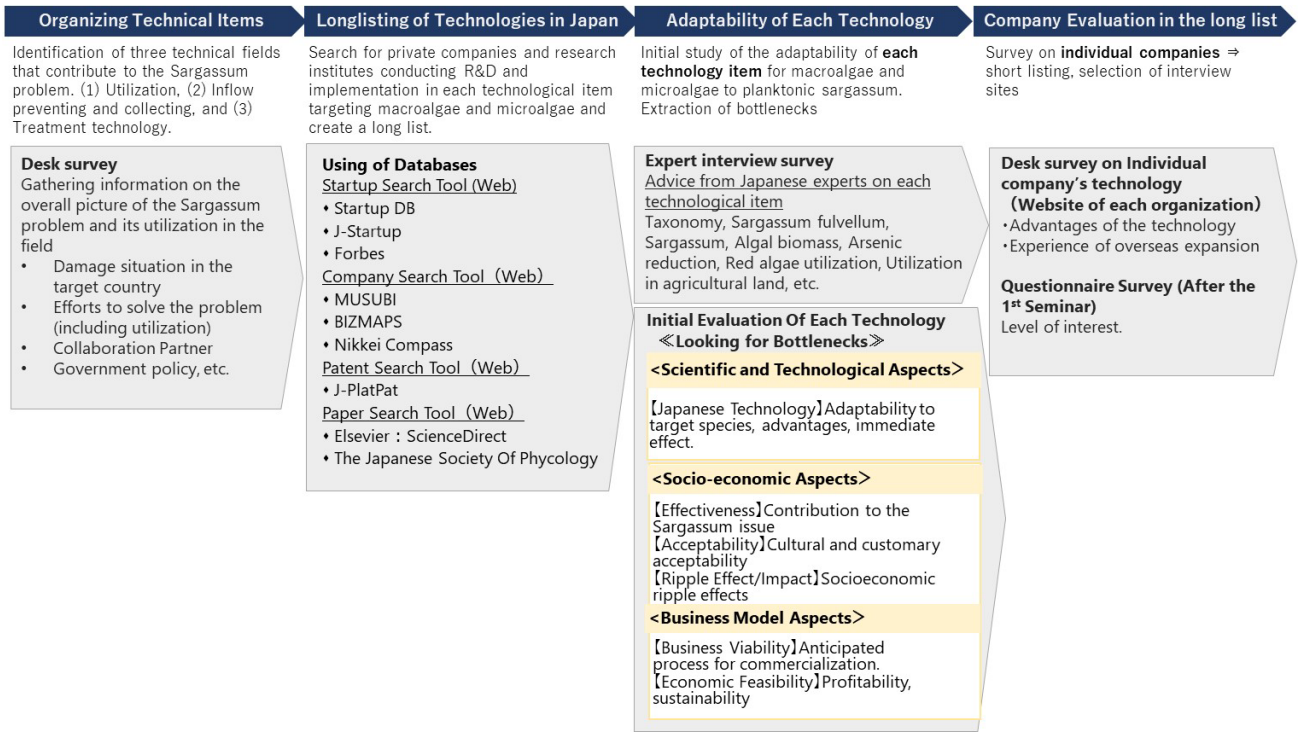
1.3 Outline of Work

Through desk survey, interviews, and online seminars, the JICA Survey examined and organized the technologies and research possessed by Japanese private companies and research institutions, as well as potential future development partners, and created a series of scenarios as a direction for future cooperation regarding the utilization of sargassum.

1.4 Survey Plan

(1) Desk Survey

The desk survey organized Japanese technologies that could potentially be adapted to the implementation method shown in Figure 1.1. First, an overall picture of the status of the sargassum problem in the Central American and the Caribbean region and the related countermeasures and utilization were compiled from existing data and other sources. Based on this information, potential technology areas for (1) utilization, (2) inflow prevention and collection, and (3) appropriate treatment were identified. In collecting information on Japanese technologies, private companies and research institutes engaged in research and development and social implementation of each technological field targeting algae (and some targeting organic wastes) were surveyed using various databases, and a long list was prepared. The applicability of each technology item to floating sargassum was initially evaluated based on interviews with experts, papers, and information provided by each company, and issues that could become bottlenecks was summarized. At this stage, the technological items were not narrow down, but rather the technological items were organized that can be judged to have potential for adaptation from the viewpoints of science and technology, socioeconomics, and business model. Next, the individual companies on the long list were checked the technological superiority and overseas development experience of each company and institution by referring to their websites for the technological items that have potential for application.



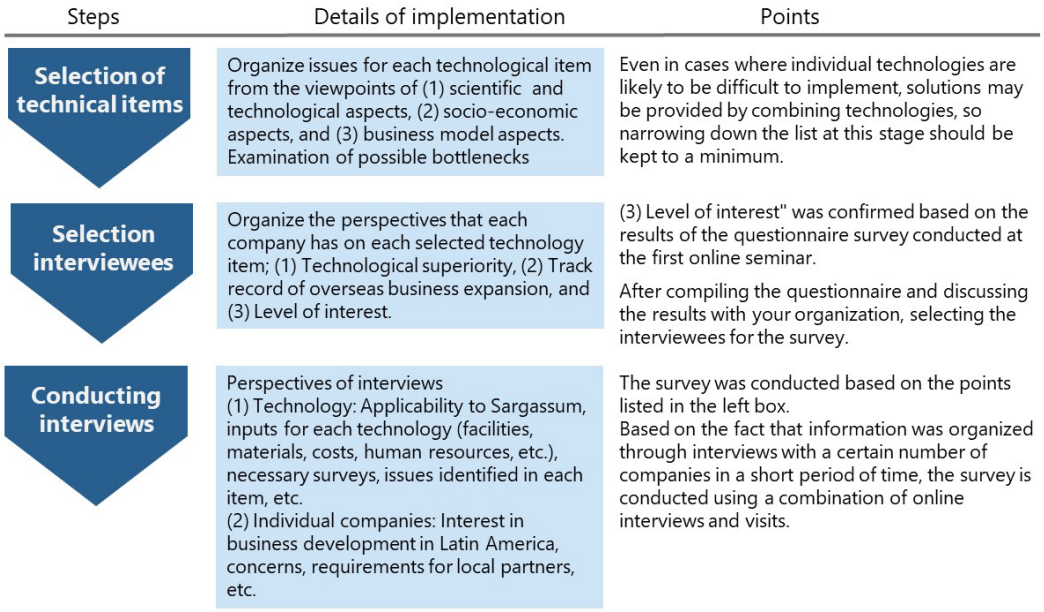
Source: JICA Survey Team

Figure 1.1 Information Collection and Summarization through Desk Survey

(2) Methods of Selecting Interviewees

As shown in Figure 1.2, the selection of interviewees was conducted in two stages, one for each technological item and one for each individual company. From the long list of Japanese technologies obtained by the desk survey, the superiority of the technologies, experience in overseas development, and level of interest of the private companies and research institutes in the potentially applicable technology items was sorted out, and the interviewees were selected.

The level of interest of each company was confirmed by conducting a simple online questionnaire to the participating companies at the first online seminar, in which the companies on the long list were invited to participate.



Source: JICA Survey Team

Figure 1.2 Selection of Interviewees and Process of Interview

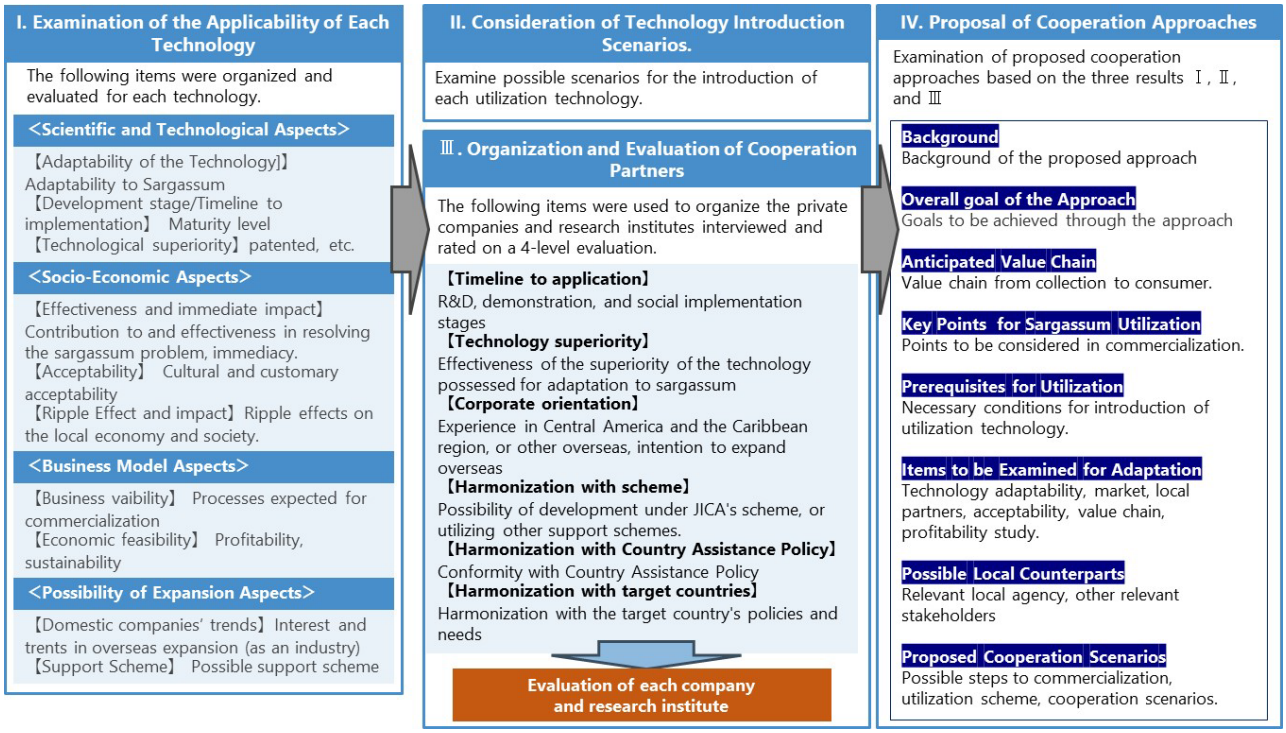
(3) Conducting Interviews

Interviews were conducted through online interviews with relevant Japanese institutions; some interviewees were visited to observe the relevant technical processes as needed. The questions mainly consisted of "product/technology-related questions," "commercialization-related questions," and "overseas development-related questions," to ascertain the applicability of technologies owned by each company and their intentions and interests in overseas expansion.

(4) Examination and Organization of Potential Future Development Partners

Figure 1.3 shows the survey process for proposing cooperation scenarios in the JICA Survey. Based on the results of the desk survey and interviews, the target technologies for utilization and appropriate treatment were organized and evaluated (I. Examination on the applicability of each technology), and then the introduction scenario of each technology was studied (II. Consideration on the technology introduction

scenarios). In addition, based on the organization and evaluation of private companies and research institutions that could be potential cooperation partners (III. Organization and evaluation of cooperation partners), a series of scenarios were proposed (IV. Proposal of cooperation scenarios).



Source: JICA Survey Team

Figure 1.3 Survey Process for Proposing Cooperation Scenarios

(5) Online Seminars

Two online seminars were conducted in phases as outlined below.

【The First Online Seminar (for related companies, research institutions, and universities)】

The first seminar was designed to foster interest in sargassum among Japanese private companies, research institutes, and universities, and to deepen their understanding of the issues related to sargassum and cooperation scheme of Japan (MOFA and JICA). Participants were mainly from companies and research institutions on the long list. After the seminar, a questionnaire survey was conducted among the participants to confirm their interest in the utilization of sargassum and their first impressions of the applicability of each company's technology, and the survey results were used as material for considering interview sites.

【The Second Online Seminar (for JICA)】

cand to introduce technologies in Japan possessed by private companies and research institutes that could be potential partners selected by the desk survey and interviews, as well as to introduce a proposed cooperation scenarios in collaboration with partners. Participants were from JICA (Latin America related departments, overseas offices, etc.) and MOFA, and opinions and suggestions were collected from each party on the draft cooperation scenario, which were reflected in the draft scenarios.

2. Summary of Results

A summary of the survey results is as follows.

(1) Desk Survey

The desk survey collected and organized information on Table 2.1.

Table 2.1 Summary of Desk Survey Results

Item	Collected information
Characteristics of algae and sargassum and recognition of the current situation regarding the utilization of sargassum	Arrangement on the biological classification and characteristics of sargassum, the target of the survey: It is a species of the family Sargassaceae, and it was confirmed that it is widely targeted as a Macroalgae when searching for utilization technologies in the JICA Survey. Confirmation of seaweed composition, especially the content of arsenic and heavy metals, along with polysaccharides, ash, and moisture content. The status and issues of sargassum control and utilization in Central America and the Caribbean region: National strategies, countermeasures and collection activities observed locally, support from international organizations, major utilization status, and status of primary processors were summarized.
Organization of the results of collecting information on the utilization of macroalgae (and organic wastes) and research in Japan.	Information on domestic private companies, universities, and research institutes involved in (1) seaweed utilization, (2) seaweed influx prevention, collection, and proper treatment was compiled for each company's technology, target algae and organic waste, business scale, and development stage, covering utilization in agriculture and aquaculture (29 companies), utilization as a material (12 companies), component extraction (15 companies), utilization in energy (6 companies), blue economy (4 companies), and utilization and treatment of organic waste (24 companies).
Organization of the results of collecting information on Japanese technologies that can be applied to the utilization of sargassum and organic waste	Based on the results of interviews with experts (six in total), points to be noted and issues to be addressed for each technology from the viewpoint of adaptability were summarized.

Source: JICA Survey Team

(2) Selection of Interviewees

Based on the results of the questionnaire conducted after the first online seminar, additional research and discussions with JICA officials, 20 companies (utilization in agriculture and aquaculture: 5; utilization as a material: 3; component extraction: 3; utilization in energy: 3; primary treatment: 3; inflow prevention and collection technology: 3) were selected for interviewing

(3) Conducting Interviews

Requests for interviews were made to the 20 companies selected in (2) above, and a total of 18 companies (including private companies, research institutions and consultative bodies) were interviewed online between mid-January and end-February 2023. On-site visits were made to four of these companies. The results of the interviews were organized into a single sheet for each company and research organization.

(4) Examination and Organization of Potential Future Development Partners

As shown in Table 2.2, the survey examined the applicability of each technology, examined scenarios for technology introduction, organized the private companies and research institutions to be interviewed, and proposed five cooperation approaches as a collaborative program.

Table 2.2 Proposal of Five Cooperation Approaches

	Approach	Overview	Preconditions	Possible Support Scheme
I	Utilization in agriculture and contribution to sustainable agriculture	Compost, fertilizer and biochar production with established technology for seaweed, which is highly locally adaptable and relatively easy to introduce, to improve productivity through soil improvement in the agricultural sector, a major industry.	- Ensuring a low-cost and stable supply of raw materials (ensuring primary processing, including the drying process) - Ensuring market stability	- JICA SDGs Business Supporting Survey and TSUBASA: support for small and medium-sized enterprises (SMEs) and companies to develop their business - JICA TCP (technical cooperation project): support for organic farming and sustainable agricultural activities
II	Contribution to energy security through carbonization and gasification technology	Energy production through the introduction of carbonization and gasification technologies with high throughput at a time. Organic waste input is also possible. Tipping fees and income from the sale of energy can be expected to guarantee long-term business viability. Expected to be used as an alternative energy source to fossil fuels, contributing to regional energy security.	- Establishment of a system that ensures profitability through processing volumes and energy sales - Cooperation with local government agencies - Cooperation with various energy suppliers	- JICA SDGs Business Supporting Survey/ NEDO demonstration: implementation of energization F/S - Grant Assistance/ Finance and Investment Cooperation: facility design, equipment provision, investment - JICA TCP: capacity strengthening, including operations
III	Extraction of useful components for value addition	The extraction process of useful components of viscous polysaccharides such as alginic acid can be carried out in the preliminary stages of agricultural and energy use, with the aim of increasing the value of the value chain.	- Low-cost and stable supply from primary treatment process - Availability of fresh water - Establishment of a value chain including residue treatment	- JICA SDGs Business Supporting Survey /TSUBASA/SATREPS: local needs, business development support, etc.
IV	(Long-term development) Extraction of high value-added components and bioethanol production for biorefinery	Although still in the research phase, the extraction of components of high pharmaceutical interest, such as marine polyphenols, and the conversion of polysaccharides to ethanol will be carried out. In the future, biorefinery creation technology will be developed, starting with the formation of seaweed farm.	- Component analysis and market research - Use of freshwater - System for social implementation through collaboration between research institutions and private sector	- JICA SDGs Business Supporting Survey /SATREPS: Cooperation with research institutions for extraction of useful components, or business development by private companies - SATREPS: Demonstration and research on bioenergy - NEDO demonstration/ private sector/Finance and Investment Cooperation: bioethanol production and sales project

	Approach	Overview	Preconditions	Possible Support Scheme
V	Promotion of utilization by providing equipment for collection and primary processing	Provision will be made for a combination of silt fences and surface cleaning vessels for collection at sea before drifting to the coast. In addition, as primary treatment (cleaning, drying, cutting and crushing) is essential for agricultural use and ingredient extraction, equipment and facilities for drying and crushing in particular will be provided to promote utilization. (However, energy saving is desirable wherever possible in order to reduce primary processing costs.)	- Cooperation with local government agencies - Cooperation with local people and fishermen	- Grant Assistance: provision of equipment for offshore collecting and primary processing facilities - JICA TCP: lateral support for collection of sargassum by municipalities

Source: JICA Survey Team

(5) Online Seminars

Two online seminars were organized for the JICA Survey, as shown in Table 2.3.

Table 2.3 Summary of Results of Online Seminars

	1st Online Seminar (For related companies, research institutions, and universities)	2nd Online Seminar (For relevant departments in JICA and MOFA)
Date	11 January 2023, 10:00-11:30 a.m.	21 February 2024, 8:00-9:30 a.m.
Participants	18 companies (private companies and research institutions)	Overseas Offices in Central America and the Caribbean, Officials from the Ministry of Foreign Affairs of Japan (MOFA)
Objective	To foster interest in the sargassum issue among Japanese private companies, research institutions and universities.	To share and discuss the image of the direction of cooperation using technologies in Japan with JICA.
Seminar outline	Explanation of the sargassum problem in Central America and the Caribbean region Explanation of technologies in Japan that are expected to be adapted Introduction of the image of commercialization and the support scheme of JICA and the Ministry of Foreign Affairs of Japan Question and answer session	Sharing of the results of the survey on technologies in Japan for the utilization of sargassum Sharing and exchange of opinions on proposed cooperation scenarios for the utilization of sargassum
Outputs	Fostering of enterprises with adaptation potential	Comments on future cooperation plans

Source: JICA Survey Team

3. Results of Desk Survey

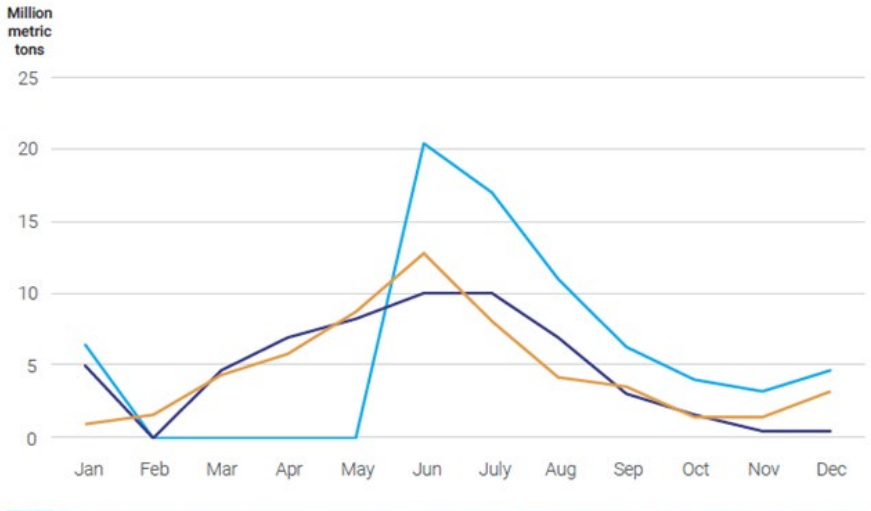
3.1 Characteristics of Algae and Sargassum and Current Awareness of Sargassum Utilization

(1) Overall Picture of Algae and Characteristics of Sargassum

1) Current Status of Sargassum

Sargassum occurs naturally in the North Atlantic and is contained in large quantities by the circulating currents, forming the Sargasso Sea. It is also common in the Gulf of Mexico in the spring and is supplied to the Sargasso Sea via the Gulf Stream, and is also known to occur occasionally in the Caribbean Sea[1]. Research on the causes of the recent massive influx of sargassum in the Caribbean and West Africa has identified a new " consolidation region " in the tropical Atlantic, between the Gulf of Guinea and the north coast of Brazil that is generally agreed to be the source of the inflow to the Caribbean and West Africa.

Since 2011, explosive reproduction has been observed in the Sargasso Sea and from northeastern Brazil to the Gulf of Guinea, with varying amounts of mating occurring from year to year, but generally increasing in early spring and decreasing after summer. Figure 3.1 shows the monthly sargassum occurrence in the Atlantic Ocean from 2018 to 2020. In June 2022, more than 24 million tons of sargassum were observed drifting along the entire Atlantic coast, a 20% increase compared to the same period four years earlier, and although the destination and amount of drifting varies from year to year, explosive reproduction is expected to continue in the future.



	Jan	Feb	Mar	Apr	May	Jun	July	Aug	Sep	Oct	Nov	Dec
2018	6.4M	-	-	-	-	20.4M	17M	11M	6.3M	4M	3.2M	4.7M
2019	5M	-	4.7M	7.0M	8.2M	10M	10M	7M	3M	1.5M	0.5M	0.4M
2020	1M	1.6M	4.3M	5.8M	8.7M	12.7M	8.0M	4.2M	3.5M	1.4M	1.4M	3.2M

Source : Sargassum White Paper 2021, UNEP

Figure 3.1 Monthly Sargassum Occurrence in the Atlantic Ocean (2018-2020)

[1] Wang et al., Science365, 83–87 (2019), The great Atlantic Sargassum belt

2) Overall Picture of Algae

Sargassum, the target of the Survey, is classified as a brown macroalgae among macroalgae. Algae are classified into two categories, macroalgae and microalgae. Microalgae are unicellular organisms with a microscopic size ranging from 1 mm to 1 micrometer, and for significant differences between the two (Refer to Table 3.1), this study focuses on Japanese technology for the macroalgae (seaweed) to which sargassum belongs.

Table 3.1 Classification of Algae

Algae	Characteristics	Contents	Difference
Microalgae	Single-celled and microscopic Phytoplankton	Classified as diatoms and dinoflagellates Includes euglena, spirulina, chlorella, etc.	- Can be cultured on land - Can be cultured in three dimensions while floating - Relatively high content of active ingredients per volume - High cost of culture medium (culture media) and extraction of components
Macroalgae	Multicellular, some exceeding 1 m Reproduce by spores without distinction between stem, leaves, and roots	Depending on the depth of the ocean they inhabit, they are classified into three main groups according to their photosynthetic chlorophyll status: Green algae, Brown algae, and Red algae.	- Basically cultivated in the sea because of the area required - Requires two-dimensional aquaculture because it grows by taking root - Low active ingredient content relative to volume - Contains toxic ingredients (arsenic, heavy metals)

Source: JICA Survey Team

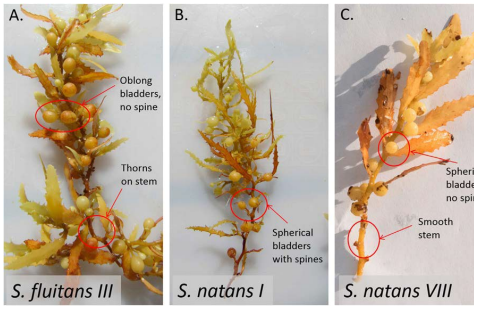
Algae, like terrestrial plants, perform photosynthesis and are said to inhabit the shallow intertidal zone of the ocean where sunlight enters as well as the ocean floor at depths of several tens of meters (complementary color adaptation theory), and large species that exceed 1m in length are found in brown macroalgae. In addition, large seaweeds are rare in tropical seas, and large seaweeds are abundant in colder regions. Most of the species stick to the seafloor in a root-like structure, but there are some species that separate from their roots and drift to the surface of the sea at a certain time. Such a solidification and drifting is called flow seaweeds. In addition, seaweed is overwhelmingly found on rocky shores, as the majority of it has its roots attached to the rocks.

In temperate zones, seaweeds are generally active from spring to early summer and inactive thereafter. This is due to the limiting factor of fertilizer content, which peaks in activity until the fertilizer content accumulated by microbial activity during the winter is used up.

Brown macroalgae are mostly marine and are found on rocky shorelines in temperate and cold-temperate zones around the world, including sargassum, the subject of the JICA Survey. *Macrocystis pyrifera*, the giant kelp known as the world's largest seaweed, forms vast seaweed forests on the west coast of North America, providing habitat and shelter for many other organisms. In tropical waters, brown macroalgae are less abundant, but species such as sargassum and *Turbinaria thunbergii* thrive in some areas and form small forests. Sargassum (Holoperdicum sargassum), the target of the JICA Survey, is also unique among large algal genera in that it includes species that are completely free-floating and do not need to be attached to the bottom as in the Sargasso Sea. The color of brown macroalgae (mainly due to the brown *subchromatase*

fucoxanthin) ranges from light beige to yellowish brown to almost black. In tropical seas, brown macroalgae range in size from microscopic filamentous to several meters in length.

The pelagic (free-floating) sargassum (belonging to brown algae) in Caribbean waters is classified into two or three species "*Sargassum fluitans* III, *Sargassum natans* I, *Sargassum natans* VIII" (Schell, Goodwin, and Siuda 2015) (Refer to Figure 3.2). These species are the only ones of the more than 300 sargassum species known worldwide that do not attach to the seafloor and spend their entire life cycle suspended. The planktonic sargassum species reported in other parts of the world are other species of sargassum that have a benthic phase in their life cycle. The sargassum species under the JICA Survey belongs to the botanical taxonomy Brown algae - Fucales - Sargassaceae family - sargassum genus, which does not grow in the coastal waters of Japan.



Source: Sargassum Uses Guide

Figure 3.2 Three Species of Sargassum in Central America and the Caribbean Region

Studies of algae in Japan have been conducted mainly on those from the seas around Japan, and 65 species of three genera of the family *Sargassaceae, Turbinaria, Hizikia,* and *Sargassum*, can be considered as references. The taxa and characteristics of Japanese macroalgae are shown in Table 3.2.

Table 3.2 Classification and Characteristics of Japanese Macroalgae

Class	Order	Family	Species
Chlorophyceae			
	9orders : Japanese knotweed, hydrilla, aosa, acrosiphonia, shiogusa, midge, cassowary, myrtle, and twinwort		
		14family : Lanthorrhiza, Aosa, Ukiolis, Shioogusa, Motsuregusa, Aomogusa, Mil, Kasanori, etc.	
			53species : Mytilus galloprovincialis, blue-green algae, mallard duckweed, Japanese knotweed, nipplefruit, sea grape, etc.
	Characteristics: As with most land plants, chloroplasts, which are cell organelles that carry out photosynthesis, contain large amounts of green pigment called chlorophyll, giving them an overall green body color. In many cases, they inhabit relatively shallow waters, and there are also many freshwater species that inhabit ponds and rivers.		
Phaeophyceae			
	10 order : Ralfsiales, Dictyotales, Chordariales, Scytosiphonales, Cutleriales, Sporochnales, Desmarestiales, Laminariales, Ishigeales, **Fucales**		
		13family : Ralfsiaceae, Dictyotaceae, Leathesiaceae, Scytosiphonaceae, Alariaceae, Chordaceae, Laminariaceae, Ishigeaceae, **Sargassaceae**、etc	
			65 species : Padina arborescens, Hydrilla verticillate, Undaria pinnatifida, Undaria pinnatifida, Nemacystis decipiens, **Hijiki**[2], **Sargassum fulvellum, Sargassum horneri,** etc
	Characteristics: In addition to chlorophyll (chlorophyll), phycoerythrin (red algae element), a red pigment, and phycocyanin (cyanobacteria element), a blue pigment, are also abundant within the chloroplast, which is why they often have a red or purple body color. In many cases, they are found in deeper waters.		
Rhodophyceae			
	10orders : Bangiales, Nemaliales, Corallinales, Gelidiales, Hildenbrandiales, Bonnemaisoniales, Gigartinales, Gracilariales, Rhodymeniales, Ceramiales		

[2] Although hijiki is classified as a member of the family Sargassaceae, there are two types of cases: those with Sargassum in the English name (Specimen Book of Seaweeds and Seagrasses, National Museum of Nature and Science) and those without (Gakken Zuken Bijutsu Zukan). The latter classifies hijiki as a member of the Sargassum genus.

Class	Order	Family	Species
		35family : Dermonemataceae, Galaxauraceae, Corallinaceae, Gelidiaceae, Endocladiaceae, Gigartinaceae, Halymeniaceae, Phyllophoraceae, Ceramiaceae, Rhodomelaceae	
			141species : Nemalion vermiculare, Gelidium elegans, Meristotheca japonica, Campylaephora hypnaeoides, Gracilaria vermiculophylla、eel gras, etc.
	Characteristics: In addition to chlorophyll (chlorophyll), they contain a large amount of a reddish-brown pigment called fucoxanthin (brown algae element), which gives them a yellowish-brown or blackish-brown body color. They are usually found in waters of medium depth, and often form large algal blooms that can reach several meters to dozens of meters in total length.		

Source : Prepared by JICA survey team with reference to "Specimen Book of Seaweeds and Seagrasses", "Specimen Book of Seaweeds and Seagrasses" (Marine Biosystems Research Center, Chiba University) 3, National Museum of Nature and Science HP4 , etc.

3) Characteristics of Sargassum

The major component composition of planktonic sargassum (*S. fluitans* III, *S. natans* I, and *S. natans* VIII) found in Central and South America is shown in Table 3.3.

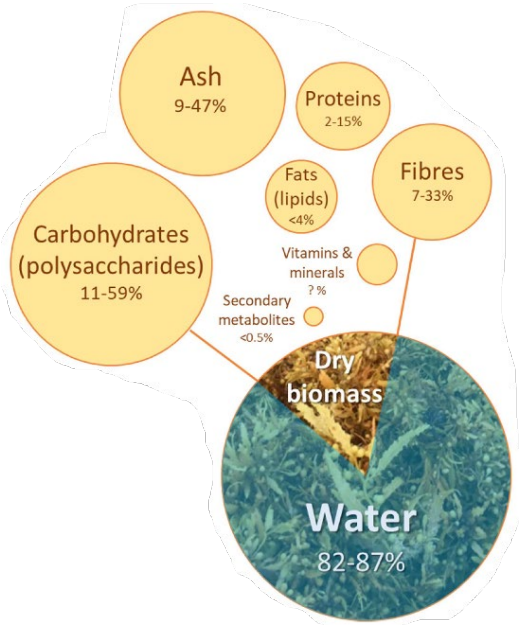
Table 3.3 Major Component Composition of Planktonic Sargassum (S. fluitans III, S. natans I, S. natans VIII)

Component	Chemical Composition
Elements	Carbon (C), sodium (Na), iron (Fe), nitrogen (N), phosphorus (P), potassium (K), magnesium (Mg), calcium (Ca), etc.
Inorganic Compounds	Water, salt, CO_2, O_2, etc.
Organic Compounds	Carbohydrates, fats, proteins, etc.

Source: JICA survey team based on Sargassum Uses Guide, etc.

In general, seaweeds comprise 70 to 90 percent of their weight in water, and the bulk of their dried biomass is composed of carbohydrates, fibers, and proteins, with small amounts of lipids (fats) and a variety of minerals. However, the exact proportions of the constituent chemicals are known to vary widely among seaweeds, especially among the three different groups (green, red, and brown algae).

The main composition of the planktonic outer sargassum is shown in Figure 3.3. While moisture comprises 82-87% of the total biomass, the dry biomass consists of carbohydrates (mainly polysaccharides), ash (mainly carbon remaining after heating at very high temperatures), fiber, protein (consisting of amino acids), lipids (consisting of fatty acids), and small amounts of vitamins, minerals, and secondary metabolites. Each of these components plays a specific role in maintaining the seaweed and has potential value for many applications. Of course, the exact



Source : Sargassum Uses Guide

Figure 3.3 Biomass Main Components of Planktonic Sargassum

[3] https://chibadai.flier.jp/algae/algae/htm/bunrui.htm
[4] https://tbg.kahaku.go.jp/research/database/seaweedworld/html/index/index2.html

chemical composition and nutritional value will vary depending on the species composition, location, timing, and environmental conditions of the planktonic sargassum (Refer to Table 3.4).

Table 3.4 Examples of Major Constituent Substances of Sargassum

Location (year)	Protein (%)	Moisture (%)	Ash (%)	Fibre (%)	Carbon Hydrate (%)	Lipids & Fatty acids (%)	C:N
B. Vergin Islands	2.6	12.68	-	-	Mannitol:10.25 Laminarin:12.6 alginic acid :15.55 fucoidan:6.19	-	-
Turks & Caicos	4.19	81.98	46.94	33.31	11.68	3.88	16.08
Martinique	-	-	-	-	-	-	17-35
Jamaica	2.2	87	-	-	Carbohydrate:20 Alginates:20 Fucoidan:20	0.27	-
Brazil	12.8	-	-	-	-	-	-
Nigeria	15.4	9.0	8.65	7.15	57.3	2.5	23
Nigeria	6.55	14.33	18.5	17	58.72	1.9	-

Source : Prepared by JICA survey team with reference to Sargassum Uses Guide

4) Heavy Metal Content

Biosorption of certain heavy metals and other potential toxins (e.g., pesticides) and the presence of high concentrations of minerals are issues of particular concern. For example, many (but not all) of the limited suspended sargassum samples tested throughout the Caribbean to date have been found to contain arsenic at concentrations exceeding most national allowable concentrations for certain agricultural and nutritional uses. Similarly, concentrations of copper, molybdenum, and manganese have been found to exceed safe limits in 5-22% of Mexican samples (Rodríguez-Martínez et al.) Chlordecone has been detected in some sargassum samples from highly contaminated areas off Martinique and Guadeloupe. Table 3.5 shows the composition of identified sargassum and Table 3.6 shows examples of heavy metals in sargassum (data: 2015-2019).

Table 3.5 Examples of Heavy Metal[5] Composition of Sargassum

Location	Total As (ppm)	Org. As (ppm)	Inorg.As (ppm)	Cd (ppm)	Hg (ppm)	Pb (ppm)	Cr (ppm)
Mexican Caribbean	24-172 (ave.80)		-	<2	-	<2-3	<8
B.Vergin Islands	45	17.3	27.7	0.169	<0.005	0.32	-
Martinique Guadaloupe	11.5-100.8	-	-	-	<0.1	<5.3-1.2	5.2-10.6
Turks & Caicos	123.69	-	-	<0.2-1.02	0.01	0.26	<0.3
Dom. Rep	14-42	-	-	0.13	-	1-2	2-56
Atlantic	4.2-19.5	-	1.9-19.5	0.1-0.3	<0.01-0.07	-	-
Ghana	13-53.5	-			1-2	86.335	-

Source : Sargassum Uses Guide

[5] Although there is a theory that arsenic is not included in heavy metals, the Sargassum Uses Guide lists six heavy metals as heavy metals: organic arsenic (Org. As), inorganic arsenic (Inorg. As), cadmium (Cd), mercury (Hg), lead (Pb), and chromium (Cr). (Cr) as Heavy Metals.

In general, arsenic is found in high concentrations in all studies, with concentrations ranging between 11.5 and 172 ppm. There are two forms of arsenic, organic and inorganic arsenic, and inorganic arsenic is considered more toxic, so it is important to distinguish between the two. There are limited studies that have examined arsenic speciation to determine the proportion of both inorganic and organic forms of arsenic, but based on a sample from the British Virgin Islands (2016), 62% of the total arsenic content is inorganic arsenic (Table 3.5). Tirolien's study (2019), Martinique in which 70 percent of the total arsenic was inorganic arsenic; a study of the Gulf of Mexico/Sargasso Sea sargassum population conducted in the 1970s found four pelagic sargassum samples at different locations (200 miles off Bermuda, eastern Gulf of Mexico, Florida Straits, and offshore Key West in deep water) and were analyzed for arsenic, germanium, and mercury, including speciation analysis (Johnson and Braman 1975). In three of the samples, more than 82% of the total arsenic was found to be inorganic arsenic in the form of arsenate (As III) and arsenate (As V), and one sample contained 29% inorganic arsenic.

Maximum allowable levels of arsenic vary by country and by what is being tested (soil, water, fertilizer, etc.), but EU standards limit total arsenic content to 20 mg/kg (dry weight) for agricultural soil, 40 mg/kg (dry weight) for fertilizer, and 2 mg/kg for feed[6], the recommended maximum for inorganic arsenic. A study conducted in Barbados for 23 sargassum crops between 2020 and 2022 found total arsenic (As) levels ranging from 2.3 to 17.8 μg/g (wet weight) with an average of 9.0 μg/g and inorganic arsenic (As i) levels ranging from 0.3 to 11.3 μg/g (wet weight) with an average of 5.0 μg/g, Inorganic arsenic accounted for 62% of the total arsenic.

According to the interviews conducted by the survey team with experts, many of them stated that heavy metals contained in seaweeds are not a major problem in Japan. In Japan, hijiki（Sargassum fusiforme）, konbu (kelp), and akamoku (Sargasssum horneri) are used for food, and although arsenic contained in hijiki in particular was once considered a problem, it has been reduced to an almost problem-free level by basically boiling the water two or three times while changing the water[7]. It was also pointed out that handling viscous polysaccharides (alginic acid and fucoidan) and heavy metals is difficult unless one has experience in eating them, and while they are not a major problem in Japan, where they are used daily for food, they are a major concern in Europe and North America, where they have not been used much for food until recently.[8]

The FAO and WHO have established the CODEX Committee to determine the content of heavy metals in food (crops), and each country has its own standards for fertilizers, so when utilizing fertilizers, arsenic and heavy metals must be reduced to meet the respective standards.

[6] An analysis of arsenic concentrations associated with sargassum influx events in Barbados, Marine Pollution Bulletin 192, 2023

[7] Fisheries Research and Education Organization (December 7, 2023), Seaweed Research Institute (December 8, 2023), Hokkaido Marine Innovation (December 11, 2023)

[8] According to the Seaweed Research Institute, some areas, such as the Shetland Islands in Scotland, have long eaten seaweed.

(2) Current Status and Issues in Utilization of Sargassum

1) Utilization of Sargassum

Also, Central American and the Caribbean countries have developed some form of management strategy for sargassum since the mass drift in 2011. The main countries that have developed strategies or management plans for sargassum are listed in Table 3.6. Common to all strategies is that they point out the difficulties in decision-making due to the lack of information on the influx of sargassum and emphasize the need for further research on the actual situation[9]. Since the potential and business environment at the time of utilization differs depending on the target country, it is necessary to keep in mind the policies, plans and regulations of each government and the potential when considering the utilization of sargassum.

Table 3.6 Status of Strategic and Management Plan Development for Sargassum in Central American and Caribbean Countries

Country	Strategy and Management Plan	Summary and description of utilization
Jamaica	National Response Strategy (2015)	- Raise public awareness, mobilize communities to clean up beaches and shorelines, and articulate measures to address sargassum through research and product development - Promotion of feasibility study of commercial use of sargassum with research institutions.
Saint Lucia	Management Strategy (2021), (2023 is in draft form)	- Guidelines and action strategies for adaptation and disaster risk (and perception of disaster risk) measures in the pre-influence, drifting and post-influence stages of sargassum. - Removed sargassum as a blue economy activity, aiming to increase economic added value through local use.
Mexico	Technical and Management Guidelines for Addressing Sargassum in the Mexican Caribbean and Gulf of Mexico (2021)	- Establishment of technical specifications for marine collection, coastal removal, pre-treatment, final disposal and quantification of sargassum for monitoring purposes. - Compliance with technical guidelines and regulations for acquisition, transportation, temporary storage and treatment for utilization.
Dominican Republic	Report on the Current Status of Sargassum (2018)	- Organize the current status of measures taken by the Ministry of Tourism, clean-up programs by hotels, scientific and technical papers related to collection, and related patents.

Source：SARGASSUM WHITE PAPER（2021）, St. Lucia Sargassum Adaptive Management Strategy (2023) (Updated draft), and Website of each country

In the local area, the efforts shown in Table 3.7 have been confirmed by government agencies of various countries, as well as international organizations, research institutes, and the tourism industry, in each of the phases of status determination/monitoring, inflow prevention, collection, and treatment. In addition to monitoring by satellite and other means, a website where residents and tourists post photos is also used for monitoring and identifying the current status of the influx. This site also confirms that large quantities of sargassum are still drifting ashore, despite the efforts of various countries to prevent the influx of sargassum and to collect it. In addition, surveys and assistance by international organizations and national governments have included problem identification, networking among stakeholders, and the provision of removal equipment for collection work, and recently, measures have been taken to utilize the recovered sargassum (Reference Table

[9] Taylor & Francis, "Polycentric Governance, Coordination and Capacity: The Case of Sargassum Influxes in the Caribbean" (2022)

3.8). Japan has been providing seaweed removal equipment to the Dominican Republic and other countries since 2020 for a total of 600 million yen. In addition, UNDP is providing equipment to five countries, strengthening monitoring and removal capacity, and building an information sharing network.

Table 3.7 Sargassum Measures found in Central America and the Caribbean Region

Initiatives	Current Status	Implementing Organizations	Issues
Monitoring	Prediction of sargassum inflow using satellite/drone and ocean current forecasting	International organizations (FAO, World Bank, etc.), national government agencies (Jamaica, etc.), NASA, research institutions (University of South Florida, University of the West Indies, etc.)	- Noise and ocean currents such as clouds, Sahara dust, and water vapor make highly accurate forecasting difficult, Insufficient access to, use of data by, and preventive and response measures by stakeholders in various countries - In practice, sargassum drifting is understood through photo submissions by citizens and tourists
Inflow prevention	Installation of floats on the sea Operation of work vessels	National government agencies, tourism industry (hotels, etc.), fishery cooperatives, etc.	- Not functional depending on water depth and beach conditions, expensive, input and maintenance costs - Requires removal in case of hurricanes
Collection	Collection by backhoe or other heavy equipment. Collection by hand	National government agencies (local governments), tourism industry (hotels, etc.), UNDP, local communities, etc.	- Labor costs for collection, heavy equipment, and truck rental costs are high. - Collection by heavy equipment is not being implemented willingly from the viewpoint of beach protection, and collection is delayed. - The collection work was halted due to the bad smell of sargassum deposited after the collection was not completed. - In tourist areas, a daily work allowance is paid for removal, but in fishing villages and general settlements, there is no incentive for removal, and removal does not proceed.
Processing	Landfilling Spreading on agricultural land	National government agencies	- Transportation costs. - Concerns about disposal methods and utilization due to high arsenic levels detected in samples collected in Belize.

Sources : Fact-finding survey regarding the influx and impacts of Sargassum seaweed in the Caribbean region : final report(2019), Study on human resources and infrastructure development for cocreation of resilient society under the with/post COVID-19 context in Central America and the Caribbean region (2023), SARGASSUM WHITE PAPER, UNEP (2021), Valeria Chaves et al. (2020), Massive Influx of Pelagic Sargassum spp. on the Coasts of the Mexican Caribbean 2014–2020: Challenges and Opportunities

Table 3.8 Support for Sargassum by Regional/International Organizations and Governments

Agency	Dealing Strategy	Summary and description of utilization
SICA	Cooperation with ACS, CARICOM, etc. based on the request of the Dominican Republic, a member country	- Mapping of projects and reference cases - Establishment of a financial mechanism in collaboration with the private sector and the financial sector
IDB	Unified regional response rather than country-specific response	- Research focused on the tourism sector - IDB Lab support to Grupo Punta Cana Foundation in the Dominican Republic
UNDP	Support for the five Eastern Caribbean countries in cooperation with the Government of Japan	- Providing sargassum removal equipment and materials - Support for management, planning, and monitoring

Agency	Dealing Strategy	Summary and description of utilization
The World Bank	From the perspective of regional cooperation, four pillars of collective, proactive, and large-scale response are proposed.	- Establishment of a Caribbean-wide regional early warning system - Mobile physical infrastructure that is a rapid response facility - Establish a regional financial architecture. - Identify and functionalize the value chain.
EU Barbados	sargassum is a priority alongside maritime transport in the Caribbean region. Monitoring and forecasting through the Satellite Network Copernicus.	- EU and CELAC joint research and innovation initiatives - All Atlantic Ocean Research and Innovation Alliance, a network of partners including the United States, Canada, Cape Verde, Brazil, and Argentina to promote, enhance, and expand ocean research in the Atlantic Ocean
Japan	Grant assistance to Dominican Republic, Grenada, Antigua and Barbuda.	- Provides sargassum collection and removal equipment on the coast. - Direction to consider how to support a "line" of effective utilization of sargassum after collection
New Zealand	Support for liquid fertilizer production in Belize in collaboration with CRFM	- The first phase (-2022) will focus on confirming the safety of sargassum, the second phase (2023-) will focus on product and process development, and the final phase will support the establishment of pilot plants and social implementation.

Source : Gran Caribe-UE Cenferencia_Sargazo_25JUL23

2) Utilization of Sargassum

Sargassum utilization methods found in Caribbean countries can be broadly classified into agriculture, energy, materials, and component extraction, as shown in Table 3.9, with research and development by private companies, including research institutes and start-ups, and government-led pilot projects. Of these, the main areas of social implementation in the Caribbean are agriculture, such as compost, growth promoters, and animal feed, and utilization as raw materials for bricks, paper products, etc. Although the results and scale vary, there are one to several companies in each area that have successfully commercialized the products.

Table 3.9 Major Utilization of Sargassum in Caribbean Countries

Field	How to Utilize Sargassum	Overview and Specific Example of Utilization of Sargassum	Stage of Development Footnote1
Utilization in Agriculture and Aquaculture	Compost, fertilizers, Bio stimulant	- At present, fertilizers and livestock feed are the most widely used methods. - In Mexico, it is also used as fertilizer for gardens and golf courses, and its benefits have been scientifically proven. - Research institutions and private companies, including start-ups, are conducting R&D (Research & Development), pilot projects, etc. AlgaeNova and SOS Carbon (Dominican Republic) have implemented everything from offshore collection of sargassum to production of compost. - The project to produce liquid fertilizer and compost from sargassum, which CRFM, a fisheries-related organization of CARICOM, has been promoting with support from New Zealand, is now in the second phase in collaboration with the University of the West Indies (UWI) and the Caribbean Agricultural Research and Development Institute (CARDI), starting in 2023. It should be noted that the first phase of the project reportedly included component analysis and safety testing of sargassum. - Algas Organics, a start-up company in St. Lucia, is manufacturing and selling a biostimulant that utilizes local sargassum. It is also listed as being capable of removing heavy metals. The company processes over 1 million pounds of seaweed into plant improvement products annually and exports to 10 countries.	R&D~ Social implementation

Field	How to Utilize Sargassum	Overview and Specific Example of Utilization of Sargassum	Stage of Development Footnote1
	Livestock feed	- While there is a lot of research and development, Awganic Inputs (Jamaica) has commercialized a supplement feed (for goats) using sargassum as the main ingredient.	R&D~ Social implementation
Utilization in Energy	Bioethanol and diesel production	- Research is in the process of being conducted by a research institute to confirm potential and methods of production. - Cenventrash RD (Dominican Republic) produces CDRN, a standardized waste-derived fuel with less than 5% moisture, less than 3 mm particle size, and a calorific value higher than trinitrotoluene (TNT), as well as a patented solution to convert solid waste and sargassum into electricity and biodiesel.	R&D (fundamental reserch)
	Biogas recovery	- Plans and pilot projects for biogas recovery mixed with other organic matters are underway in the Dominican Republic, Mexico, Barbados, and other countries. - FWM (Germany) is planning to install small-scale facilities in hotels. - In Belize, a government-led biofuel production pilot project (MSW and sargassum) is under development (in collaboration with Variodin (Germany).	Experimental study
	Production of biochar	- Mexico, Guadalupe, and other countries are in the research phase to confirm potential and generation methods.	Fundamental reserch
Utilization as a material	Production of bricks	- Bricks and construction boards made from sargassum are under development in Mexico.	Small-acale social implementation.
	Production of bioplastics	- Bioplastic manufacturers, universities, and research institutes are conducting R&D; Abaplas (Mexico) is testing a method to use sargassum as a feedstock (30%). Dominica is developing disposable plates made from sargassum and cassava.	R&D~Social implementation
	Production of paper products	- Start‐up companies are marketing the product as environmentally friendly (Mexico, Curacao, etc.). - Sargasse Project (France) is conducting research to commercialize paper products to a commercial level.	R&D~ Small-scale Social implementation
Component Extraction	Manufacture of medicines	- Several research projects are underway at the University of the West Indies.	R&D
	Manufacture of cosmetics	- A start-up company is developing a skin care product using sargassum.	R&D

Footnote 1; "Development stage" is indicated by [R&D (from basic research to applied research)] the research and development stage of technology, [Demonstration Experiment] the adjustment stage for dissemination, and [Social Implementation] the stage for dissemination to society based on research results obtained.

Source; Milledge, J. J. and Harvey, P. J. (2016) Golden Rides: Problem or Golden Opportunity? The Valorisation of Sargassum from Beach Inundations. Journal of Marine Science and Engineering. 4(3), 60., Sargassum Uses Guide, Gran Caribe-UE Cenferencia_Sargazo_25JUL23, Unión Europea, Gobierno de República Dominicana,etc Based on these sources, JICA Survey Team made that.

Some of the local companies that utilize sargassum also possess technologies for primary processing (washing, drying, crushing/shredding, and storage) of sargassum and offer their services to other companies. Since these companies could be potential local partners for Japanese companies to utilize sargassum in the region, we have compiled a long list of relevant local companies and research institutions based on the following survey data (Refer to Appendix 1 for details).

1) La conferencia regional Gran Caribe-UE sobre sargazo～convertir el Sargazo en una oportunidad, Informe Final

2) 2)Centre for Resource Management and Environmental Studies (CERMES) and University of the West Indies, Cave Hill Campus, Barbados, "Sargassum Uses Guide: A resource for Caribbean researchers, entrepreneurs and policy makers" (October 2020)

3) EU Blue Economy Report 2023, Phyconomy Seaweed Organizations Database https://phyconomy.net/database/

A summary of the long list by sector is summarized in Table 3.10 (Refer to attached list for individual information and contact information). Although there are a considerable number of organizations that are engaged in collection and inflow prevention, there is one research institute that specializes in arsenic and heavy metal removal as well as purification[10], although the details of primary treatment are not clear, but no pretreatment such as drying and crushing were found. It is possible that some of the organizations that are making use of the data are also engaged in primary treatment. By sector, most of the respondents were involved in crop production and biofuels.

[10] Attachment List No. 6-4 (Bioremediation & purification) Mexican Institutes

Table 3.10 Local Companies and Research Institutions on Collection, Primary Processing and Utilization by Sector

Field	No. org.	MEX	DOM	JAM	CYM	GLP	MTQ	KNA	LCA	BRB	TTO	CUW	GUF	ESP	DEU	DNK	NLD	FRA	ITA	NOR	GBR	USA	JPN
Inflow Prevention and Recovery	7		3											1	1	1						1	
Agriculture - Livestock Production	4	1		1		2	1																
Agriculture - Crop Production	27	7	1		1	5	5	1	2	3	1				1						1	2	
Alginate	4	3		1						1	1												
Antifouling Treatment	2					2																	
Biofuels	20	4	2			5	2			3	1		1		1		1	2	1		1		
Bioplastics	9	3	1			2	2			1	1		1					1				1	
Bioremediation and remediation	9	2	2			4	2			1	1		1										
Clothing, Shoes & Accessories	1	1																					
Building materials	7	4				1	1			1													
Cosmetics	2	1								1													
Electrochemical Industry	2					2	1																
Environmental protection	5	2	1							1												1	
Food & Beverage	4	1			1																	1	1
Lubricants, surfactants, adhesives	1					1																	
Paper & Corrugated Products	8	4				1	2					1						1					
Pharmaceuticals & Biomedical	2			1			1				1												
Health Effects	2						1											1					
General Research	8	4															1	1		1	1	1	

Note: If multiple countries are involved in the same project, each country is accounted for.

Abbreviations are based on ISO 3166-1: MEX Mexico, DOM Dominican Republic, JAM Jamaica, CYM Cayman Islands, GLP Guadalupe, MTQ Martinique, KNA Saint Kitts and Nevis, LCA Saint Lucia, BRB Barbados, TTO Trinidad and Tobago, CUW Curacao, GUF French Guiana, ESP Spain, DEU Germany, NLD Netherlands, FRA France, ITA Italy, NOR Norway, GBR United Kingdom, USA United States, JPN Japan

Source : JICA Survey Team

In addition, two companies (Martinique, France) are conducting research on the evaluation of arsenic and other substances and their effects on the human body in the field of health effects, reflecting the high level of interest in the inclusion of heavy metal components, which are often pointed out in reports from Europe, the United States, and other countries. Although any information on companies that actually remove heavy metals were not found, exchanging information with these companies and research institutions would be useful when considering the utilization of the site for agriculture, forestry, fisheries, and food and beverage industries.

In addition, the World Bank (2023) [11]analyzed 10 areas in Table 3.11 as potential commercial opportunities for the relatively new use of algae. The most promising of these markets are biostimulants, pet food, livestock feed, and feed additives with methane-reducing effects. The JICA Survey also collects and organizes potential technologies for these potential markets.

Table 3.11 Potential Market Analysis for Utilization of Seaweed

Potential Market	Overview
Biostimulants	Increases plant productivity by alleviating stress through increased biological activity. Can improve yield and quality without increasing agricultural materials and fertilizers.
Feed additives	Replaces feed that competes with human food such as soybeans and corn.
Pet food	Pet food is more expensive than animal feed and could be a commercial opportunity for seaweed producers.
Methane-reducing feed additives	Commercial sales of methane-reducing seaweed additives are still limited, and the global methane-reducing additives market is expected to be $47 million in 2022, while the potential seaweed-based market forecast is $306 million in 2030, at a CAGR of 57% from 2022 to 2030.
Nutritional supplements	Several niche applications for seaweed-based nutraceuticals already exist, but data on market size is limited. The global nutraceutical market is expected to be $450 billion in 2022, with projected market growth of 7.5% CAGR from 2022 to 2030, and projected seaweed nutraceutical market potential of $3.9 billion by 2030.
Alternative Proteins	Global alternative protein market: $10.2 billion in 2022, with a projected CAGR of 36% from 2022 to 2030 and a potential of $448 million by 2030.
Fabrics and textiles	Seaweed fiber with less than 10% seaweed content is commercially available, but in small quantities
Bioplastics	Biogenic plastics to replace petroleum-based plastics
Medical products	No seaweed-based medical products have been successfully commercialized (research on seaweed-based medical products takes at least 5-10 years for pre-clinical trials and is costly for approval)
Building materials	Seaweed building materials show promise, but availability of biomass is a challenge. There is interest in sargassum colonies, as in the Caribbean

Source :World Bank "Global Seaweed New and Emerging Markets Report 2023"

[11] The World Bank "Global Seaweed New and Emerging Markets Report 2023"

3.2 Collection and Organization of Information on the Results of Seaweed Utilization and Research in Japan

(1) Survey Methodology Overview

In the JICA Survey, a desk survey was conducted on the technologies and research possessed by domestic private companies, universities, research institutes, etc. related to (1) seaweed utilization, and (2) prevention of seaweed inflow, collection and proper treatment of seaweed. Information on the utilization of seaweed was collected and organized in the areas of agriculture, energy use, material use, component extraction, and others (e.g., blue economy). The survey methodology is outlined below.

(a) Information Items Organized

For each field, information on companies and institutions (including business scale, etc.), target algae, fields of utilization, technological content, and development stage was organized.

(b) Information Collection Methods

A wide range of potentially relevant private companies, research institutes, universities, etc. were searched using company/startup search tools, patent search tools, article search tools, and search engines. The specific searches conducted, and their results are shown in Table 3.12.

Table 3.12 Information Collection Methods for Technologies in Japan

Tools & Databases	Overview	Search methods	Search Results
Startup Search Tool			
STARTUP DB	Platform specializing in startups with over 22,000 companies	Search by keywords such as seaweed, Sargassum fulvellum, sargassum, red algae, etc. Also, search for organic waste utilization.	No hits for sargassum, Sargassum horneri, and Sargassum fulvellum, respectively. There were 35 hits for seaweed.
J-Startup	List of startups selected by METI, JETRO and NEDO as part of the government's support for startups		2 hits for utilization of organic waste.
Forbes	200 companies are introduced as the Big Book of Startups in Japan		4 hits for seaweed utilization (all are microalgae). (All are microalgae).
Company Search tool			
MUSUBI	Database of more than 1.4 million company information	Search by keywords such as seaweed, sargassum, Sargassum fulvellum, Sargassum horneri, etc.	Too many to narrow down by seaweed. Narrowing down the search to hijiki, Sargassum horneri, Sargassum fulvellum, etc., several hits were found.
BIZMAPS	Search service for more than 1.7 million companies. It can be searched by industry and by region.		3 hits for seaweed and compost
Nikkei Compass	Industry reports, company data, etc. can be searched.		1 item found by ‘’ Sargassum horneri’’
Patent Search Tool			
J-Platpat (Patent Information	Searchable for patents, utility models, designs, and	Search for patents related to sargassum	52 hits for the keyword "sargassum’’ There are several technologies related to

Platform)	trademarks in Japan.		ingredient extraction technology by research institutes and companies.
Paper Search Tool			
ScienceDirect （Elsevier）	Paper database (about 1/4 of the world's major English-language papers)	Search for examples of utilization of Sargassum fulvellum, mainly papers with a Japanese first author, published in 2003 or later.	20 hits for papers on Sargassum ecology, components, etc.
The Japanese Society Of Phycology	Conference papers are published on the conference website.	Search for papers published since 2011	No papers on the utilization of sargassum

Source ：JICA Survey Team

（2） Result of the Survey

Table 3.13 and Table 3.14 provide an overview of the main Japanese technologies identified through desk survey for seaweed utilization and seaweed influx prevention, collection, and proper disposal, respectively.

Table 3.13 Outline of Major Technologies in Japan for Utilization of Seaweeds

Field	Main Technology	Number of longlists	Major algae	Technology Overview／Development Stage／Challenges
Utilization in agriculture and aquaculture	fertilization on agricultural land	1	Including Sargassum fulvellum	It is also a traditional agricultural method and can be used for all types of crops. It is being implemented in many areas, as crops can become high value-added products.
	Fertilizers ・ Composting	5	Including Sargassum fulvellum	There are many manufacturers that produce and sell composting equipment. Several companies were identified that manufacture and sell seaweed-derived fertilizers or fertilizers containing some seaweed-derived powder. Seaweed-derived fertilizers are traded online, including those made overseas.
	Livestock feed	4	Asparagopsis taxiformis etc.	Asparagopsis taxiformis has been shown to reduce ruminant-derived greenhouse gases, and feeds are being developed.
	Growth promotion (biostimulants)	13	Ascophyllum・Nodosum etc.	Although Europe leads the way, the market is expected to expand in Japan in recent years, and many products are made from seaweed, which contains many polysaccharides, minerals, and vitamins. Many products are made from Ascophyllum・Nodosum, which is native to Europe.
	Aquaculture/fish feed	6	Sargassum fulvellum、Kelp	Various studies have confirmed the benefits of mixing algae in feed (e.g., increased sea urchin filling and growth), and its use in aquaculture feed was confirmed by several companies. However, the use of unprocessed Sargassum fulvellum as feed was not confirmed.
Utilization as a material	Bioplastic	3	Seaweed, Kelp, Floating mats of sargassum Seaweed	At the Research & Development level, research institutes, industry-academic institutions, and start-ups have reported research and development of biodegradable plastic films made from seaweed. Production cost is a major issue for practical application.
	Functional Food	6～	Sargassum horneri, Okinawa	Many supplements and powdered foods (functional foods) made from seaweeds already used for food, such as Sargassum horneri, Okinawa Mozuku

Field	Main Technology	Number of longlists	Major algae	Technology Overview／Development Stage／Challenges
			Mozuku Seaweed, Kelp, Seaweed	Seaweed, kelp, and seaweed, are now available. Noodles kneaded with extracted alginic acid are also available. Sargassum horneri which has been consumed in some regions for a long time, has come to be featured as a food and processed product in recent years due to the health boom. Adaptation of seaweeds that have not been previously used for food is likely to require additional research and demonstration, including safety.
	Others	3	—	As value-added processed food manufacturing, companies were identified that manufacture and sell edible film derived from seaweed, sell and manufacture algal salt, and develop products made from unutilized agricultural products.
Component Extraction	Extraction of viscous polysaccharides (fucoidan, alginic acid, etc.)	2	Sargassum horneri、Kelp、Lessonia（made in Chiri）	The extraction of viscous polysaccharides (fucoidan and alginic acid) is socially implemented in Japan. However, price competition is an issue due to the influx of cheap foreign products (the concentration of which is unknown). In addition, stable supply of raw materials and storage technology are also issues.
	Extraction of fucoxanthin	2	Sargassum hoerine, other Sargassum fulvellum	A private company that has established a stabilization technology for fucoxanthin, which is easily degraded, has been identified, but has not been put to practical use due to cost and profitability issues.
	Extraction of other useful ingredients/ cosmetics	10～	Macroalgae (Sargassum fulvellum, Kelp, Sargassum horneri, etc.）	Regarding the discovery, extraction, and commercialization (functional foods, cosmetics, and pharmaceuticals) of useful components of each seaweed, research institutes and private companies are conducting research and development, and products containing some of these components are being implemented in society. Skin care and hair care products containing fucoidan extracted from seaweed are manufactured and sold.
Energy utilization	Methane fermentation (biogas)	2	Macroalgae (Microalgae)	Although technically possible, there are few examples in Japan. Among them, research mainly focuses on microalgae-derived research, with only a few examples of research targeting Macroalgae.
	Hydrothermal liquefaction（HTL）	（2）	(Microalgae)	Research cases utilizing microalgae were identified in Japan.
	Bioethanol	1	(Microalgae)	Requires special microorganisms and tends to be expensive. Technically feasible, but there are few examples in Japan. There is a case in which a demonstration project using water hyacinth was converted to craft gin production due to difficulties in commercializing the technology due to profitability concerns.
Blue Economy	Blue carbon (Climate change measures)	4	Macroalgae	CO_2 sequestration of seaweed as a CO_2 sink during its growth period and long-term sequestration in seabed sediments after it dies, etc. can be converted. However, the blue carbon credit market is not yet mature. Only new seaweed beds are considered to be eligible for carbon credits.

Source：JICA Survey Team

Table 3.14 Overview of Major Technologies in Japan for Prevention of Seaweed Influx, Collection, and Proper Treatment of Organic Waste

Field	Main Technology	Number of longlists	Major Seaweed	Technology Overview / Development Stage / Challenges
Inflow prevention	Satellite monitoring	—	Seaweed	Research on satellite-based marine monitoring of seaweed. Development of technology to identify drifting objects using deep learning, etc. are seen. *Research and practical application are already underway in the U.S. (University of South Florida), and there is no merit for Japan to newly advance into this field.
	Inflow prevention netting / log boom / silt fence	3	Drifting debris / Jellyfish	Since problems caused by seaweed inflow do not occur frequently in Japan, no products specifically designed to prevent seaweed inflow were confirmed to be manufactured. However, the development and implementation of nets to prevent inflow of jellyfish and dust particles when seawater is taken for cooling water for power generation, and products to prevent drifting pumice stone were confirmed.
Collection	Sea surface cleaning ship	4	Waterweeds and other floating debris	There is a small to medium-sized company that designs and manufactures cleaning boats equipped with a device that collects waterweeds such as Japanese hollyhock and other floating debris on the surface of the water.
Aptitude treatment	Landfill	—	Organic Waste	There are few cases of seaweed drift damage in Japan. Industrial waste treatment or landfill is the main treatment method.
	Fodder conversion, composting	6～	Organic Waste	Various, including human power, mechanization, etc.
	Carbonization	2	Organic Waste	Carbonization is achieved by pyrolyzing organic waste under oxygen-free conditions. The carbonized material can be used as energy or as a soil conditioner. Requires plant.
	Material use(Paper Products)	2	Organic Waste	Technology for making paper from vegetable residues, coffee residues, rice husks, etc. by papermaking technology and blending.
	Energization	2	Organic Waste	Technology to generate energy through carbonization and gasification of organic waste.
	Primary treatment (separation, crushing, dewatering, drying)	4	Organic Waste	Technologies for sorting, crushing, dewatering, and drying organic waste. Various types of separation, including separation of lunchbox shells, solid-liquid separation, etc.

Source : JICA Survey Team

A long list of Japanese technologies in each utilization area obtained from the desk survey is organized in Table 3.15 through Table 3.21.

1) Utilization in Agriculture and Aquaculture

Although many manufacturers are thought to have fertilizer conversion equipment, very few companies are targeting seaweed. As for feed, several companies were utilizing Asparagopsis taxformsis, which reduces ruminant-derived GHGs. Biostimulants, which are growth stimulants for agricultural crops, have been recognized as effective in Europe and the U.S. and are attracting a lot of attention, and since seaweed is used as a major ingredient, it is thought that it could be adapted to the planktonic sargassum found in Latin America. Most of the raw materials produced in Japan were *Ascophyllum nodosum*, which is of European origin.

Table 3.15 Companies and Research Institutes with Technologies for Utilization of Seaweed in Agriculture and Aquaculture

No.	Name of Company・Institution	Business Scale	Location	Field of Utilization	Target algae	Contents of Technologies	Development Stage[12]
1-1	WEF Technology Development Co., Ltd.	SMEs	Otsu City, Shiga Prefecture	Composting	Water plant	Selling waterweed drying and composting equipment and being business of composting waterweeds and organic waste. Macroarge can be composted because; Reason 1: Although people tend to think that composting with seaweed causes salt damage, seaweed fertilizer is actually rich in minerals, amino acids, and polysaccharides, and is rich in nutrients necessary for the growth of animals and plants. It is a very useful material as a raw material for feed and fertilizer. Reason 2: The use of halophilic microorganisms is said to prevent salt damage.	Social implementation
1-2	Ina Food Industry Co., Ltd. ／ Papa-na Farm LLC	Big Enterprises	Ina city	Fertilizer	Red algae（Gelidium amansii、gracilaria）	Manufacture and sale of seaweed-derived fertilizer "Yodo-mo". The seaweed residue left over after agar production is reused, fermented, and composted.	Social implementation
1-3	Seaweed Research Institute (Director (Akihiro Arai)	SMEs	Fukuoka Prefecture	Spraying on farmland	Macroalgae (Sargassaceae, Laminariaceae)	Published a paper titled "Effectiveness and Potential of Seaweed Fertilizers." Recommended seaweed application to agricultural land.	Research / Social implementation

[12] "Development Stage" is indicated by [R&D]; (from basic research to applied research) technology research and development stage, [Experimental study] ;adjustment stage for dissemination, and [Social implementation]; stage for dissemination to society based on research results obtained.

No.	Name of Company・Institution	Business Scale	Location	Field of Utilization	Target algae	Contents of Technologies	Development Stage[12]
1-4	Nan Shoji & Co.	SMEs	Kagoshima Prefecture	Fertilizer	Macroalgae (Sargassaceae, Laminariaceae)	Production and sale of organic fertilizers and powdered soil activators using seaweed (Nordic seaweed and domestic Nemacystus decipiens) as part of the raw materials. Manufacture of fertilizers with formulas suitable for local crops (crushing, fermentation, blending with chemical fertilizers, etc.) Support for acquisition of GAP and other international standard certifications (branding)	Social implementation
1-5	Alnour Co., Ltd., Yamakawa Town Fisheries Cooperative Association in Kagoshima Prefecture	SMEs	Tokyo Metropolis ／ Kagoshima Prefecture	Livestock feed	Asparagopsis taxiformis	The Blue Carbon Project, an environmental project to reduce blue carbon and methane gas from cow burps by using the seaweed " Asparagopsis taxiformis ", is underway. →The Blue Carbon Project is an environmental project aimed at reducing blue carbon and methane from cow burps through the use of the seaweed " Asparagopsis taxiformis ". In the future, the company will consider developing feed that reduces methane derived from cow burps by using " Asparagopsis taxiformis ".	R&D
1-6	Sea-blena Inc.	SMEs	Sano City, Tochigi Prefecture	Biostimulants	Red algae	Stem and leaf spreading material "Pikakoh" utilizing the high spreading ability of polysaccharides of algae is a special fertilizer (Tochigi Prefecture 856) patent "4599607" using three kinds of dried edible seaweeds belonging to the family Myrinidae of Red algae order collected in the southern seas.	Social implementation
1-7	Alga International Co., Ltd.	SMEs	Awaji City, Hyogo Prefecture	Composting	Wakame (Undaria pinnatifida), Hijiki	It manufactures and sells "Seaweed Power 100," a special fertilizer made by adding seaweed minerals such as Wakame and Hijiki to fermented cow manure.	Social implementation
1-8	Sachiumi Heroes	SMEs	Yokohama City	Composting	Konbu	A project to feed Konbu to livestock to reduce the amount of methane, one of the greenhouse gases. A project that collaborates with a public bathhouse and a tea farmer to compost Konbu and prepare the soil for tea harvesting. A project to increase fishery resources and preserve the ecosystem by cultivating Konbu at the root of an offshore wind farm.	R&D

No.	Name of Company・Institution	Business Scale	Location	Field of Utilization	Target algae	Contents of Technologies	Development Stage[12]
1-9	Nippon Beet Sugar Manufacturing Co.,Ltd. Taisei Rotec Corp. (Tokyo), Kuroshio Biology Research Institute (Kochi)	SMEs	Tokyo Metropolis ／ Kochi Prefecture	Livestock feed	Asparagopsis taxiformis	Taisei Rotec will construct an aquaculture facility on land, and the institute will cultivate Asparagopsis taxiformis. Nichitet will be in charge of verifying the effectiveness of the product and manufacturing and marketing it. ＜Asparagopsis taxiformis＞ A type of red algae. Research has shown that adding 0.2% to the feed of antiparous animals such as cattle and sheep can suppress methane gas produced in the digestive tract by up to 98%. The methane suppression effect has attracted attention, and research on its use in animal feed is underway around the world, including in Japan. In Japan, it grows naturally in the waters of the Kuroshio Current, including Okinawa, Kagoshima, and Kochi.	R&D
1-10	Hitachi Zosen Corporation	Large corporation	Tokyo Metropolis	Livestock feed	Sargassum macrocarpum, etc.	It conducted a study on the conversion of unused seaweed into seaweed feed (high value-added production of unused seaweed) and presented the results of the study, which confirmed that seaweed powder can be produced at low cost using impact drying and pulverizing technology and has the potential to contribute to anti-disease properties in livestock and to enrich eggs. Possesses carbonization equipment for unused organic matter.	R&D ～ Social implementation
1-11	Arysta LifeScience Corporation	Large corporation	Tokyo Metropolis	Biostimulants	Ascophyllum nodosum	It manufactures biostimulants made from seaweed and seaweed extracts, such as “Tough Plant Charge”, “Tough Plant Color”, and “Router” Raw material: Ascophyllum nodosum and Laminaria digitata	Social implementation
1-12	OAT Agrio Co., Ltd.	Large corporation	Tokyo Metropolis	Biostimulants	Ascophyllum nodosum	Product name: Algamix Raw material: Ascophyllum nodosum	Social implementation
1-13	Agro Kanesho Co.,Ltd.	Large corporation	Tokyo Metropolis	Biostimulants	Macroalgae	The liquid compound fertilizers that the company manufactures and sells (Morning Fresh, Morning Rutin, etc.) contain seaweed extracts. No information on specific seaweeds.	Social implementation
1-14	ROYAL INDUSTRIES Co., Ltd.	SMEs	Tokyo Metropolis	Biostimulants	Ecklonia maxima (South Africa)	It manufactures several biostimulant materials, among which "Kelpac 66" is produced by extracting seaweed extract from the giant South African seaweed Ecklonia maxima.	Social implementation

No.	Name of Company・Institution	Business Scale	Location	Field of Utilization	Target algae	Contents of Technologies	Development Stage[12]
1-15	Bayer Crop Science K.K.	Large corporation	Tokyo Metropolis	Biostimulants	Ascophyllum nodosum	"Ambition Alga," a liquid gel formulation biostimulant fertilizer Balanced combination of seaweed Ascophyllum nodosum extract and fertilizer ingredients	Social implementation
1-16	Mitsui Bussan Agro-Business Co.,Ltd.	Large corporation	Tokyo Metropolis	Biostimulants	Macroalgae	Manufacture and sale of "Elder One", a mixture of seaweed-derived extracts and plant extracts	Social implementation
1-17	Phytochrome Inc.	SMEs	Tokyo Metropolis	Biostimulants	Ascophyllum nodosum	Product name: "Marine Impact" seaweed biostimulant material Raw material: Ascophyllum nodosum	Social implementation
1-18	Andes Trading Co., Ltd.	SMEs	Tokyo Metropolis	Biostimulants	Sargassum fulvellums	Seaweed meal for agricultural use made from Sargassum fulvellums. Origin is Southeast Asia.	Social implementation
1-19	SAKAE GREEN Corp.	SMEs	Toyama City	Biostimulants	Ascophyllum nodosum	Production and sales of "Kelp Pellets", an organic fertilizer made from powdered and pelleted seaweed Ascophyllum nodosum from Northern Europe, and "Sankai no Megumi", seaweed powder blended with humic acid materials for plants and animals.	Social implementation
1-20	Sunbiotic by Daichi No Inochi Co., Ltd.	SMEs	Nagasaki Prefecture	Biostimulants	Ascophyllum nodosum	Seaweed mineral material "Kai-Oh" is manufactured using 100% Nordic seaweed (Ascophyllum nodosum).	Social implementation
1-21	Harada Agrobusiness Co., Ltd.	SMEs	Nagano Prefecture	Biostimulants	Ascophyllum nodosum	Product is “Seaweed Energy” made from Ascophyllum nodosum. (It is not known if it is manufactured in-house or not.)	Social implementation
1-22	Sanatech Seed Co.,Ltd.	SMEs	Tokyo Metropolis	Biostimulants	No information	Product is “PS Marine Power” It can conduct soil, plant, and water quality analysis.	Social implementation
1-23	Saga Prefecture Ariake Fisheries Promotion Center	Research institution	Saga Prefecture	Aquaculture feed (sea urchin)	Sargassum fulvellums	"Changes in gonad quality by feeding of ground seaweed in red sea urchin aquaculture." It annouced that higher quality red sea urchins can be produced by mixed feeding of arame and other seaweeds of the family Sargassum. *When it became difficult to secure fresh seaweed, it used seaweed frozen at -20°C (Hijiki).	R&D
1-24	Fisheries Technology Department; Kyoto Prefectural Agriculture, Forestry and Fisheries Technology Center.	Research institution	Kyoto Prefecture	Aquaculture feed (sea urchin)	Sargassum fulvellums, Konbu	Dried Konbu and Sargassaceae were used as food in a short-term sea urchin stocking study => Sea urchins were more filling, tasty, and sweet when fed Sargassaceae. No mention of drying process.	R&D

No.	Name of Company・Institution	Business Scale	Location	Field of Utilization	Target algae	Contents of Technologies	Development Stage[12]
1-25	Mie University (Pratiwy, F.M., Jun Kamihara)	Research institution	Mie Prefecture	Aquaculture feed (tilapia)	Sargassum fulvellums	"Effectiveness of Sargassum meal as feed additive on growth performance of Nile tilapia, Oreochromis niloticus." Three diets were fed to Nile tilapia in which rice bran was gradually replaced with Sargassum sp. powder at 0%, 4%, and 8% of the diet. The results suggest that the addition of rice bran to the diet may be effective in promoting the growth of Nile tilapia.	R&D
1-26	Ehime Prefectural Agriculture, Forestry and Fisheries Research Center Poultry Research Institute	Research institution	Ehime Prefecture	Livestock feed	Sargassum fulvellums	Effective use of Sargassum fulvellum: Feed for egg-laying hens Sargassum fulvellum was sun-dried and then air-dried at approximately 60~70°C and crushed (1 mm dia.).	R&D
1-27	Oita Prefecture Fisheries Public Corporation	Research institution	Oita Prefecture	Aquaculture feed (sea urchin)	Sargassum fulvellums	Marine fish and shellfish aquaculture test (cultivation of white-spotted sea urchins) Switching from formula feed only to formula feed + fresh Sargassum fulvellum → increased fleshiness	R&D
1-28	uninomics Inc.	SMEs	Tokyo Metropolis	Aquaculture feed (sea urchin)	Konbu	It engages in sea urchin farming, providing farming technology, and selling sea urchins. The feed is produced primarily from sustainably harvested edible Konbu scraps that are effectively utilized. It established corporations in Canada and Norway, and other overseas investments.	Social implementation
1-29	Hamachi Corporation	SMEs	Wakayama Prefecture	Fish feed (White–spotted parrotfish)	Sargassum fulvellums	Production and development of bait for White–spotted parrotfish. Sargassum fulvellum, a favorite food of White–spotted parrotfish, is combined with krill powder, minced Wakame, rice bran, moromi, and other ingredients to create a top-quality bait exclusively for White–spotted parrotfish.	Social implementation

Source: Information published on the websites of companies and research institutes, as well as on J-Startup, J-Platpat, ScienceDirect, etc., was compiled by the JICA Survey Team

2) Utilization as a Material

Regarding the utilization of sargassum for bioplastics as raw materials, universities, research institutions, and start-ups have reported research on the production of biodegradable plastics from polysaccharides contained in seaweeds. The market for biomass plastics in Japan and around the world is expanding and is expected to continue to do so for some time. At present, however, most of the raw materials for biomass plastics commercialized in Japan are land plants such as corn, sugarcane, and soybeans, and many of these raw materials are imported. As for the practical application of products made from seaweed, the production cost is a major issue.

In terms of utilization for functional foods, many supplements and powdered foods made from seaweeds that are already used for food (and whose safety is assured) in Japan, such as Akamoku, Okinawa mozuku (Cladosiphon okamuranus), Konbu, and Wakame, are being marketed. In particular, fucoidan, a polysaccharide extracted from seaweed, is attracting attention for its effectiveness in maintaining health.

Table 3.16 Companies and Research Institutes with Technologies for Utilization as a Material

No.	Name of Company・Institution	Business Scale	Location	Field of Utilization	Target algae	Contents of Technologies	Development Stage [13]
2-1	Iwate University (Associate Professor Miwa Yamada) + Toyota Boshoku Corporation	Industry-academia collaboration	Morioka City/ Kariya City	Bioplastics (BHA)	Wakame, Konbu（Alginic acid）	By feeding alginic acid, the main ingredient of Konbu and Wakame, to microorganisms, it was confirmed that a plastic component (PHA: polyhydroxyalkanoic acid) is produced in the microorganisms' bodies. It succeeded in extracting this component and producing a film.	R&D
2-2	Green Science Alliance	Start-up	Kawanishi City, Hyogo Prefecture	Bioplastics	Suspended Sargassum (Natans,Fluitans）	Biodegradable plastic was developed from sargassum, a seaweed that occurs abnormally in the Caribbean Sea. The seaweed is washed, crushed, and dried before being used as a raw material. The current production cost is about 10 times that of ordinary plastic.	R&D
2-3	TSUKASA PETCO Ltd.	SMEs	Kanagawa Prefecture	Bioplastics (PHA)	Konbu, Wakame	It succeed in developing technology to extract PHA, the raw material for biodegradable plastic, from the residue of Konbu and Wakame, together with the Environmental Research Institute of Tel Aviv University and Technion Japan K.K., the	R&D

[13] "Development Stage" is indicated by [R&D]; (from basic research to applied research) technology research and development stage, [Experimental study] ;adjustment stage for dissemination, and [Social implementation]; stage for dissemination to society based on research results obtained.

No.	Name of Company・Institution	Business Scale	Location	Field of Utilization	Target algae	Contents of Technologies	Development Stage [13]
						official Japanese organization of the Technion-Israel Institute of Technology.	
2-4	Ina Food Industry Co., Ltd.	Large corporation	Ina City	Edible film	Seaweed (unidentified)	Production and sales of edible film derived from seaweed. 	Social implementation
2-5	VENTUNO Co.,Ltd.	SMEs	Fukuoka Prefecture	Functional food, cosmetics	Cladosiphon okamuranus	It conducts joint research with Kyushu University on the functionality of fucoidan and immunity. It involves in the cultivation of Cladosiphon okamuranus, the extraction of fucoidan from the harvest, and the development of related products. (skin care, hair care, supplements, etc. containing fucoidan)	Social implementation
2-6	DHC Corporation	Large corporation	Tokyo Metropolis	Functional food	Mekabu（Root of the Wakame seaweed）	It manufactures and sells supplements containing Mekabu extract, which contains 80% high concentration of fucoidan, a polysaccharide contained in the unique sliminess of seaweed.	Social implementation
2-7	Health & Wild Grass Tea Center Co., Ltd.	SMEs	Yokohama City	Functional food	Akamoku	Sale of Akamoku 100% domestic additive-free powder	Social implementation
2-8	AKKI FOODS Co.,Ltd.	SMEs	Fukuoka Prefecture	Functional food	Akamoku	It manufactures and sells natural Akamoku fucoidan raw material, supplements of Akamoku powder, and noodles with extracted alginic acid, by acquiring a patent for the fucoidan extraction method from Akamoku.	Social implementation
2-9	KAMAGARI BUSSAN.,Co., Ltd (Manufacturing) Houwa Shoji Co., Ltd. (Sales)	Start-up	Kure City	Food and beverages	Sargassum fulvellums (from Japan)	Production of algae salt using natural domestic Sargassum fulvellum. Soak dried Sargassum fulvellum, make brine from which seaweed ingredients are extracted (boiled), and add bittern to produce salt.	Social implementation
2-10	ASP Inc.	SMEs	Osaka Prefecture	Food products	Seaweed	A startup that produces raw materials and products from underutilized agricultural products. They are also involved in the development of new raw materials using whey and seaweed.	Experimental study
2-11	Nippon Akamoku Science, Inc.	Start-up	Koriyama City	Foods,	Akamoku	Consulting on Akamoku Planning and guidance for local industry promotion using Akamoku	Social implementation

No.	Name of Company・Institution	Business Scale	Location	Field of Utilization	Target algae	Contents of Technologies	Development Stage [13]
				Functional Foods & Beverages		Development, planning, manufacturing, and sales of functional food products made from Akamoku.	
2-12	Biogenic Co., Ltd.	SMEs	Tokyo Metropolis	Functional food	Ecklonia stolonifera	Processing and sales of powdered natural Ecklonia stolonifera collected in Nishinoshima Island, Shimane Prefecture.	Social implementation

Source：Information published on the websites of companies and research institutes, as well as on J-Startup, J-Platpat, ScienceDirect, etc., was compiled by the JICA Survey Team (Photos from each company's website)

3) Component Extraction

With regard to component extraction from seaweeds, there are established technologies for component extraction for fucoidan and alginic acid, which are viscous polysaccharides, and they have been implemented in society. Fucoidan extraction technology has been implemented in society as well, but the stabilization of the extracted compound remains a challenge. Due to the influx of cheap products of fucoidan and alginic acid produced in other countries, reducing production (especially pretreatment and storage) costs and stable domestic procurement of raw materials have proven to be challenges. In addition, various useful components of seaweed have been attracting attention in recent years, and research institutes and private companies are discovering useful components, conducting research and development related to their extraction techniques, selling some of the extracted components, and developing and commercializing cosmetics and other products that incorporate the extracted components.

Table 3.17 Companies and Research Institutes with Technologies for Component Extraction

No.	Name of Company・Institution	Business Scale	Location	Field of Utilization	Target algae	Contents of Technologies	Development Stage [14]
3-1	Hokkaido Marine Innovation Inc. (Seaweed Lab)	SMEs	Hokkaido	Fucoidan Fucoxanthin Arsenic reduction	Akamoku, Konbu（from Japan）	Extraction of fucoxanthin and fucoidan (polysaccharides), production of fucoidan-extracted products, viscous polysaccharide performance testing, and establishment of Akamoku arsenic reduction methods.	R&D～Social implementation

[14] "Development Stage" is indicated by [R&D]; (from basic research to applied research) technology research and development stage, [Experimental study] ;adjustment stage for dissemination, and [Social implementation]; stage for dissemination to society based on research results obtained.

No.	Name of Company・Institution	Business Scale	Location	Field of Utilization	Target algae	Contents of Technologies	Development Stage [14]
3-2	KIMICA Corporation	SMEs	Tokyo, Chiba, Chile, USA, Germany, China etc.	Alginic acid	Chilean Lessonia (order of kelp), etc.	Extraction of alginic acid (after drying and crushing, alginic acid is extracted and purified by ion exchange reaction, coagulation precipitation, and dehydration, then dried and milled into products) Seaweeds (Lessonia/Laminariales Migula) that drifted ashore in Chile, South America, are used as raw materials. After alginic acid is extracted, the seaweed residue is processed into powder and used as a soil conditioner in local farmland.	Social implementation
3-3	Seaweed Biorefinery Research Center, Mie University (Professor Toshiyuki Shibata)	Research institution	Mie Prefecture	Extraction of useful components	Macroalgae (Sargassaceae, Laminariaceae)	Education and research to explore useful organic compounds such as phenolic compounds, pigment components, rare sugars, polysaccharides, and lipids derived from seaweeds, and to produce, utilize, and develop them as tertiary functional components. Extraction of components useful for living organisms produced from large seaweeds (including Sargassum fulvellum). NEDO Leading Research Program in FY2021 "Development of Production Technology for Useful Components from Large Sea Algae: Production of Marine Polyphenols® and Functional Carbohydrates" (joint research with Kaigen Pharma Co., Ltd.) *Marine polyphenols® is a registered trademark of Mie University.	R&D
3-4	Faculty of Fisheries Sciences, Hokkaido University, Division of Marine Life Science / Field of Fisheries Science and Technology (Associate Professor Hideyuki Kurihara, Professor Kishimura)	Research institution	Sapporo City	Elucidation, extraction, and analysis of functional components of seaweeds	Seaweed from Hokkaido	Research related to the elucidation of functional components contained in Hokkaido seaweeds and the establishment of analytical methods, as well as the development of effective utilization methods for unutilized seaweeds. ・ Establishment of a method to easily measure the content of polysaccharides (fucoidan, alginic acid, and laminaran) ・ Research on enzyme inhibitory components ・ Performance analysis of xylan (polysaccharide)	R&D

No.	Name of Company・Institution	Business Scale	Location	Field of Utilization	Target algae	Contents of Technologies	Development Stage [14]
						abundantly contained in low-utilized red algae dulse from Hokkaido (selective growth-promoting action on bifidobacteria) and research related to the development of functional food materials, etc.	
3-5	Kaneka Corporation	Large corporation	Tokyo, Osaka, etc.	Functional food material (fucoxanthin)	Genus Sargassum (18 species, including red mullet, Stephanocystis hakodatensis, Sargassum confusum, Sargassum thunbergia, Hijiki, etc) ※ Natans, Fluitans are not included.	In 2014, as part of the development of functional food materials, stabilized fucoxanthin powder production technology was established (joint research with Hokkaido University) *Confirmation of implementation status required. [Patent] Fat-soluble oil containing fucoxanthin and its production method and fucoxanthin production method. ※ Kaneka Corporation has developed a 100% plant-derived biodegradable biopolymer called Green Planet and is engaged in the manufacturing and sales of Green Planet products, including straws, shopping bags, and disposable plastic items.	Social implementation
3-6	Naris Cosmetics Co., Ltd.	Large corporation	Osaka City, Miki City in Hyogo Prefecture, etc.	Discovery of functional ingredients, development of extraction technology (incorporation into cosmetics)	Hypnea cervicornis, Sargassum ringgoldianum	It discovered that mooi extract, extracted from the seaweed Kazunoibara, has a highly effective effect of improving the skin barrier function. It holds patents on the discovery and extraction of other functional components of seaweed. The company is already using seaweed extracts in skincare products. [Patent] Discovered that extracts of Genus Sargassum (Sargassum fulvellum, Akamoku, Sargassum ringgoldianum, etc.) have activity to inhibit apoptosis of skin keratinocyte cell lines and produced an apoptosis inhibitor. A hair and hair-growth agent containing as an active component extraction of Sargassum ringgoldianum, a seaweed belonging to the Genus Sargassum, as an active ingredient.	R&D ～ Social implementation

No.	Name of Company・Institution	Business Scale	Location	Field of Utilization	Target algae	Contents of Technologies	Development Stage [14]
3-7	POLA Chemical Industries, Inc.	Large corporation	Yokohama City	Ingredient formulation in cosmetics/pharmaceuticals	Macroalgae (Sargassaceae, Laminariaceae)	The extract from the root part of the Chigasaceae family of seaweeds cultivated in France is used in cosmetics. In the "orally administered composition for arthritis and arthropathy," it is stated that brown algae sargassum, green algae Ulvaceae, or red algae Myrtaceae are preferred, and Akamoku is more preferred.	Social implementation
3-8	Sanyo Pharmaceutical Co., Ltd.	Large corporation	Fukuoka Prefecture	Ingredient formulation in cosmetics	Akamoku, 、Mekabu	[Patent] Anti-aging agent by blending active ingredient extracted from Akamoku.	Social implementation
3-9	FANCL Corporation	Large corporation	Yokohama City	Ingredient formulation for pharmaceuticals	Sargassum fulvellums	[Patent] Thrombolytic agent using a component derived from Sargassum fulvellum (Turner) C. Agardh)	Social implementation
3-10	Nagase & Co., Ltd.	Large corporation	Osaka, Tokyo, etc.	Pharmaceuticals (trading company)	Sargassum fulvellums, Hijiki, Akamoku,	[Patent] AGD formation inhibitor and its manufacturing method, aldose reductase inhibitor and its manufacturing method urease inhibitor, β-glucuronidase inhibitor, angiogenesis inhibitor, prolyl endopectidase inhibitor (partly using Sargassum fulvellum, hijiki, and akamoku)	Social implementation
3-11	Sea Act Co., Ltd.	Start-up	Tokyo, Tsukuba, Kawasaki	Beauty products (seaweed extract)	Makonbu (Saccharina japonica), Mekabu, Akamoku (from Japan)	Makonbu extract, mozuku extract, and akamoku extract: Beauty ingredients are extracted from the boiled juice of raw materials. Research is also being conducted to develop new active ingredients (cosmetic ingredients and health food ingredients).	R&D～ Social implementation
3-12	Muramatsu, Inc.	Large corporation	Yaizu, Tokyo, Koriyama, etc.	Food powder (seaweed active ingredient extraction powder)	Akamoku	It is a bonito flakes industry and bonito extract producer, it also manufactures and sells a powder made by extracting active components from akamoku using its own unique method. It has a technology to extract active ingredients from materials by combining four technologies (crushing, extraction, separation compartment, and concentration). [Patents] Patented technology for the production of food materials using akamoku's extracted components and for culturing specific cells in a medium containing aqueous extracts of akamoku.	Social implementation

No.	Name of Company・Institution	Business Scale	Location	Field of Utilization	Target algae	Contents of Technologies	Development Stage [14]
3-13	LEAD CHEMICAL Co.,Ltd.	Large corporation	Toyama City	Component Extraction	Sargassum micracanthum	(Search only in Patents) [Patent] Extraction of "New Chromene Compounds" from Sargassum micracanthum of the sargassum family.	Unconfirmed
3-14	Kimuraya Marine Products	SMEs	Tottori Prefecture	Component Extraction (Fucoidan)	Nemacystus decipiens	Research and production of fucoidan and mozuku. Through joint research with Shimane University on mozuku seaweed, the company developed a technology to extract fucoidan from mozuku seaweed and established a dedicated plant in 2006. No information on the commercialization of the extracted fucoidan has been confirmed.	R&D？
3-15	Fucoidan Okinawa Corporation	SMEs	Naha City	Component Extraction (Fucoidan)	Nemacystus decipiens	It extracts Fucoidan from natural mozuku seaweed collected in Okinawa Prefecture. The product is manufactured and marketed as "Okinawan Fucoidan.	Social implementation

Source ：Information published on the websites of companies and research institutes, as well as on J-Startup, J-Platpat, ScienceDirect, etc., was compiled by the JICA Survey Team

4) Utilization in Energy

Most algae used in energy is derived from microalgae. From an economic standpoint, the use of algae for energy is rarely implemented in Japan because the cost is not commensurate when compared to the price of petroleum. In terms of technology, biogasification, hydrothermal liquefaction (HTL), and ethanol conversion are each considered to be applicable to sargassum, but there are few examples of practical applications due to price competition with fossil fuels.

Table 3.18 Companies and Research Institutes with Technologies for Utilization in Energy

No.	Name of Company・Institution	Business Scale	Location	Field of Utilization	Target algae	Contents of Technologies	Development Stage [15]
4-1	Algae Industry Incubation Consortium	SMEs	Tsukuba City	Biomass Research	Microalgae	Utilization of "algal biomass" such as oil produced by microalgae. It conducts research covering a wide range of areas	R&D

[15] "Development Stage" is indicated by [R&D]; (from basic research to applied research) technology research and development stage, [Experimental study] ;adjustment stage for dissemination, and [Social implementation]; stage for dissemination to society based on research results obtained.

No.	Name of Company・Institution	Business Scale	Location	Field of Utilization	Target algae	Contents of Technologies	Development Stage [15]
	University of Tsukuba Algae Research Unit					from basic technology to applied use of next-generation algae biomass energy production systems. It completed large-scale demonstration facility for the practical application of oil from algae in 2014. Moeena, a hand cream containing oil from Botryococcus, was launched in November 2014 as a product of joint research with Denso Corporation. In addition, a demonstration run of a vehicle using biofuel was conducted in 2014.	
4-2	Hiroshima University (Professor Yutaka Nakashimada)	SMEs	Hiroshima City	Biogas, HTL	Macroalgae (Sargassaceae, Laminariaceae)	Research on methane fermentation (biomass power generation) using Konbu (including Sargassum fulvellum) as a raw material. Polysaccharides such as alginic acid and agar contained in seaweed are converted into methane by decomposition of microorganisms, which lives in tidal flats and is capable of living in a saline environment. It can be adaptable to Sargassum fulvellum.	R&D
4-3	Obihiro University of Agriculture and Veterinary Medicine Professor Kazutaka Umezu Professor Masahiro Iwasaki	SMEs	Obihiro City	Biogas	Macroalgae (Sargassaceae, Laminariaceae)	The following paper was published; "Potential of biogas production from the anaerobic digestion of Sargassum fulvellum macroalgae: Influences of mechanical, chemical, and biological pretreatments." "Thermophilic anaerobic digestion of Sargassum fulvellum macroalgae: Biomass valorization and biogas optimization under different pre-treatment conditions"	R&D
4-4	Tokyo University of Marine Science and Technology, Department of Marine Environmental Sciences Professor Naoto Urano / Ishida-Okai Laboratory	Research institution	Tokyo Metropolis	Bioethanol	Unused aquatic biomass (including brown algae)	Research on the production of bioethanol from hydrospheric biomass (Eichhornia crassipes, Ulvaceae, and Akamoku).	R&D
4-5	Kyoto University Graduate School of Agriculture, Division of Applied Life Sciences	Research institution	Kyoto Prefecture	Bioethanol	Macroalgae	Succeeded in breeding a yeast that can easily produce bioenergy from large algae (inedible Ecklonia cava ssp. in the experiment).	R&D

No.	Name of Company・Institution	Business Scale	Location	Field of Utilization	Target algae	Contents of Technologies	Development Stage [15]
	Professor Mitsuyoshi Ueda						
4-6	Takenaka Corporation	Large corporation	Osaka Prefecture	Bioethanol	Macroalgae	” Investigation of Capable CO2 Fixation and Economical Study about Seaweeds Cultivation and Utilization Products Business on an Offshore Platform Facility" ⇒ Research is being conducted on the use of technology, including ethanol production and methane fermentation, in the study of large-scale offshore facilities that cultivate and utilize large algae in large quantities.	R&D

Source : Information published on the websites of companies and research institutes, as well as on J-Startup, J-Platpat, ScienceDirect, etc., was compiled by the JICA Survey Team

5) Blue Economy

Seaweed beds are attracting attention as blue carbon ecosystems with the ability to store organic carbon for a long period of time. However, the market for blue carbon credits has not been established, the initiative for blue carbon is still in the research stage in Japan. In Japan, only newly created seaweed beds are recognized as GHG sinks, but no methodology has been established for existing sargassum, which is the target of the JICA Survey.

Table 3.19 Companies and Research Institutes with Technologies for Blue Economy

No.	Name of Company・Institution	Business Scale	Location	Field of Utilization	Target algae	Contents of Technologies	Development Stage [16]
5-1	Kyoto University Graduate School of Agriculture, Division of Applied Life Sciences Professor Mitsuyoshi Ueda	Research institution	Kyoto Prefecture	Blue carbon (climate change mitigation measures)	Macroalgae (Sargassaceae, Laminariaceae)	Creation of Fast CO_2 Fixing Macroalgae by Functional Improvement and Development of its Utilization Technology 2022 "NEDO" Moonshot R&D Project	R&D
5-2	The Japan Fisheries Research and Education	Research institution	Yokohama City	Blue carbon (climate change	Macroalgae (Sargassaceae, Laminariaceae)	Research from a broad perspective of protecting the global and marine environment, including the evaluation and utilization of the carbon absorption and sequestration function (blue carbon) of	R&D

[16] "Development Stage" is indicated by [R&D]; (from basic research to applied research) technology research and development stage, [Experimental study] ;adjustment stage for dissemination, and [Social implementation]; stage for dissemination to society based on research results obtained.

No.	Name of Company・Institution	Business Scale	Location	Field of Utilization	Target algae	Contents of Technologies	Development Stage [16]
	Agency (Hiromori Shimabukuro)			mitigation measures)		seaweed beds, as well as community-based research and development that contributes to the stable increase in cultivation by clarifying the physiological and ecological characteristics of useful algae, such as hijiki and wakame seaweed. The "Guidebook for Calculating CO_2 Sequestration in Seaweed and Seaweed Beds" (November, 2023) was formulated.	
5-3	Sasakawa Peace Foundation The Ocean Policy Research Institute (Atsushi Watanabe)	Research institution	Tokyo Metropolis	Blue carbon (climate change mitigation measures)	Macroalgae (Sargassaceae, Laminariaceae)	Coral bleaching, blue carbon (mention Sargassum)	R&D
5-4	JBE (Japan Blue Economy Association)	Research institution	Yokosuka City	Blue carbon (climate change mitigation measures)	Macroalgae (Sargassaceae, Laminariaceae)	Private research organization. It develops a methodology for calculating blue carbon for Sargassaceae such as Akamoku.	R&D

Source：Information published on the websites of companies and research institutes, as well as on J-Startup, J-Platpat, ScienceDirect, etc., was compiled by the JICA Survey Team

6) Prevention of inflow and Collection

As for prevention of inflow, no products specialized for prevention of seaweed inflow were identified in Japan, since problems caused by seaweed inflow into coastal areas and beaches do not occur frequently in Japan. As for collecting pumice stone on the water surface, there were several cases of manufacturing and implementation of water surface cleaning vessels for collecting and treating water plants such as water hyacinths, which occur in large quantities in lakes and dam reservoirs and pose a problem.

Table 3.20 Companies and Research Institutions with Technologies for Inflow Prevention and Collection

No.	Name of Company・Institution	Business Scale	Location	Field of Utilization	Target algae	Contents of Technologies	Development Stage [17]
6-1	KANAE CO.,LTD	SMEs	Tokyo Metropolis	Inflow prevention equipment	Floating debris such as jellyfish, marine debris and driftwood	Design, manufacture, and sales of jellyfish inflow prevention nets for thermal and nuclear power plants and coastal plants (types installed on jetties, from buoys on the water surface to the sea floor, etc.). They design equipment based on three-dimensional simulation of seawater flow using numerical fluid dynamics analysis. 	Social implementation
6-2	Tohoku Electric Power Co., Inc	Large Corporation	Sendai city	Silt Fence	Marine debris	Install a dust inflow prevention net (e.g., 40 m long) in the harbor and periodically remove accumulated dust. Measures to be taken when seawater is taken as cooling water for power generation.	Social implementation
6-3	Maeda Kosen Co.,Ltd	Large Corporation	Tokyo Metropolis	Net Fence	Marine debris	Used to prevent intrusion of garbage, floating weeds, driftwood, jellyfish, etc. A net stretched under the fence. Hard, sturdy type of fence to keep out garbage. They have experience in overseas delivery. 	Social implementation
6-4	Kure Daiya Co., Ltd.	SMEs	Kure City	Water surface cleaning vessels	Water plants (for floating and emergent plants)	Designs, manufactures, sells, and maintains water surface cleaning vessels. Delivered lake waterweed collection boats to Kumamoto City and other cities. Conducted a JICA SDGs Business supporting Survey on marine litter in Kota Kinabalu, Malaysia.	Social implementation
6-5	TEQUANAUTS Co.,Ltd（Group Company of Asuka Construction Co.,Ltd, formerly Nodak)	SMEs	Kawaguchi City	Water weed cutter, Water surface cleaning boats	Water Plant	It has been engaged in the design, manufacture, and sale of waterweed collection vessels for the Suwa and Inawashiro lakes, as well as the harvesting and treatment of hemp seed. Also conducted waterweed collection boats in Malawi and Indonesia as part of JICA projects.  	Social implementation

[17] "Development Stage" is indicated by [R&D]; (from basic research to applied research) technology research and development stage, [Experimental study] ;adjustment stage for dissemination, and [Social implementation]; stage for dissemination to society based on research results obtained.

No.	Name of Company・Institution	Business Scale	Location	Field of Utilization	Target algae	Contents of Technologies	Development Stage [17]
6-6	Laboratory of Practical Theology	SMEs	Nagasaki City	Water surface cleaning vessels	Floating debris	Development of a floating debris collection vessel "Suimensumashi": Development of a vessel capable of collecting all kinds of floating debris on the water surface, including spilled oil, red tide, blue-green algae, and floating micro-debris in the early stages of an oil spill incident, etc.	Social implementation
6-7	Hakata Bay Environmental Maintenance Co.,Ltd	SMEs	Fukuoka City	Water surface cleaning vessels	Water Plant	Manufacture of "Kankyo No. 8 (Aquatic Plant Removal Work Vessel)" that efficiently collects water pant. It is equipped with a system that enables direct cutting and collection of aquatic plants collected by a stainless steel conveyor. 	Social implementation

Source : Information published on the websites of companies and research institutes, as well as on J-Startup, J-Platpat, ScienceDirect, etc., was compiled by the JICA Survey Team (Photos from each company's website)

7) Utilization and Treatment of Organic Waste

In Japan, seaweed is often disposed of as industrial waste or directly buried in landfills. Organic waste can be utilized and treated by composting and carbonization. In addition, drying of organic waste with high moisture content and companies that possess crushing technology were also organized.

Table 3.21 Companies and Research Institutions with Technologies for Utilization and Treatment of Organic Waste

No.	Name of Company・Institution	Business Scale	Location	Field of Utilization	Target algae	Contents of Technologies	Development Stage [18]
7-1	Fermanstation Co.,Ltd	Startup	Tokyo Metropolis	Ethanol, conversion to compost	Ethanol, conversion to compost	A research and development startup with a mission of fermentation to build a society that recycles and recirculates unused resources. The company has its own R&D center and factory (Oshu Laboratory) in Oshu City, Iwate Prefecture, where it develops and manufactures ethanol and sustainable cosmetic ingredients using its proprietary fermentation and distillation technologies.	R&D

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"Development Stage" is indicated by [R&D]; (from basic research to applied research) technology research and development stage, [Experimental study] ;adjustment stage for dissemination, and [Social implementation]; stage for dissemination to society based on research results obtained.

No.	Name of Company・Institution	Business Scale	Location	Field of Utilization	Target algae	Contents of Technologies	Development Stage [18]
						Fermentation lees produced in the process of ethanol production are used as raw materials for cosmetics and as feed for local chickens and cows, and chicken manure is used as fertilizer for rice paddies and fields, creating a recycling model with zero waste. Using unutilized resources and fermented raw materials, original development	
7-2	MUSCA Inc.	Startup	Tokyo Metropolis	Animal feed、Composting	Organic waste	Utilizing the seeds of houseflies that have been selectively bred for 1,200 generations of superior species over a period of about 50 years, the company has developed a 100% biomass recycling system that converts organic waste into feed and fertilizer. The feed and fertilizer produced from this system have been recognized for their high functionality through joint research with universities.	Experimental study
7-3	A-Tech Co., Ltd.	SMEs	Tokyo Metropolis	Composting	Organic waste	The "Feasibility Study for Establishing a Resource Recycling Waste Disposal System by Introducing Crusher Separation Machines" (FY2019 Second SME/SDGs Business Support Project - Feasibility Study (SME Support Type) External Human Resources: Mikuniya Co. The company manufactures and sells a liquid feed production system that utilizes food residues from convenience stores, etc., and a system to produce raw materials for fertilization/ animal feed/ fuel by separating food residues from plastic, paper, and other waste and drying them.	Social implementation
7-4	MIKUNIYA Corporation	SMEs	Kawasaki City	Composting	Organic waste	Company: Organic matter volume reduction equipment using high-temperature aerobic fermentation and decomposition technology. Has a implementation of overseas installations.	Social implementation
7-5	ASD (Asia System Development)	SMEs	Yokohama city	Fertilization	Organic waste	Food waste, sludge, etc. are crushed and dried simultaneously in the dryer to efficiently reduce volume in a short time and produce recyclable raw materials such as fertilization and animal feed.	Social implementation
7-6	TOWING Ltd.	SMEs	Nagoya city	Carbonization	Organic waste	Production and sales of biochar made from organic matter. Acquisition of carbon credits on behalf of biochar utilization amount. Sales of crops produced using biochar.	Social implementation

No.	Name of Company・Institution	Business Scale	Location	Field of Utilization	Target algae	Contents of Technologies	Development Stage [18]
7-7	Delica Foods Holdings CO., LTD.	Large Corporation	Tokyo Metropolis	Paper products	vegetable residue	Developed "Napper," a sheet made from vegetable waste using papermaking technology (2007). If pulp is added to vegetable residue, it can be used as paper, and if 100% vegetable residue is used as material, it can be used for edible purposes such as wrapping food like nori (seaweed). In the case of edible use, while vegetables are more than 90% water, the water content is reduced to less than 10% by making it into a sheet, and the nutritional components and fibers of the vegetable are condensed, making it a highly nutritious edible sheet.	Social implementation
7-8	Daio Paper Corporation	Large Corporation	Tokyo Metropolis	Paper products	Organic waste	Mixed paper is produced by reusing manufacturing residues (rice husks, coffee grounds, etc.) as raw materials for paper "Rems"	Social implementation
7-8	Street-Design, Inc.	SMEs	Yokohama city	Energy	Organic waste	Organic waste-to-energy conversion system. Organic wastes that can be input include wood (construction waste, pruning branches, thinned wood, etc.), waste plastic, sewage sludge (sludge cake), livestock dung, paper, cloth, and food residues. After carbonization, they can be gasified and converted into various types of energy.	Social implementation
7-9	Bio Energy Corporation	Large Corporation	Tokyo Metropolis	Energy	Organic waste	Businesses related to power generation and heat utilization using gas energy generated by methane fermentation systems and gas supply business by accepting food waste (general waste and industrial waste).	Social implementation
7-10	Okawara Corporation	Large Corporation	Shizuoka prefecture	Crushing・Drying	Organic waste	Sales of 20 types of dryers for organic waste sludge and biomass resources.	Social implementation
7-11	Sanyu Kyoritsu Industry Co.,Ltd.	SMEs	Sagamihara city	Crushing・Drying	Organic waste	Providing rotary blade crushing and sorting machines and waste drying and recycling systems.	Social implementation
7-12	KENKI Corporation	SMEs	Fukuoka city	Crushing・Drying	Organic waste	High water content organic waste drying: KENKI DRYER, which employs internationally patented technology, can dry adherent, sticky, sticky, and liquid materials with high water content. Even solid materials are dried while being crushed inside the dryer, so that dried materials are crushed into small pieces and heated sufficiently to be dried inside the dryer before being ejected.	Social implementation
7-13	ARAKAWA Manufactory CO., LTD.	SMEs	Nagoya city	Crushing・Drying	Organic waste	Rotary dryer / 3-pass dryer	Social implementation

No.	Name of Company・Institution	Business Scale	Location	Field of Utilization	Target algae	Contents of Technologies	Development Stage [18]
						Efficiently dries high-moisture sludge, lumps, adhesive granular materials, food residues, etc., rendering them harmless and reducing their weight.	
7-14	Wako Techno Service Co.,Ltd.	SMEs	Tokyo Metropolis	Crushing・Drying	Organic waste	CCDW Dryer Crushes and dries non-processed materials instantaneously, enabling stable drying to a moisture content of about 10%.	Social implementation
7-15	OKADA Manufactory CO., LTD.	SMEs	Gunma	Crushing・Drying	Organic waste	Okada Fermentation Drying Plant Series Automatic and continuous operation, performing 4 operations: conveying, agitating, reverse conveying, and crushing. The plant does not use fire power, but uses natural atmospheric air for drying, resulting in low maintenance costs. Mainly used for drying livestock manure, but also used for composting food waste for overseas projects, JICA projects, etc.	Social implementation
7-16	Powder Bank Japan Corporation	SMEs	Fukui Prefecture	Crushing・Drying	Organic waste	Low temperature drying and crushing machine Drying and pulverizing raw materials containing moisture 》 * Raw materials with a moisture content of 15% or more Okara (pressed), vegetable scraps and other food residues (out-of-specification fruits and vegetables, etc.), tea and coffee grounds, fishery processing residues, livestock processing residues, etc.	Social implementation
7-17	Shizuoka Plant Co., Ltd.	SMEs	Shizuoka Prefecture	Crushing・Drying	Organic waste	The "Cyclone Mill 150S" is an ultrafine grinding machine that is ideal for food products and chemical powders that require high purity. It can handle hard materials such as carbon as well as soft materials such as tea leaves and can also handle materials with high water and oil content.	Social implementation
7-18	SANYO Engineering Corporation.	SMEs	Hiroshima Prefecture	Crushing・Drying	Organic waste	Even high-moisture materials can be milled without clogging.	Social implementation
7-19	NARA Machinery CO., LTD.	SMEs	Tokyo Metropolis	Crushing・Drying	Organic waste	Free Grinding Machine Application example: Wet milling is possible by feeding raw materials and liquid at the same time	Social implementation
7-20	TOMOE Engineering CO.,LTD.	Large Corporation	Tokyo Metropolis	dehydration	Organic waste	Centrifuge for solid-liquid separation from liquid. Can also be introduced into the process of extracting seaweed-derived components.	Social implementation

No.	Name of Company・Institution	Business Scale	Location	Field of Utilization	Target algae	Contents of Technologies	Development Stage [18]
7-21	A Public Interest Incorporated Foundation KANAGAWA Coastal Beautification Foundation	Foundation	Chigasaki city	Landfill	Macroalgae	It conducts a research study on accurate Macroalgae treatment. Remove mixed plastic bottles, and other artificial trash, dig a 1.5m-deep hole in the upper part of the beach that is not exposed to seawater, and cover with 50cm of sand after Macroalgae is placed in the hole. If EM bacteria are added, the sand will decompose in about 2 weeks. The following methods other than landfill were considered, but all of them were concluded to have low feasibility. ・ Biogas technology for food waste ・ Use as food. ・ Use as feed for livestock. ・ Use as feed for aquaculture. ・ Use as fertilizer. ・ Utilization as seaweed (seaweed that floats on the surface of the sea, such as Sargassum fulvellum) ・ Incineration treatment (large amounts of auxiliary combustion agents are required, and incinerators are worn out due to salt damage). It is necessary to establish a system for acceptance at municipal solid waste incineration plants with a mixing ratio of 20% for municipal solid waste.	Social implementation
7-22	One World Corporation	Large Corporation	Osaka prefecture	Pyrosis Treatment (Carbonization)	Mixed marine debris (organic waste, plastic, stone, wood, etc.)	The "Urban Rig" developed by the Company sends high-temperature steam from a superheated steam generator into the reactor to create a high-temperature, oxygen-free state inside the reactor to pyrolyze marine debris, which is a mixture of plastics, stones, seaweed, metals, wood, and other materials. (Pyrolysis under anoxic conditions produces no dioxin or CO_2.) Organic materials such as garbage can be converted to charcoal, plastics can be recovered as oil, and metals can be recovered as metal. The system can be operated with water, electric power, and a catalyst, and oil extracted from waste can be used as electric power.	Social implementation (Operating in China)

No.	Name of Company・Institution	Business Scale	Location	Field of Utilization	Target algae	Contents of Technologies	Development Stage [18]
7-23	SDGs Yokohama Kanazawa Living Lab	General Incorporated Association	Yokohama city	Composting, Environmental Education	Macroalgae	Environmental Education through Utilization of Macroalgae, Through industry-government-academia collaboration, it considers the utilization of Macroalgae (about 100 tons of eelgrass per year) that is disposed of in marine parks, and supporting children's education on self-creation through agricultural research activities, compost research, insect breeding research, and so on.	Social implementation
7-24	Hokkaido University, Environmental Science Faculty of Environmental Earth Science （Prof. Onoda）／University of La Serena. etc.（SATREPS／2022~）	R&D	Chile	Utilization of biomaterials in marine waste	Marine Waste	In Chile, where fishery activities are flourishing, the project evaluates and identifies high value-added biomaterials in fishery waste, establishes a production process for high-purity biomaterials, and develops new biomaterials.	R&D

Source : Information published on the websites of companies and research institutes, as well as on J-Startup, J-Platpat, ScienceDirect, etc., was compiled by the JICA Survey Team

3.3 Technologies in Japan that can be Adapted for Use in Sargassum

(1) Views of Japanese Experts on the Utilization of Seaweeds including Sargassum

First, for each technology in Japan identified in "3.2 Collection and organization of information on the results of seaweed utilization and research in Japan" interview survey was carried out to the experts shown in Table 3.22 As a result, Table 3.23 summarizes the issues that the experts advised and pointed out for each technology item in considering the possibility of adaptation to sargassum in Central American and Caribbean waters.

Table 3.22 Areas of expertise of experts interviewed

	Expertise
1	Specializing in Sargassum fulvellum
2	Research on sargassum
3	Utilization of macroalgae in agricultural land
4	Algae classification, algae biomass
5	Utilization of red algae, arsenic reduction technology, and others
6	Soil environment analysis for agricultural applications

Source : JICA Survey Team

Table 3.23 Advice and Issues on the Adaptability of Seaweed Utilization by Experts

Application	Main utilization	Challenges for Utilization
Common matters		- Arsenic and heavy metal content varies by species, season, and growing environment. (Problems in utilization depend on the application.) - Europe is leading in the field of macroalgae utilization. - Seaweeds that have been used for food are easy to be utilized.
Utilization in Agriculture and Aquaculture	Spreading on Farmland, Conversion to Compost	- There may be a lack of understanding among farmers regarding the issue of heavy metal removal and the correct way to use seaweed compost. - High salt content has a negative impact on production, but in general, the amount of sodium chloride less than 0.85% is not harmful to cause salt damage. The amount of salt in seaweed after drying doesn't reach that amount. - More correct understanding of seaweed fertilizer technology needs to be promoted. It is correct to remove seaweed to the ground surface; mixing it with soil will reduce its effectiveness. Spreading of seaweed has the effect of making it less likely to attract pests. - Drying before decomposition
	Biostimulants	- The market is expanding every year, partly due to the promotion of organic farming methods and fertilizer shortages. Enhanced crop resistance has also been scientifically proven. - Bacteria and crustacean deposits are also likely to be harmless. (Regulations in each country should be reviewed.) - Decomposed material can be usable. - As the main raw material is Ascophyllum nodosum, it is necessary to confirm the applicability of sargassum in Central and South America. Analysis of the contents such as heavy metals should be done. - Development of a plant is necessary.
Utilization as a material	Bioplastics	- Research and development in progress. Removal of garbage, crustaceans and others from seaweed are necessary. - Production costs are high and cannot compete with existing plastics.
	Materials (bricks, paper, etc.)	- Securing a stable volume is a challenge.

Application	Main utilization	Challenges for Utilization
Component Extraction	Extraction of Viscous Polysaccharides and Fucoxanthin	- Fucoxanthin decomposes quickly, making it difficult to maintain stability. Stabilization technology has been developed, but some companies have withdrawn from the market because they could not guarantee profitability. - Extraction and heavy metal removal of fucoidan and alginic acid are already technically feasible and implemented, but the capital investment for production is significant. Another major challenge is the technology for preserving seaweed before processing. Since frozen preservation is costly, the development of room temperature preservation using fermentation technology is expected. - Procurement of raw materials in Japan has also been a challenge in recent years. In addition, price competition is severe because inexpensive fucoidan is being produced in Southeast Asia and other regions.
	Cosmetics	- Uncertainty regarding technical limitations and characteristics. - While boiling and sun-drying are sufficient for food use such as hijiki, further reduction of heavy metal content is required for use as a supplement and is being developed in collaboration with related organizations.
	Foods	- Need to search for food deterioration factors in marine biomass, examine control technology for food quality, control deterioration, and examine processing technology for higher quality.
Utilization in Energy	General	- The biggest challenge to commercialization is cost reduction (there is a big difference in competitiveness with oil and other energy sources) - It is necessary to secure large amount of seaweed for the purpose of aquaculture technology, however research in microalgae is leading the way in Japan. - HTL technology (hydrothermal liquefaction) can be used to convert organic matter into oil components, and there is potential for adaptation. - Research is being conducted to elucidate physiological functions and metabolic mechanisms effective for bioenergy production, etc., and to improve energy production efficiency by controlling these mechanisms. - Bioconversion of brown algae requires technologies different from those developed for terrestrial biomass processing
	Biogas	- The cost of each facility is high: equipment for crushing seaweed to make it easier for microorganisms to decompose, equipment for decomposing it into methane gas, and equipment for storing the decomposed methane gas.
	Bioethanol	- There used to be talk of converting flow algae into ethanol, but it never materialized because of the important role flow algae play in the ecology of the oceans. Even decomposed algae can be used to make ethanol.
Others	Blue Carbon	- Ethanol fermentation technology from large algae and development of equipment for accelerated CO_2 fixation. - Existing algae beds are not eligible for credits. - Methodology for crediting was developed by Japan Blue Economy Technology Research Association (JBE). - Deep-sea storage of flow algae can be a CO_2 sequestration. Seabed carbon sequestration by sinking to the seabed is considered most promising for red algae, but the impact on the seabed environment is unknown.

Source : JICA Survey Team

(2) Initial study of adaptability

Based on the information collected, initial study was conducted to examine the applicability of each of the Japanese technologies identified in "3.2 Collection and organization of information on the results of seaweed utilization and research in Japan" to sargassum. In the examination, the possible issues from the viewpoints of science and technology, socioeconomics, and commercialization are summarized in Table 3.24.

Table 3.24 Initial Study on the Applicability of Utilization Technologies of Seaweed to Sargassum

Inventory	Points to be Considered
＜Science and Technology＞	
Adaptation of Japanese Technology	Adaptability of Japanese technology to the utilization of floating sargassum in Central and South America. Items to be checked to determine if the technology can be adapted and the advantages of Japanese technology. Immediate effect to the adaptation.
＜Socio-economic＞	
Effectiveness	The possibility that the introduction of Japanese technology will contribute to solving the sargassum problem in Latin American countries. Status in the targeted countries.
Local Acceptability	Cultural and customary acceptability of the Japanese technology and the products manufactured by the technology to the communities.
Ripple Effect/Impact	Socioeconomic Impact and Possible Ripple Effects of the Introduction of Japanese Technology.
＜Commercialization＞	
Business feasibility	Anticipated process for commercialization, taking into account the maturity level of the Japanese technology.
Economic efficiency	The viability and sustainability (profitability) for commercialization.
＜Others＞	Any other points to be considered.

Source : JICA Survey Team

Table 3.25 summarizes the results of the study on utilization technologies, and Table 3.26 summarizes the results of the study on inflow prevention, collection, and appropriate treatment. The "Issues/Confirmation Items for Adaptation" are also intended to be used for the next interview survey.

Table 3.25 Results of the Study of the Adaptability of Seaweed and Organic Waste Utilization Technology to Sargassum

Field	Main Technology	Challenges for Adaptation / Issues to be Identified	Adaptability to Sargassum
Utilization in Agriculture and Aquaculture	Fertilization	【Japanese Technology】This is an ancient farming method practiced in Japan. The initial investment is relatively low due to the simplicity of the seaweed processing process. Japanese technology lacks superiority because it does not require advanced technology. 【Effectiveness】Area of farmland that can be sprayed. Necessity of enlightenment of local residents. 【Acceptability】Acceptability of seaweed use by local residents, concerns about the impact of arsenic on farmland. *Trial operation is underway. 【Business feasibility】Transportation to farmland where spreading is possible. Quantitative effects. 【Economic feasibility】Costs associated with collection, transportation, pretreatment, and preservation of sargassum. Cost recovery is difficult due to low added value. 【Others】Reduction of arsenic and heavy metal content, and reduction in the commercialization process.	- Implementable with low initial investment - Effective to produce fertilization from residue in the process of component extraction.
	Compost	【Japanese Technology】Already implemented in neighboring countries. The total cost is higher than that of fertilizer because of the fertilizer conversion process. Japanese technology lacks superiority because it does not require advanced technology. 【Effectiveness】Possible to produce compost from residue in the process of component extraction. Effectiveness to include other organic wastes into a project. 【Acceptability】Already implemented, but market size and accessibility need to be confirmed. 【Impact】Dissemination of organic farming, strengthening of the agricultural sector, and contribution to food self-sufficiency.	- Implementable with low initial investment - Effective to produce compost from residue in the process of component extraction.

Field	Main Technology	Challenges for Adaptation / Issues to be Identified	Adaptability to Sargassum
		【Business feasibility】Access to markets and potential market area, securing manpower and land for seaweed pretreatment, preservation, and composting. 【 Economic feasibility 】 Costs related to collection, transportation, pre-processing and preservation of sargassum. 【Others】Arsenic and heavy metal content, reduction of those content in the commercialization process, and analysis of products and soil may also be required.	
	Livestock feed	【 Japanese Technology 】 Already implemented in neighboring countries. The initial investment is relatively low due to the simplicity of the seaweed processing process. Japanese technology lacks superiority because it does not require advanced technology. 【Effectiveness】 It is effective to consider to include other organic wastes as raw materials as a processing method after extracting the components. 【Acceptability】 Although already implemented, the scale of the market needs to be confirmed. Acceptability of seaweed utilization by local residents. 【Impact】Dissemination of organic farming, strengthening of the agricultural sector, and contribution to food self-sufficiency. 【Business feasibility】 Distance to market, size of market, primary processing and preservation of seaweed, securing manpower and land for feed production. 【Economic feasibility】 Cost related to collection, primary processing and preservation of sargassum. 【 Others 】 Arsenic and heavy metal content, limited countries with demand for livestock feed.	- Implementable with low initial investment - Effective to produce livestock feed from residue in the process of component extraction.
	Biostimulants	【Japanese technology】 As most of the raw materials at present are Ascophyllum nodosum, it is necessary to analyze the applicability, composition, and efficacy of the species. Japanese technology lacks superiority because it does not require advanced technology. 【 Effectiveness 】 Contributes to a certain amount of consumption. Possible to produce compost in the process of component extraction. 【Acceptability】Acceptability of residents for seaweed use, arsenic. 【Impact】Dissemination of organic farming, strengthening of the agricultural sector, and contribution to food self-sufficiency. 【Business feasibility】 Pre-treatment and preservation of seaweed, related regulations, business plan in consideration of intra-regional consumption and export. 【Economic feasibility】 Costs related to recovery, primary processing and preservation of sargassum. Diversification is required due to the fluctuations in the number of raw materials require diversification of materials. 【Others】 Already implemented by local private sector.	- Effective to produce biostimulants from residue in the process of component extraction.
	Aquaculture/ fish feed	【 Japanese Technology 】 Analysis of applicability, composition, and efficacy of the sargassum is necessary. Japanese technology lacks superiority because it does not require advanced technology. 【 Effectiveness 】 Contributes to a certain amount of consumption. Possible to produce fish feed in the process of component extraction. 【Acceptability】 Acceptance: Acceptability of aquaculture for seaweed utilization, component analysis for arsenic and heavy metals.	- Effective to produce fish feed from residue in the process of component extraction.

Field	Main Technology	Challenges for Adaptation / Issues to be Identified	Adaptability to Sargassum
		【Impact】Acceptability of aquaculture for seaweed utilization, component analysis for arsenic and heavy metals. Improvement of aquaculture technology, business efficiency by promoting growth of fry, and contribution to food self-sufficiency. 【Business feasibility】Need to understand the current status of seaweed pretreatment and preservation, related regulations, and the market size of the local aquaculture business. 【Economic feasibility】Costs related to recovery, Primary Processing and preservation of sargassum. Diversification is required due to the fluctuations in the number of raw materials require diversification of materials.	
Utilization as a material	Bioplastic	【Japanese Technology】Not yet implemented in Japan. 【Effectiveness】The form and amount of input as raw materials are unknown. 【Acceptance】－ 【Impact】Contribution to the marine plastic problem. 【Business feasibility】Removal work when seaweed containing impurities as raw material, unstable raw material procurement. 【Economic feasibility】High cost to sort row materials and manufacture product	- Some technologies take time to implement. Uncertainty and cost are issues but will be considered from a long-term perspective.
	Food	【Japanese Technology】Analysis of applicability, composition, and efficacy of the sargassum is necessary. 【Effectiveness】The form and amount of input as raw materials are unknown. 【Acceptance】Interest of residents in preventive medicine (health), and understanding of the market with an eye to overseas markets. 【Impact】Preventive medicine 【Business feasibility】Verification and safety of the species, and related regulations. 【Economic feasibility】Costs related to collection, Primary Processing and preservation of sargassum. 【Others】Processing technology for higher quality (value-added improvement), regulations on arsenic and heavy metals, etc. must be confirmed.	- Uncertainty exists
Component Extraction	Extraction of Viscous Polysaccharides (Fucoidan, Alginic Acid etc.)	【Japanese Technology】The technology for extracting viscous polysaccharides and arsenic reduction has been established and is at the implementation level. 【Effectiveness】The form and amount of input as raw materials are unknown. 【Acceptance】Interest of local residents in preventive medicine (health) and overseas markets. 【Impact】Creation of preventive medicine and high value-added industry 【Business feasibility】Implementation system for Primary Processing (drying) and storage. Securing stable production lines by procuring multiple raw materials, securing a market, and related regulations. 【Economic feasibility】Costs of collection, Primary Processing and storage of sargassum. 【Others】Contents of ingredient when raw materials fermented, regulations on arsenic and heavy metals, etc. must be confirmed.	- Adaptable to floating sargassum as it also contains a certain number of viscous polysaccharides.
	Extraction of other effective ingredients/cosmetics	【Japanese Technology】Viscous polysaccharide extraction from brown algae 【Effectiveness】The form and amount of input as raw materials are unknown.	- Many in research& development stage but could lead to high value-added.

Field	Main Technology	Challenges for Adaptation / Issues to be Identified	Adaptability to Sargassum
		【Acceptance】Interest of local residents in preventive medicine (health) and overseas markets. 【Impact】Creation of preventive medicine and high value-added industry 【Business feasibility】Implementation system for Primary Processing (drying) and storage. Securing stable raw materials, and related regulations. 【Economic feasibility】Costs of collection, Primary Processing and storage of sargassum. 【Others】Processing technology for higher quality (value-added improvement), regulations on arsenic and heavy metals, etc. must be confirmed.	
Utilization in Energy	Methane fermentation (Biogas)	【Japanese Technology】There are few examples of utilizing seaweed (limitation with freshwater-derived microorganisms). 【Effectiveness】Large-scale consumption is expected. 【Acceptance】Coexistence with the local community, stabilization of raw material input. 【Impact】Contribution to climate change through methane gas recovery and utilization. 【Business feasibility】Because seaweed contains a large amount of water, it is essential to select a suitable location for the processing plant. Utilization of salt-tolerant microorganisms. Securing a stable raw material procurement line. Pre-treatment (desalination?) 【Economic feasibility】Price competition with locally used energy. (Consideration should be given to government subsidies and the use of subsidies related to decarbonization for initial investment.)	- Although it is still in the research stage and there are many issues to be addressed to ensure business feasibility and economic viability, it is expected to be consumed in large quantities and can be applied to decomposed sargassum. Hence, this will be studied from a long-term perspective. - Effective to produce biogas from residue in the process of component extraction.
	Hydrothermal liquefaction (HTL)	【Japanese Technology】Targeted for microalgae, and there are no applications in the field of large algae. 【Effectiveness】Large-scale consumption is expected. 【Acceptance】Coexistence with the local community 【Impact】- 【Business feasibility】Stabilization of raw material input 【Economic feasibility】Price competition with locally used energy sources.	- In Japan, only research& development in microalgae have been proceeded.
	Bioethanol	【Japanese Technology】This technology is still in the research and development stage, but it is technically feasible. 【Effectiveness】Large-scale consumption is possible. Considered as a treatment after extraction of high value-added components. 【Acceptance】Coexistence with the local community, demand for organic waste treatment other than sargassum is necessary. 【Impact】Decarbonization 【Business feasibility】Costs for collection, transportation, Primary Processing, and preservation of sargassum. Confirmation of market route. 【Economic feasibility】Price competition with locally used energy. 【Others】Because special microorganisms are needed to decompose alginate, cost is high.	- Although it is still in the research stage and there are many issues to be addressed to ensure business feasibility and economic feasibility. However, since mass consumption is expected, the study will be conducted from a long-term perspective. - Effective to produce bioethanol from residue in the process of component extraction.
Blue Economy	-	【Japanese Technology】The United States is already ahead of Japan in the development of monitoring systems (satellite image analysis, deep learning decoding, etc.). There is no superiority for Japan. 【Effectiveness】Seabed storage 【Acceptance】Need to create a mechanism to return to the local community	- Not a direct problem-solving proposal, but to be considered in combination with utilization technology.

Field	Main Technology	Challenges for Adaptation / Issues to be Identified	Adaptability to Sargassum
		【Impact】CO_2 storage, decarbonization 【Business feasibility】Blue carbon credit market is not yet mature. 【Economic feasibility】The credit market is immature at present and will remain unstable in the future. 【Others】Methodologies applicable to sargassum have not yet been developed, and there is no mechanism for cost recovery at this point.	

Source : JICA Survey Team

Table 3.26 Results of Adaptability Study for Prevention of Macroalgae Influx, Collection and Proper Treatment

Field	Main Technology	Challenges for Adaptation / Issues to be Identified	Potential Bottlenecks	Adaptability to Sargassum
Prevention of Influx	Inflow Prevention Netting / Log Boom / Silt Fence	【Japanese Technology】This technology is used in dam lakes and harbors. 【Effectiveness】Suppression of large amounts of drifting and treatment that have become lodged. (Controlling drift onto beaches is controversial considering the maintenance effectiveness of beach erosion and beach maintenance (e.g., impact on spawning of sea turtles). 【Acceptance】Collection of sargassum lodged in the net. 【Impact】Reduce adverse effects on the fishing and tourism industries, erosion, sea turtles, and other ecosystems by collecting them before they drift ashore. 【Business feasibility】Interference with fishing and shipping activities, establishment of effective installation methods. 【Economic feasibility】Business Continuity	Advantage to use Japanese Technology	- Low dominance of Japanese firms, but effective for maritime collection
Collection	Water Surface Cleaning Ship	【Japanese Technology】The design and manufacture of vessels and collection equipment can be adapted to suit the marine environment and suspended solids conditions. 【Effectiveness】The capacity of the vessel is an challenging. 【Acceptance】Not confirmed 【Impact】Reduce adverse effects on the fishing and tourism industries, erosion, sea turtles, and other ecosystems by collecting them before they drift ashore. 【Business feasibility】Landing and proper disposal of collected waste. 【Economic feasibility】Sales and maintenance business	Not confirmed	- Effective utilization with log boom
Proper Treatment	Landfill	【Japanese Technology】The landfill on the beach together with EM bacteria. No technical problems are expected. 【Effectiveness】The seaweed is decomposed and treated in about 2 weeks, but securing a treatment site to handle the amount of seaweed generated is an issue. (On the other hand, it is difficult to transport seaweeds with high water content.) 【Acceptance】Acceptability to residents. Difficult to implement in tourism sites and beaches. 【Impact】Immediate impact. 【Business feasibility】Fermented natural raw material is required. A place for landfill is needed. 【Economic feasibility】Difficult for cost recovery. 【Others】Inhibition of generation of hydrogen sulfide, etc.	Securing a place for landfill	- Little advantage for Japanese firms.

Source : JICA Survey Team

4. Result of Interview Survey

(1) Interview Methodology

Based on the results of the initial desk survey on the applicability of each utilization and appropriate treatment technology, and taking into account the overseas expansion experience of each company, the long list was prepared. Then, the companies for the first online seminar were selected (Table 3.15 to Table 3.21). Conducting the questionnaire survey after the first online seminar, additional research, and discussions with JICA, Interviewees were selected. Finally, interviews were conducted with a total of 18 companies. The interviews were conducted online, and site visits were conducted as felt necessary.

The questions asked during the interviews are shown in Table 4.1.

Table 4.1 Lists of Major Questions for the Interview Survey

Questions	Detail
【Products and Technologies】	
Features of Products and Technologies	Product, treatment capacity of facility, size, sales and installation price
Work Process at the Time of Utilization	Pretreatment (flow-through treatment), post-treatment (e.g., residue treatment)
Development Stage of the Technology at Present	Social implementation stage, research stage
Required Materials, Equipment, and Related Facilities	Washing facilities, drying facilities, storage facilities
Necessity of Maintenance	Engineers needed on site, parts replacement
Advantages of the Product/Technology	Patents, etc.
【Commercialization】	
Expected Value Chain	Flow from procurement to production, distribution, and sales, the businesses (partner companies) to collaborate with, investors, target customers, etc.
Expected Local Partners	Sargassum primary processing, agency, etc.
Target Markets	Existing domestic and international markets, sales prices, and potential competitors
Services to be Provided Locally	Affinity with local needs
Inputs for Operation and Maintenance	Operation and maintenance costs, human resources, etc.
【Overseas Expansion】	
Items to be confirmed for adaptability and surveys required (technical, institutional, and social aspects)	Technical: Component analysis (items) Institutional: Environmental standards (exhaust gas, wastewater) Social: Local acceptability, customs, etc.
Concerns related to overseas expansion	Local laws, regulations, permits, and approvals for the proposed product/technology itself
Time frame for local implementation	Number of employees available for overseas operations
Interests and concerns about business development in Latin America	Languages, etc.
Expected support and schemes	Required financial scale and phase

Source : JICA Survey Team

(2) Result of Interview Survey

Interviews were conducted with private companies and research institutions that have agricultural and aquaculture applications, material use, component extraction, energy use, primary treatment (washing, drying, cutting/crushing, storage), and inflow prevention and collection technologies. Table 4.2 lists the

major answers. Detailed results of the interviews with each company are not disclosed because they contain confidential information.

Table 4.2 Outline of the Result of Survey

Field of Utilization	Result of Survey
Utilization in Agriculture and Aquaculture	- Fertilizer production with large algae is feasible, and thus highly adaptable to sargassum. - Considering business continuity, it is necessary to include organic materials other than sargassum in the project, or long-term storage of sargassum is necessary. - Issues such as the securing local partners for primary processing (washing, drying, and grinding), reduction of costs, and manufacturing methods that reduce costs and energy consumption in the drying process. - Advance research (composition of sargassum, compatibility with existing equipment, impact on soil and crops, development of local partners) is needed. - Biostimulants derived from seaweeds are only available for sale.
Utilization as a Material	- Research is underway on the production of plastic made of 100% macroalgae. - Material use mixed with a part of products (mixed paper, bioplastics) has already been implemented and proven in society. - Market development is important because the production cost is higher than that of regulated plastic products. - Possible use for public relations purposes. - Issues such as the securing local partners for primary processing (washing, drying, and grinding), reduction of costs, and manufacturing methods that reduce costs and energy consumption in the drying process.
Component Extraction	- Alginic acid, bio polyphenols, etc. are considered extractable, but component analysis is required. Stable quality of extracted components is required to sell them as products. - Water is used in the extraction process for alginic acid. (Confirmation of the impact on water intake and drainage is required.) - Residue after component extraction can be used as fertilizer. - Issues such as the securing local partners for primary processing (washing, drying, and grinding), reduction of costs, and manufacturing methods that reduce costs and energy consumption in the drying process.
Utilization in Energy	- Sargassum does not require cleaning and can be consumed in large quantities. - Contributes to energy security and carbon neutrality. - Carbonization and gasification treatment technology for organic matter (patented) requires semi-drying but is at the level of social implementation. - Bioethanol production (patented) is at the small-scale demonstration level. This will take time until industrialization. (Washing and drying are not necessary). - Methane fermentation of large algae uses marine methanogenic bacteria, but co-fermentation with other organic matter is possible.
Primary Processing	- Suitable for primary treatment process as raw material for fertilizer and other products. - Drying process is more expensive than other processes in terms of equipment
Inflow Prevention and Collection Technology	- Design and manufacture of locally adapted water surface clean-up vessels is possible through field surveys (manufactured in Japan, equipment exported for sale) - Installation of silt fence improves efficiency of offshore collection. - Confirmation of the scope of collection, landing methods and points, installation of floats, collaboration with the local community, etc. is required on site.

Source : JICA Survey Team

5. Consideration of the Directions of Cooperation and Proposal of Scenarios

5.1 Examination and Organization of Potential Partners

(1) I. Examination of the Applicability of Each Technology

The perspectives for organizing the applicability of each technology are summarized in Table 5.1, based on interviews with experts and relevant organizations and information from papers and other sources. Based on these perspectives, each utilization and treatment technology were organized and assessed, taking into account the results of the interview survey.

In terms of science and technological aspects, the adaptability was scored high if the technology has been adapted for macroalgae or organic waste. Furthermore, technologies protected by patents, as well as newly developed or currently under development technologies, are considered superior and to be of significance for the expansion and support utilizing the said technology. In terms of socio-economic aspects, the contribution to the solution of the sargassum problem in Central America and the Caribbean region was assessed by the sargassum's processing capacity, immediacy and effectiveness. Also, technologies that contribute to local socio-economic development, such as food security and energy security, were assessed by recognizing their significant ripple effects and impact. In terms of the business model aspects, the local implementation structure and necessary equipment was organized. In addition, the sustainability of business development was organized in terms of the response to unstable inflows of sargassum and the adaptability for other organics.

Table 5.1 Perspectives on Organizing the Adaptability of the Technology

Item	Points to consider	Assessment viewpoints
＜Scientific and Technological Aspects＞		
Adaptation of technology	Track record of technologies for the utilization of macroalgae or organic waste as raw material	High: Proven track record Medium: Under technological development Low: Not confirmed
Development Stage / Timeline to Implementation	Whether the technology development stage is at the level of social demonstration, demonstration or research stage with macroalgae and/or organic waste	High: Social implementation or demonstration with macroalgae Medium: Social implementation or demonstration with organic waste Low: At research development stage, or not confirmed
Technological Superiority	Whether the technology's superiority is recognized, such as through the acquisition of patents.	High: Patent acquired for macroalgae Medium: Patent acquired for other organic materials Low: Not confirmed
＜Socio-Economic Aspects＞		
Effectiveness & Immediate Impact	The potential contribution of technology to solving the sargassum issue, including the processing capacity of sargassum.	High: Large consumption of seaweed is possible Medium: Seaweed consumption depends on the technology Low: Low consumption of seaweed
Acceptability	The cultural and habitual acceptability of the domestic technology and the products manufactured by it among the residents.	High: No significant barriers to technology adoption Medium: Changes in business practices, adjustments needed

Item	Points to consider	Assessment viewpoints
		Low: Significant barriers to technology adoption
Ripple Effect & Impact	The socio-economic impact and potential ripple effects of introducing domestic technology.	High: Contributes to the local socio-economy Medium: Indirectly contributes to the local socio-economy Low: Other
＜Business Model Aspects＞		
Business Viability	The envisioned process towards commercialization considering the maturity of the technology, including the necessary equipment.	High: Low initial investment and feasible business operation Medium: Medium to large initial investment required Low: Difficult to introduce technology
Economic Feasibility	The feasibility and sustainability of the business model (profitability), market prospects, etc.	High: No barriers to ensuring economic viability Medium: Dependent on market and local needs Low: Significant barriers to ensuring economic viability
＜Possibility of Expansion Aspects＞		
Domestic Companies' Trends	The trend of domestic companies in the relevant field regarding overseas expansion.	High: Aggressive towards expansion in Central America and the Caribbean region Medium: Some interest in overseas expansion Low: Not confirmed
Support Scheme	Possible support schemes	-

Source: JICA Survey Team

Based on Table 5.1, each technology was organized and evaluated in Table 5.2.

Adaptability/Evaluation

	High
	Medium
	Low

Table 5.2 Organization and Evaluation of Each Utilization and Treatment Technology

		Utilization in Agriculture and aquaculture				Utilization as a Material		Component extraction	Utilization in Energy			Collection	Primary processing	Treatment
Items to measure adaptability		Composting (seaweed fertilization)	Biochar	Bio stimulants	Livestock feed	Biodegradable plastics	Other (paper)	Extraction of useful components (Alginic acid, etc.)	Bioethanol	Methane fermentation	Organic waste treatment	Marine collecting and log booming	Crushing, shredding, and drying	Waste reduction
Scientific and Technological Aspects	Adaptation of technology	Adaptable	Proven track record in other organic materials	Domestic companies mainly only sell	Seaweed powder is being manufactured and sold as livestock feed	Technology under development to utilize large algae	Other organic materials are mixed with paper and commercialized as mixed paper	Extraction from Sargassum fulvellum is underway and has high potential for application	Adaptation of large algae has been confirmed on a lab scale	Adaptation of large algae has been confirmed on a lab scale	Carbonization and gasification of organic matter is conventionally conducted	Experience with removal of waterweeds in inland waters	Proven track record with organic materials	Proven track record of rapid reduction through microbial fermentation of organic matter
	Development Stage / Timeline to Implementation	Social implementation exists for seaweed, depending on the technology	Under demonstration (seaweed)	- (Not many manufacturing achievements in Japan)	Social implementation	R&D / Social implementation (small scale & mixed only)	Social implementation already achieved with other organic materials	Social implementation	R&D	R&D	Social implementation, but not targeted at seaweed	Social implementation	Social implementation	Social implementation, but not targeted at seaweed

		Utilization in Agriculture and aquaculture				Utilization as a Material		Component extraction	Utilization in Energy			Collection	Primary processing	Treatment
Items to measure adaptability		Composting (seaweed fertilization)	Biochar	Bio stimulants	Livestock feed	Biodegradable plastics	Other (paper)	Extraction of useful components (Alginic acid, etc.)	Bioethanol	Methane fermentation	Organic waste treatment	Marine collecting and log booming	Crushing, shredding, and drying	Waste reduction
	Domestic Technological Superiority	Ancient Japanese Technology / Patents Related to Active Oxygen Utilization	Ancient Japanese technology	Not confirmed, but Europe is ahead of Japan	Not confirmed	Biodegradable plastics derived from seaweed are ahead of others	Not confirmed	Not confirmed	Patented technology for ethanol production from seaweed components	Not confirmed	There are patented technology	Not confirmed	Not confirmed	Depending on company
Socio-Economic Aspects	Effectiveness & Immediate Impact	Seaweed fertilizer applied to soil can consume a large amount of raw materials	Due to its application to soil, a significant amount of seaweed can be consumed	The consumption of seaweed is low because the original liquid is diluted hundreds to tens of thousands of times before use	The consumption of seaweed is low because it is mainly mixed in a few percent with regular livestock feed	The content of seaweed depends on the manufacturing method	The mixing ratio in products is a few percent, resulting in low consumption of organic material raw materials	Extracts components around tens of percent from dried solids, leaving ash residue. The residue can be used as compost	Capable of processing large quantities of sargassum	Capable of processing large quantities of sargassum Possible to mix with other organic waste	Capable of processing large quantities of sargassum Possible to mix with other organic waste	Effective for the maritime collection of sargassum	The technology is adaptable, but the energy required for drying poses a challenge	Capable of processing large quantities of sargassum
	Acceptability	Switching from chemical and other fertilizers to alternatives is	Switching from chemical and other fertilizers to alternatives is	Concerns about arsenic/heavy metals exist for foliar application	Concerns about arsenic/heavy metals exist	Concerns about arsenic/heavy metals may exist depending on the application	Concerns about arsenic/heavy metals may exist depending on the application	Concerns about arsenic/heavy metals may exist depending on the application	Energy and industrial use is possible	Energy use is possible	Energy use is possible	None in particular	None in particular	None in particular

		Utilization in Agriculture and aquaculture				Utilization as a Material		Component extraction	Utilization in Energy			Collection	Primary processing	Treatment
Items to measure adaptability		Composting (seaweed fertilization)	Biochar	Bio stimulants	Livestock feed	Biodegradable plastics	Other (paper)	Extraction of useful components (Alginic acid, etc.)	Bioethanol	Methane fermentation	Organic waste treatment	Marine collecting and log booming	Crushing, shredding, and drying	Waste reduction
		necessary for farmers	necessary for farmers											
	Ripple Effect & Impact	Effective as soil amendment	Effective as soil amendment	Effective for crop vitality	Effective in improving the intestinal environment of livestock	Replaces fossil fuel products. Contribution to the marine plastic problem	Publicize the sargassum issue by blending with publicity products	Depending on the manufacturing process, it can be returned to local residents and industries through the production of value-added products	Contribution to energy security Various ways to utilize ethanol as a raw material	Contribution to energy security	Contribution to energy security	Marine collection is preferable for utilization	Introduced as a pretreatment for other utilization technologies	Significant reduction in final disposal volume

		Utilization in Agriculture and aquaculture				Utilization as a Material		Component extraction	Utilization in Energy			Collection	Primary processing	Treatment
Items to measure adaptability		Composting (seaweed fertilization)	Biochar	Bio stimulants	Livestock feed	Biodegradable plastics	Other (paper)	Extraction of useful components (Alginic acid, etc.)	Bioethanol	Methane fermentation	Organic waste treatment	Marine collecting and log booming	Crushing, shredding, and drying	Waste reduction
Business Model Aspects	Business Viability	Possible if primary processing (collecting, drying, and shredding) is in place. Stable raw material procurement is possible if other raw materials can be used	Possible if optimal carbonization equipment can be introduced Stable raw material procurement is possible if other raw materials can be used.	Production by domestic companies is difficult.	Possible if primary processing (collecting, drying, and shredding) is in place	Processing volume is small. Methods to increase the content are still in the research stage	Overseas expansion is still in the future stage due to domestic technology	Requires primary processing and capital investment. Large amount of water is required	Requires shredding and yeast fermentation tanks. Transport to industrial complexes in the future	Requires a large plant. Stable raw material procurement is possible if other raw materials can be fed in	Requires a processing and energy conversion plant. Useful for treatment of other organic materials	Requires heavy equipment for installation and collection of sargassum	Further pre-processing (e.g. crushing) is necessary depending on the shape of the sargassum	Requires salt removal cleaning or processing of equipment
	Economic Viability	Competition with conventional chemical fertilizers Securing other seaweeds	Competition with conventional chemical fertilizers Securing other seaweeds	—	Competing with conventional feed Securing other seaweed	Market is a challenge to secure as it is several times more expensive than petroleum-derived products	Market security is an issue because the price is several times higher than conventional products.	Securing a stable supply of sargassum and stabilizing its quality is an issue.	Securing a stable supply of sargassum is an issue/ Consideration is being given to aquaculture	Dependence on tipping fees and energy sales prices	Dependence on tipping fees and energy sales prices	Developing a market (buyers) is an issue	Utilization is a prerequisite for introduction.	Possible mixed treatment with other organic matter

		Utilization in Agriculture and aquaculture				Utilization as a Material		Component extraction	Utilization in Energy			Collection	Primary processing	Treatment
Items to measure adaptability		Composting (seaweed fertilization)	Biochar	Bio stimulants	Livestock feed	Biodegradable plastics	Other (paper)	Extraction of useful components (Alginic acid, etc.)	Bioethanol	Methane fermentation	Organic waste treatment	Marine collecting and log booming	Crushing, shredding, and drying	Waste reduction
Possibility of Expansion Aspects	Domestic Company Trends	High interest in expanding into Central America and the Caribbean region	High interest in expanding into Central America and the Caribbean region	—	Interest from domestic companies has not yet been confirmed	High interest in expanding into Central America and the Caribbean region	Respond to manufacturing requests from customers if any	Uncertain about inflows, ingredient content, etc., but there is interest	Interest in demonstration phase	Technology provision is acceptable	High interest in expanding into Central America and the Caribbean region	High interest in expanding into Central America and the Caribbean region	High interest in expanding into Central America and the Caribbean region	High interest in expanding into Central America and the Caribbean region
	Support Scheme※	SME Collaboration TSUBASA Technical Cooperation (JICA Partnership Program: JPP& TCP)				SATREPS	SME Collaboration／TSUBASA	SME Collaboration／TSUBASA SATREPS	SATREPS Private Sector	Private Sector	SME Collaboration／TSUBASA Private Sector	Grant Assistance SME Collaboration／TSUBASA Private Sector		
Comprehensive Evaluation		2.7	2.4	1.2	1.9	2.2	1.7	1.9	2.2	1.9	2.4	2.6	2.6	2.6

Note: Calculated as the average score for each item (high: 3, medium: 2, low: 1)
※SME Collaboration：JICA SDGs Business supporting Survey、TSUBASA: Transformational Start Ups' Business Acceleration for the SDGs Agenda, 、JPP：JICA Partnership Program,
SATREPS: Science and Technology Research Partnership for Sustainable Development, TCP：JICA Technical Cooperation Project
Source: JICA Survey Team

Based on Table 5.2, each utilization and treatment technology were summarized as follows.

1) Utilization in Agriculture and Aquaculture

Among the technologies of utilization of seaweed in agriculture and aquaculture, the production and sale of seaweed and organic waste as raw materials have already been implemented for the use of dried seaweed as fertilizer for soil application, carbonized biochar, and livestock feed. The technologies have high potential for adaptation because of the large quantities applied to soil and the simplicity of the treatment process. On the other hand, biostimulants are mostly produced in Europe, and since Japanese technology is not highly superior, the potential for adaptation was judged to be low. In addition, some information on the use of seaweed as livestock feed could not be obtained because the JICA Survey Team was unable to conduct an interview survey.

The private companies can use the JICA's scheme such as SDGs Business Supporting Survey and TSUBASA for business development. Technical cooperation scheme (such as Technical Cooperation Project (TCP) and individual cases such as Dispatch of Experts) and Citizen Participation (Partnership Program (JPP)) may be effective in establishing a stable raw material procurement system and in promoting the use of seaweed-based fertilizers and other products in the local community. Alternatively, the possibility of importing sargassum as a raw material and expanding production capacity using existing facilities is also considered as potential business expansion.

2) Utilization as a Material

The use of biodegradable plastic is considered as a material use. There are two technologies: one is to use it as part of the product, and the other is to use it as 100% of the product through microbial degradation, The former is in the demonstration stage and the latter is in the research stage. In the case of the technology that uses sargassum as part of the product, the point of effectiveness and immediate effect is slightly lower in that the amount of sargassum consumed is considered to be relatively small.

The private companies can use the JICA's scheme such as SDGs Business Supporting Survey and TSUBASA for business development. For technologies in the research stage, SATREPS can be used in which research institutions and private companies conduct research and commercialization in a single integrated manner. Alternatively, the possibility of importing sargassum as a raw material and expanding production capacity using existing facilities is also considered as potential business expansion.

3) Component Extraction

The technologies of extraction of components have been established for valuable substances such as alginate and biopolyphenols derived from macroalgae. There are many cases to use extracted component in food and pharmaceutical applications, however in Japan there is no case to use it extracted from species which is not previously eaten and it is required to ensure stable quality of the extracted component. When Japanese companies consider business development using sargassum as a raw material, more detailed preliminary studies on business continuity and quality stability, including primary processing, are necessary.

As the same as the case of the above technology, the private companies can use the JICA's scheme such as SDGs Business Supporting Survey and TSUBASA for business development. Additionally, for technologies that are in the research stage, a mechanism for comprehensive implementation through SATREPS, where research institutions and private companies collaborate from research to commercialization, can also be considered. Alternatively, the possibility of importing sargassum as a raw material and expanding production capacity using existing facilities is also considered as potential business expansion.

4) Utilization in Energy

Among the technologies of utilization of seaweed in energy, bioethanol technology using macroalgae as a raw material is still under research and development, but it is capable of mass consumption of sargassum and has a high contribution to energy security. The same applies to methane fermentation technology, but the potential for technological deployment is not high, as no company in Japan has been identified as owning or attempting to deploy seaweed methane fermentation technology. Carbonization and gasification technologies, which have been implemented as organic waste treatment methods, can be applied to large algae, and although the initial investment is larger than other utilization technologies, the possibility of mass consumption and profitability from energy conversion are high, and the contribution to energy security is also high.

In the case of energy utilization, considering the expected business scale, it is conceivable to apply Japan's Grant Assistance for facility and equipment procurement or JICA's scheme of Finance and Investment Cooperation.

5) Collecting and Primary Processing Technology

Regarding maritime collection, log booms and surface cleaning vessels already implemented in Japan can be mentioned. The method of using log booms to contain sargassum and then collecting it with surface cleaning vessels is considered effective.

While crushing, shredding, and drying technologies can be adapted as primary processing technologies, the inclusion of dryers and the associated energy use can lead to higher costs. Therefore, it is necessary to consider utilizing local resources such as sun drying.

6) Treatment Technology

Treatment technologies for the reduction of organic waste have been established, proving to be effective from a final disposal perspective, especially considering the current practice of disposing sargassum in landfills or vacant areas after collection. However, since there is no confirmed implementation for seaweed with high salt content, further consideration is required for addressing this issue.

(2) II. Examination of Technology Introduction Scenarios

Following the analysis conducted in "I. Examination of the Applicability of Each Technology," the prerequisite conditions, considerations, and potential integrations with other technologies related to the introduction of each utilization technology have been systematically organized in Table 5.3. Furthermore, based on this analysis, the anticipated overall flow of utilization related to sargassum is depicted in Figure 5.1.

In the use for agriculture, aquaculture, and fisheries, if drying and milling treatments are applied, the use as seaweed fertilizer becomes possible. Additionally, as residuals from material use, component extraction, or energy use, it can be applied to agricultural land, serving as a useful effort as an exit for each utilization project. Moreover, energy use (ethanol, carbonization, gasification) technologies do not require primary processing of sargassum as a pretreatment and allow for the large consumption of sargassum, drawing a straight flow from sargassum collection to appropriate processing. Depending on the energy technology, the use of residuals after component extraction is also possible, so combining these as an exit effort for sargassum utilization can be considered.

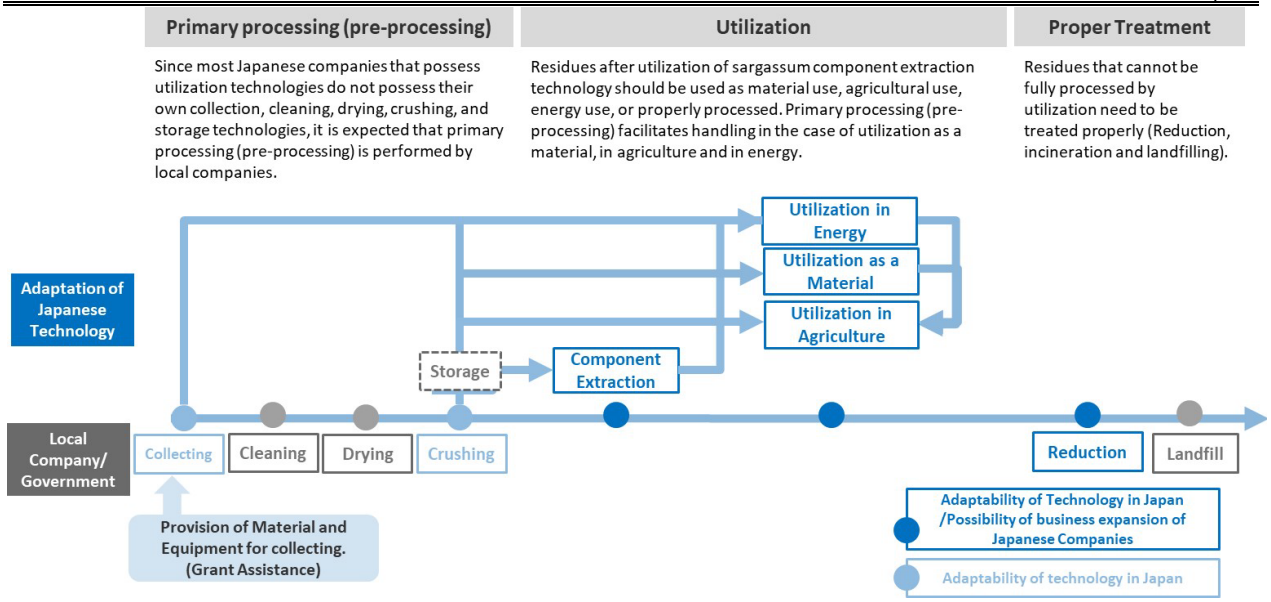
Including maritime collection in primary processing, especially from the viewpoint of securing a stable supply of raw materials, stockpiling through drying of sargassum is necessary. There is a history of introducing equipment related to maritime collection through Grant Assistance from the Ministry of Foreign Affairs, but since the introduction of equipment related to washing, drying, cutting/milling is based on the premise of utilizing technology, collaboration with local primary processing companies can be considered until the introduction of utilization technology is definitively decided. If the utilization projects stabilize or scale up, internalizing primary processing could also be considered.

Table 5.3 Prerequisite Conditions, Points to Consider, and Integration with Other Technologies

	Prerequisite Conditions	Considerations	Integration with Other Technologies
Utilization in Agriculture and Aquaculture	- From the viewpoint of securing stable raw materials, a drying process of sargassum is necessary for stock storage.	- Blending with other fertilizers and application methods should be adjusted according to soil composition and crops. - If arsenic and heavy metals are found to be contained in sargassum, it is necessary to introduce reduction technologies and application methods to keep the content below the established arsenic and heavy metal content standards.	- The material can be applied to field land as a residue after material use, component extraction, or energy use.
Utilization as a Material	- Primary processing (some cleaning, drying, cutting and crushing) is necessary.	- Since bioplastic cutlery is more expensive than inexpensive plastic products, it should be purchased by the government or sold to Europe and the U.S., where there is a	- Residues generated after processing can be applied to soil and used for agricultural and fisheries purposes.

	Prerequisite Conditions	Considerations	Integration with Other Technologies
		market for products with low environmental impact.	
Component Extraction	- Although a cleaning process is not required, a drying process of sargassum is necessary for stock storage from the viewpoint of securing stable raw materials	- In order to confirm the quality of the product, it is necessary to check the ingredients at each step of useful components varies depending on their content.	- Residues after extraction can be utilized as energy or for agricultural use.
Utilization in Energy	- In the case of carbonization and gasification, some drying is necessary for the final heat treatment. - Confirmation is required to confirm whether sargassum can be taken over for a fee. - Confirmation of local regulations, permits, etc.	- From the viewpoint of securing stable input, it is necessary to combine the storage of sargassum, co-processing with other organic wastes, and aquaculture technology.	- Residues after component extraction can be used as energy.
Proper Treatment	- Confirmation of local regulations, permits, etc.	- Since not all of the waste can be treated for utilization, support for collection, transportation, and burial mechanisms is also needed.	- Co-processing of other wastes (e.g., fishery wastes, organic wastes, etc.) through the introduction of incineration facilities could be considered.
Primary Processing	- Confirmation of log boom installation conditions (wave height, sand quality, weather conditions, etc.) - Confirmation of availability of onshore facilities and heavy equipment for landing the collected sargassum, and confirmation of a shipyard as a partner.	- Securing buyers for the products is an issue, as they are more expensive than foreign products. - Dryers use energy, so primary processing costs will soar. - Since the introduction of materials and equipment for cleaning, drying, cutting, and crushing is contingent on the introduction of utilization technology, it is necessary to collaborate with local primary processing companies until the introduction of utilization technology is confirmed.	- Regardless of the field of utilization, it is necessary to stock primary processed sargassum in a dried state from the viewpoint of securing stable raw materials. - In-house production may be considered depending on the scale of the utilization project.

Source: JICA Survey Team



Source: JICA Survey Team

Figure 5.1 Anticipated Overall Flow of Utilization

(3) III. Organization and Evaluation of Collaboration Partners

A total of 18 private companies and research institutes were interviewed, taking into account the following contents in order to organize information on them (Refer to Table 5.4). It is noted that the results were not included in this report because they non-public information of each company were included.

Table 5.4 Points of Information on Collaboration Partners

Item	Organizing Points
Timeline to application	While immediate solutions are required, organizing the expected timeline for the implementation of application of individual technologies in Central America and the Caribbean region.
Technological superiority	Organizing the technological superiority, in terms of their applicability to sargassum, their advantages in the Central American and Caribbean region, and the ripple effects and impact on the region resulting from the introduction of the technologies.
Corporate orientation	Compiling information on individual companies' overseas expansion experiences (Central America and the Caribbean Region, or other overseas countries) and their intentions regarding expansion into Central America and the Caribbean region based on interview survey.
Harmonization with scheme	Organizing the possibility of utilization of JICA Schemes (SATREPS, Partnership Program, SDGs Business supporting Survey, TSUBASA, Finance and Investment Cooperation, etc.) and other domestic institutional schemes (NEDO's International Demonstration Projects, etc.).
Harmonization with Country Assistance Policy	Whether the technology of each company and research institute can be contribute to the Priority Areas set in the Country Assistance Policy formulated by Ministry of Foreign Affairs for 23 countries in Central America and the Caribbean region. Since the target countries were not limited in the JICA Survey, focus was placed on (1) sustainable economic development (agriculture, fisheries, etc.), (2) building a resilient society (regeneration, energy conservation, climate change countermeasures), and (3) disaster prevention and environmental

Item	Organizing Points
	conservation, which are the Priority Areas for more than 10 of the 23 Central American and Caribbean countries.
Harmonization with target countries	Although it is recognized that harmonization with the strategies of sargassum and other national strategies of the recipient countries needs to be organized, putting on hold since it is out of the scope of the JICA Survey.

Source: JICA Survey Team

Based on the results of I. Examination of the Applicability of Each Technology, II. Examination of Technology Introduction Scenarios and III. Organization and Evaluation of Collaboration Partners, the five cooperation approaches shown in the next section are proposed.

5.2 Proposal of Cooperation Scenarios

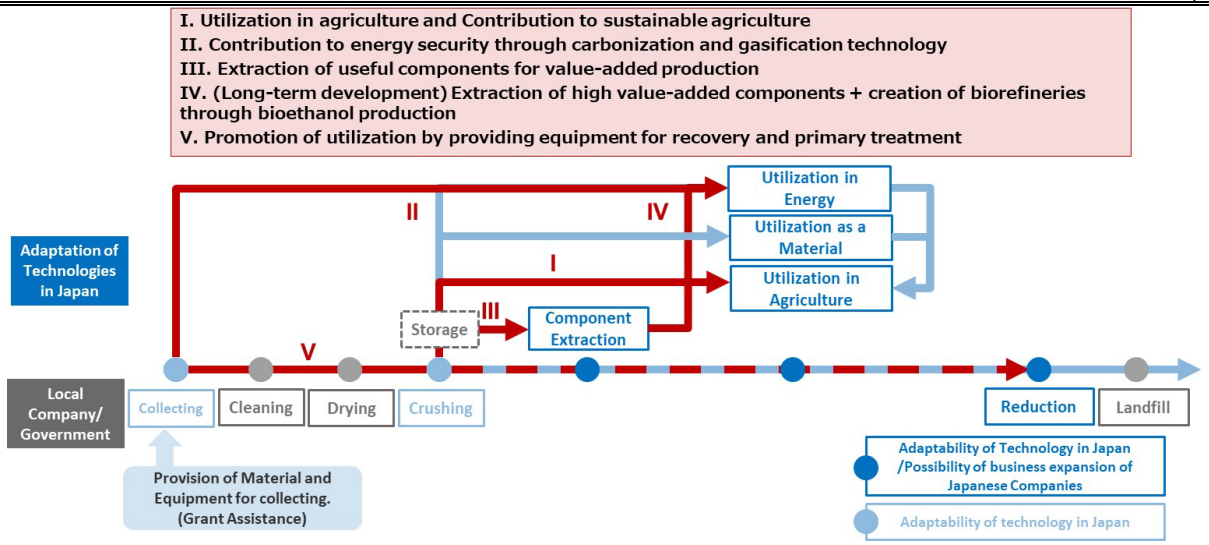
(1) Five Cooperation Approaches

Based on the above survey, five cooperation approaches are proposed as shown in Table 5.5 and Figure 5.2.

Table 5.5 Proposal of Five Cooperation Approaches

	Approach	Overview
I	Utilization in agriculture and contribution to sustainable agriculture	Technology of the production of compost, fertilizers, or biochar which is high adaptability with relatively simple implementation is adapted, aiming to enhance productivity in the key agricultural sector through soil improvement.
II	Contribution to energy security through carbonization and gasification technology	Energy production is carried out through the introduction of carbonization and gasification technologies that have the capacity to process a large amount of sargassum at a time. Input of organic wastes is also possible. Tipping fees and revenues from the sale of energy can be expected to guarantee the long-term viability of the project. Expected to be utilized as an alternative energy source to fossil fuels, contributing to regional energy security.
III	Extraction of useful components for value addition	The process of extracting useful components of viscous polysaccharides such as alginic acid will be carried out in the preliminary stages of agricultural and energy use, aiming to increase the value of the value chain.
IV	(Long-term development) Extraction of high value-added components and bioethanol production for biorefinery	Although still in the research stage, the extraction of components that are also of interest as pharmaceuticals, such as marine polyphenols, and the conversion of polysaccharides to ethanol will be carried out. In the future, the project will develop biorefinery creation technology starting with the formation of algal beds.
V	Promotion of utilization by providing equipment for collection and primary processing	Provision will be made for a combination of silt fence and water surface cleaning vessels for collection at sea before drifting to the coast. In addition, since primary processing (cleaning, drying, cutting, and crushing) is essential for utilization of sargassum for agriculture or component extraction, equipment and facilities for drying and crushing in particular will be provided to promote its utilization. (However, it is desirable to save as much energy as possible in order to reduce primary processing costs.) Furthermore, investment in facilities related to proper processing technologies such as waste reduction is also beneficial.

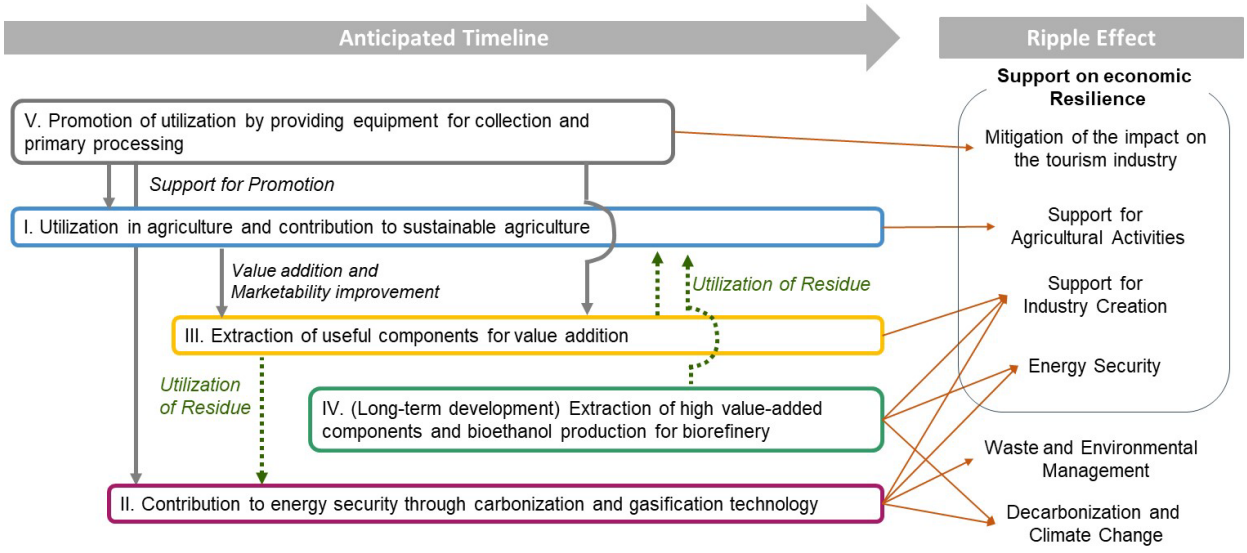
Source: JICA Survey Team



Source: JICA Survey Team

Figure 5.2 Overall Flow of the Cooperative Approach

Figure 5.3 illustrates the relationships between each of five collaboration approaches. To utilize sargassum effectively, both its collection and primary processing (cleaning, drying, cutting/shredding) are required, with the specific content varying depending on how to utilize sargassum. Currently, active utilization of sargassum is not being promoted in Central America and the Caribbean Region; It leads to a lack of proactive implementation of collection and primary processing for utilization. Expanding the initiatives on collection and primary processing by local government agencies and/or local partners are crucial, while provision of equipment utilizing technologies owned by Japanese companies for collection and primary processing manufactured by Japanese companies is considered effective to build foundation of its utilization at the local level. The adaptation of useful component extraction technology is assumed to be beneficial when the processing for generated residue is established in the process for utilization in agriculture and in energy.



Source: JICA Survey Team

Figure 5.3 Proposed Five Cooperation Approaches

Each of five cooperation approaches is summarized below.

Cooperation Approach I：Utilization in agriculture and Contribution to Sustainable Agriculture

Background

As shown in the table below, the agricultural sector is a primary industry in the key target countries of Central America and the Caribbean region. Furthermore, in 2020, CARICOM Heads of State and Government declared a 25% reduction in total food imports from outside the region by 2025 ("Vision 25% by 2025") and are reinforcing efforts toward food and nutrition security in the region. However, in recent years, challenges such as high climate change risks (floods, temperature variations, etc.), shortages of chemical fertilizers in the market due to its high prices in the post-COVID-19 period, decreased land productivity, and labor shortages have been identified.

Target Country	Business Environment for Technology in Japan for Utilization in Agriculture	Status of Agricultural Land Area
Dominican Republic	Agriculture is thriving throughout the year. High expectations for the effective use of agricultural residues (rice, bananas, etc.). Active research by universities and entry of private companies.	Of the total land area of about 4.84 million ha, about 2.46 million ha are agricultural land (51% of the country's land area) (about 1.25 times the size of Japan).
Saint Lucia	Agriculture is small-scale. Good access within the island due to its small size.	Of the total land area of 62,000 ha, about 10,000 ha are agricultural land (16.3% of the country's land area).
Belize	Farmland is scattered. High expectations for the effective use of residues from agricultural products (sugarcane, bananas, etc.).	Of the total land area of about 2.3 million ha, about 180,000 ha are agricultural land (8% of the country's land area).
Jamaica	Implementation of JICA's paid financial cooperation, great expectations for expansion to CARICOM.	Of the total land area of 1.1 million ha, about 423,000 ha are agricultural land (38.5% of the country's land area).
Mexico	Vast agricultural land area (production of avocados, corn, tomatoes, etc. is thriving). Agriculture is often managed by large corporations, but there are issues such as labor shortages, decreased land productivity, and the need to obtain certifications like Global GAP.	Of the total land area of 197 million ha, about 99 million ha are agricultural land (50% of the country's land area) (about 50 times the size of Japan).
Honduras	High dependency on primary products such as coffee and bananas.	Of the total land area of 11.25 million ha, 3.6 million ha are agricultural land (32% of the country's land area) (about 1.8 times the size of Japan).

Overall Goal of the Approach

This approach is to develop a business model for the production and sale of soil conditioners and organic fertilizers made from sargassum to support soil conservation and improvement against declining productivity of farmlands due to the expansion of erosion areas, etc., and to support the establishment of sustainable agricultural activities through local production for local consumption as an alternative to

fertilizer imports. This will contribute to the creation of employment and value-added products in the agricultural sector, as well as reduce the high cost of fertilizer imports in the region used by farmers.

Key Points for Sargassum Utilization

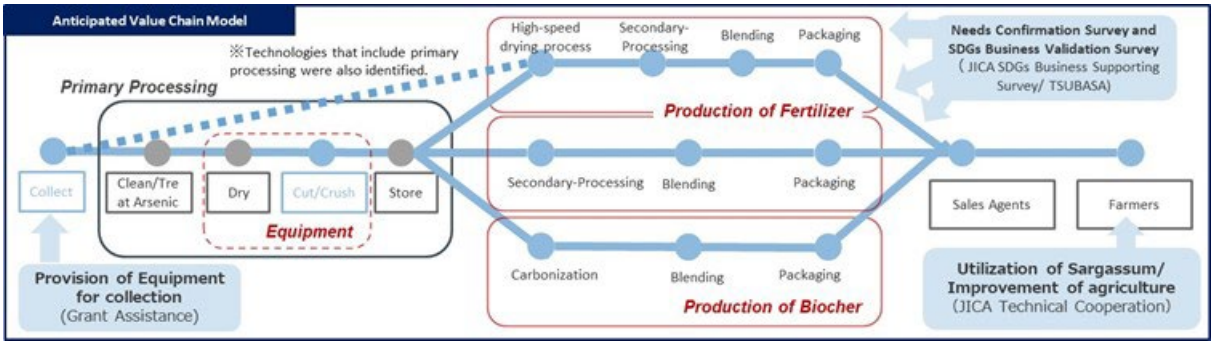
Established seaweed fertilizer technology: Seaweed components have long been used in agriculture in Japan. Various research on development of various products of fertilizer and soil conditioners and fertilizer application methods have been ongoing, making it possible to support not only product manufacturing but also farming utilizing the seaweed fertilizer.

Variety of methods of application to agricultural lands: Since there are various forms of seaweed for soil application, such as crushed seaweed, composting, and biochar, it is possible to develop products and blend nutrients to suit the soil, thereby enabling the production of high value-added fertilizers.

Benefit to farmers: The project will contribute to reducing the high purchase cost of chemical fertilizers used by farmers, and the seaweed effect will be beneficial for sustainable agricultural activities by improving fertile land and promoting organic farming methods.

Anticipated Value Chain

Depending on the technology utilized, primary processing and the necessary facility/equipment may differ. Procurement of raw materials requires coordination with local government agencies with collection jurisdiction and primary processing partners. In the fertilizer application stage, technical guidance on fertilizer application and methods for each crop will be required, so the technical cooperation project will train agricultural extension agents.



Source: JICA Survey Team

Figure 5.4 Anticipated Value Chain (Cooperation Approach I)

Prerequisites for Utilization

Securing primary processing, including the drying process, for a stable and inexpensive supply of raw materials: To be viable as a business, the raw materials for fertilizer and biochar production must be inexpensive and stably supplied. In order to ensure a stable supply, a business model must be developed that can guarantee a stable input of raw materials by considering a process for storing the amount of sargassum collected at the time of mass drift of sargassum in a dried state after primary processing, given the seasonal inflow of sargassum and the fact that the future occurrence of sargassum

is not yet known. In addition, the possibility of inputting biomass other than sargassum may also be considered. In order to ensure business feasibility, it is also necessary to study the process method from the perspective of economic and energy balance in the primary and secondary processing.

Ensuring Market Stability: Given the confirmed manufacturing of soil conditioners using sargassum in Central America and the Caribbean region, there is a certain potential market of organic fertilizers and soil conditioners derived from seaweed. By implementing support for farmers in utilizing these products, there is the potential for market expansion and stabilization. Central America and the Caribbean region heavily relies on imported chemical fertilizers; therefore, a localized consumption model could be plausible with increased understanding and acceptance among farmers for fertilizers and soil conditioners derived from sargassum.

Cooperation with Local Government Agencies: Cooperation with government agencies with agricultural authority is required to provide assistance to farmers regarding the use of seaweed-based fertilizers and soil conditioners to build sustainable agricultural activities.

Items to be Examined for Adaptation of the Technology

【Technology Adaptability】Sargassum composition survey (including arsenic/heavy metals and salts), agricultural soil, fertilizer quality based on demonstration, experiments with fertilizer application, and finalization of equipment.

【Market】Needs, market prices, and competitive environment in and around the target country

【Local partners】Primary processing / Sales agents

【Acceptability】Relevant laws and regulations, degree of cooperation from local government, target region

【Value Chain】Verification of primary processing/sales agents and potential customers.

【Profitability study】Cost/Sales analysis

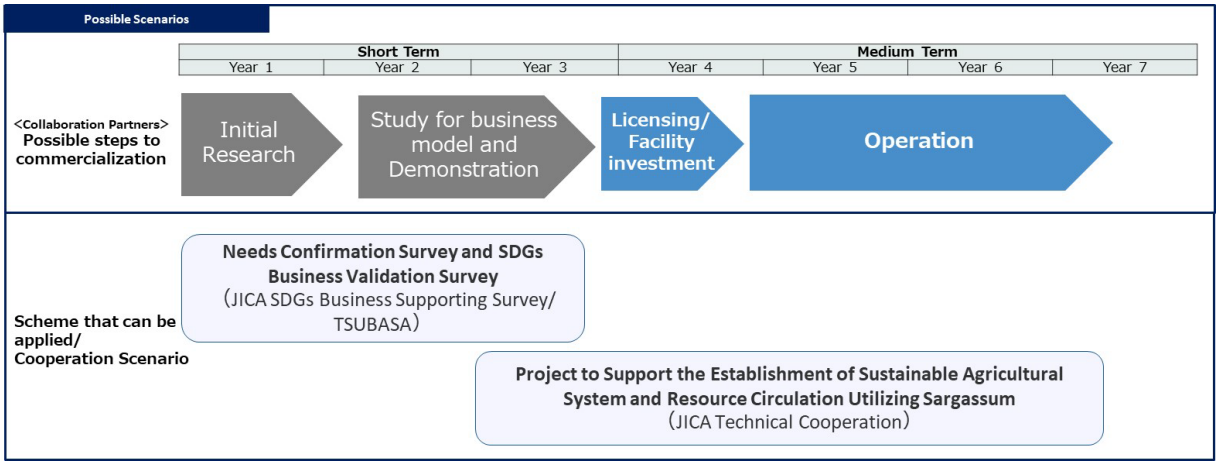
Possible Local Counterparts	**Other Key Stakeholders**
− Ministry of Agriculture, Forestry and Fisheries (for agriculture) − Ministry of Environment and Natural Resources (for marine environment, waste management, etc.) − Local Government in the Target Area (responsible for collecting sargassum and waste management)	− Local farmers − Private companies (primary processing, fertilizer production, sales agents)

Proposed Cooperation Scenarios

Needs Confirmation Survey and SDGs Business Validation Survey for the fertilizer and biochar technology utilizing sargassum (JICA SDGs Business Supporting Survey /TSUBASA): The field

survey on needs, market, competitive environment, and related laws and regulations in Central America and the Caribbean region, and study of business models will be conducted by JICA SDGs Business Supporting Survey. TSUBASA can be applied to identify development partners.

Project to support the establishment of sustainable agricultural system and resource circulation utilizing sargassum (JICA Technical Cooperation): Training of agricultural extension workers will be provided as technical cooperation for the entry point (collection) and exit point (agricultural extension) to facilitate the agricultural use of sargassum. Along with the establishment of a resource cycle from collection to utilization of sargassum, the project will also support the application of climate change in the agricultural sector, including the dissemination of organic farming methods.



Source: JICA Survey Team

Figure 5.5 Possible Timeline and Cooperation Scenarios of the Cooperation Approach I

Cooperation Approach II : Contribution to Energy Security through Carbonization and Gasification Technology

Background

Many Central American and the Caribbean countries are still highly dependent on fossil fuels as an energy source and import dependent. For example, in the Dominican Republic, approximately 88% of energy supply (based on electricity generation) comes from fossil fuels, 9% from biofuels, and only 3% from other renewable energy sources. Furthermore, about 52% of fossil fuels are imported (IEA Energy Statistics, 2021) (Refer to Figure 5.6). More than half of the countries

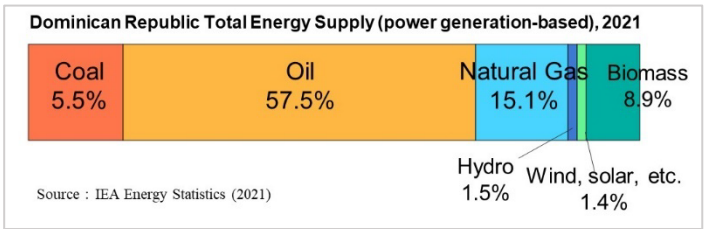


Figure 5.6 Dominican Republic Total Energy Supply (2021)

have identified building resilient societies as the Priority Area in their Country Assistance Policy, and energy security is an important factor.

The adaptation of carbonization and gasification technology utilizing organic waste to sargassum will enable the creation of green energy as well as the treatment of large quantities of sargassum.

In addition, the current waste management in the Central American and the Caribbean Region, where general and business wastes are mainly dumped in final disposal sites without intermediate treatment (e.g., incineration), the future application of this technology to the treatment of organic wastes would be beneficial.

Since the above utilization and proper treatment efforts will contribute to CO2 reduction, it is conceivable to establish a carbon credit generating business.

The initiatives in utilization and proper processing mentioned above will not only contribute to building a decarbonized society but also present an opportunity for establishing a carbon credit business.

Overall Goal of the Approach

This approach is to create biomass energy by introducing carbonized gasification technology from sargassum to reduce the import and use of fossil fuels, and to provide a boost to the promotion of energy security and climate change action.

Key Points for Sargassum Utilization

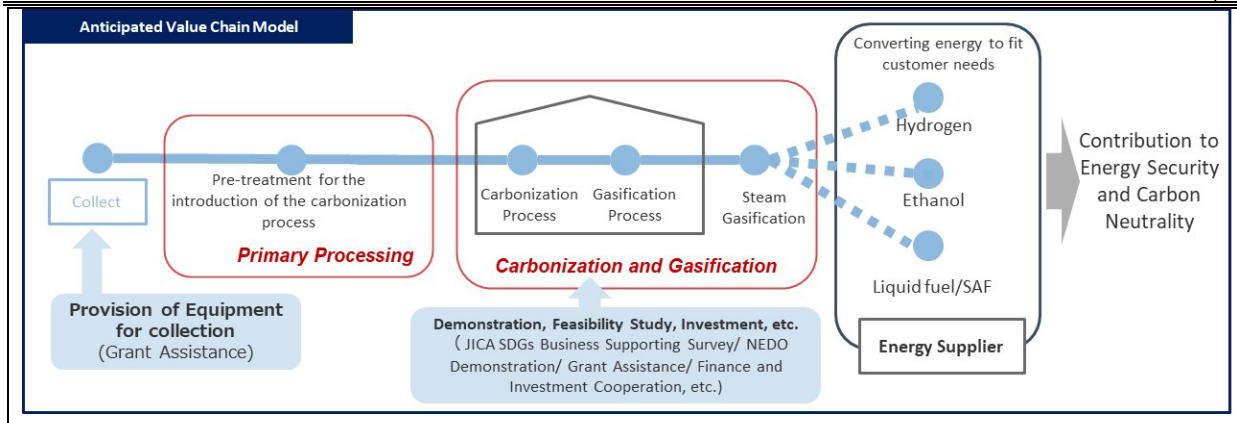
Utilization of new Japanese technology: The primary processing technology and carbonization and gasification technology developed by a Japanese small-medium-sized company will enable the conversion of sargassum an well as organic waste with high water content into biomass energy. The primary processing process will enable a stable fuel supply to the carbonization and gasification equipment, and at the same time, other organic wastes can be considered for input. The technology has minimal environmental impact because there are no wastewater emissions and only a small amount of inorganic material (e.g., phosphorus) is discharged from the residues.

Technology with low CAPEX: OPEX requires capital investment in each process, but the energy input is limited to ignition only, as the system is continuous and self-combustion during operation.

Diversification of energy to be extracted: Since the output can be tailored to the customer in the form of energy, there are many options for sales destinations.

Anticipated Value Chain

The collected sargassum is treated by primary processing to a form suitable for introduction into the carbonization unit, and then undergoes carbonization and gasification processes, followed by various energy conversions according to market demand.



Source: JICA Survey Team

Figure 5.7 Anticipated Value Chain (Cooperation Approach II)

Prerequisites for Utilization

Profitability: Whether there is a system that can secure revenue from tipping fees and energy sales, as in the case of conventional waste power generation.

Cooperation with local government agencies: It is very important to cooperate with local government agencies in the development of a system to accept collected sargassum (cost sharing, selection of a suitable site for primary processing, establishment of a comprehensive and efficient system, etc.), and establish a framework for cooperation with relevant government agencies regarding connection to the energy supply network, etc..

Coordination with various energy suppliers: It is necessary to confirm whether there is a place to sell the energy to be generated, the form of energy, and the coordination system.

Items to be examined for Adaptation of the Technology

【Technology Adaptability】Technology demonstration using similar seaweeds using demonstration systems in Japan

【Market】The needs, sales methods, and prices related to various forms of energy

【Local partners】Trading partners for energy sales

【Acceptability】Relevant laws and regulations (tipping fees, FIT system, etc.), degree of cooperation from local government, target area

【Value Chain】Consideration of facility layout considering the scope of the project

【Profitability study】Cost/sales analysis

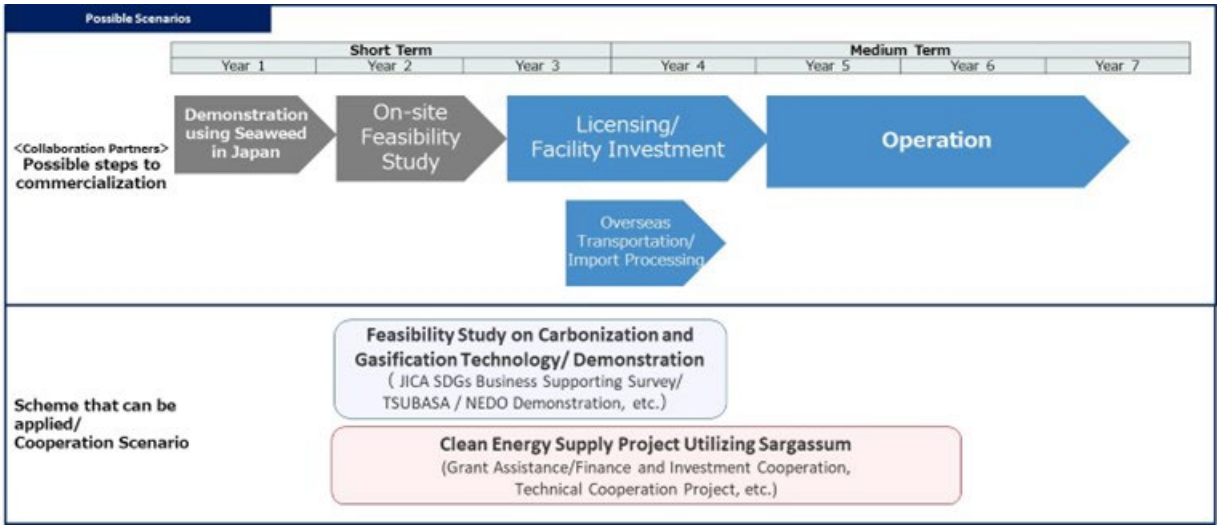
Possible Local Counterparts	**Other Key Stakeholders**
- Ministry of Energy - Ministry of Environment and Natural Resources (for marine environment, waste management, etc.)	- Energy Supplier

- Local Government (responsible for collecting sargassum and waste management)	

Proposed Cooperation Scenarios

Feasibility Study on Introduction of Organic Carbonization and Gasification Technology (JICA SME/SDGs Business Support Program/NEDO Demonstration): Conduct a field survey on the needs, city, competitive environment, and related laws and regulations in the Central American and Caribbean region, study business models, and confirm the technological adaptation to sargassum through a demonstration.

Clean energy supply project utilizing sargassum (Grant Assistance/ Finance and Investment Cooperation (JICA Scheme/Private sector), Technical Cooperation Project): Grant Assistance, JICA Scheme on Finance and Investment Cooperation, or private sector investment will be utilized for the introduction of energization technology. In addition, a capacity building project including the operation of the facility can also be implemented with support of the Technical Cooperation Project.



Source: JICA Survey Team

Figure 5.8 Possible Timeline and Cooperation Scenarios of the Cooperation Approach II

Cooperation Approach III：Extraction of Useful Components for Value Addition

Background

Useful components of seaweed such as alginic acid and biopolyphenols are highly versatile in foods, pharmaceuticals, cosmetics, feeds/fertilizers, etc., and the global market size is said to be expanding. Some components can be traded as expensive products. Residues from the extraction of the components can be used for energy or agriculture, and thus linkage from cooperative approach III to cooperative approaches I and II is possible, which is expected to increase the added value of the entire value chain. In Central America and the Caribbean region, research on the extraction of useful components from seaweed (e.g., University of the West Indies, Barbados) and private companies (e.g., Mexico) have been

identified, and further expansion as an industrial sector can contribute to economic growth and the creation of a strong economic foundation.

Overall Goal of the Approach

Increase the added value of sargassum by establishing the process of extracting useful components as a preliminary step for agricultural use and energy use, and bring about business security and economic benefits by increasing value throughout the value chain.

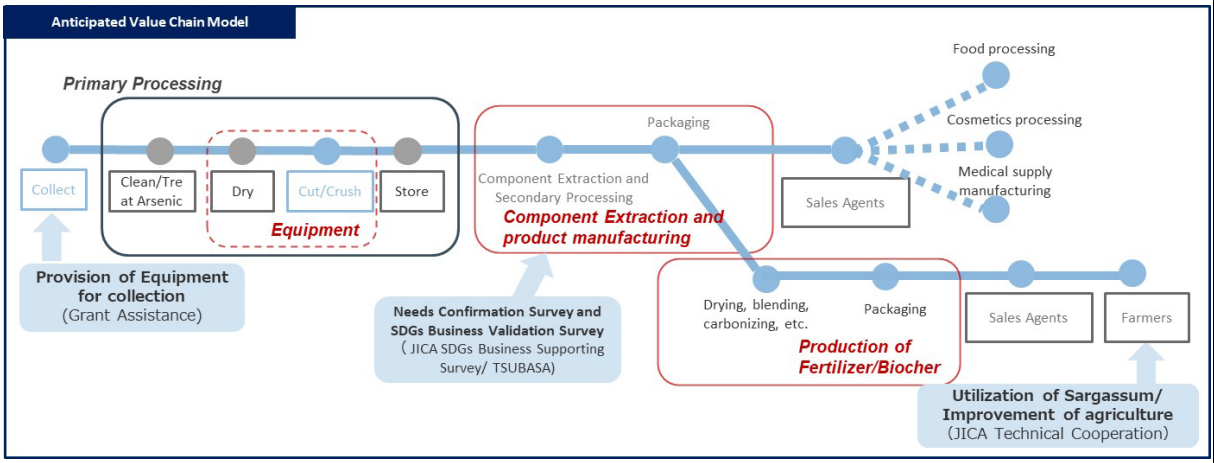
Key Points for Sargassum Utilization

Stable supply through stock storage: To achieve a stable product supply, it is important to keep the cost of the drying process below the cost of the raw material, sargassum, because the storage of sargassum must be implemented at a low cost.

Utilization of residues after component extraction: Residues after component extraction can be utilized as energy or agricultural use. Since it can be utilized as energy use or agricultural use, appropriate residue treatment methods should be considered.

Anticipated Value Chain

After primary processing for storage of sargassum as raw material, component extraction will be conducted. The residue will be used as seaweed fertilizer or biomass fuel.



Source: JICA Survey Team

Figure 5.9 Anticipated Value Chain (Cooperation Approach III)

Prerequisites for Utilization

Component analysis and market research: Analyze the percentage of high value-added components contained in sargassum, estimate the scale of commercialization, and consider whether cleaning is necessary.

Stable supply from inexpensive primary processing: Since the unit price may not be high depending on the useful components to be extracted, it is necessary to establish a value chain that can procure raw materials (dried and crushed sargassum) as inexpensively as possible. Depending on the energy used in

the drying process, it may be expensive in regions that depend on imports, so this needs to be considered. Dried and crushed sargassum can be stored at room temperature to some extent, and storage in this condition will lead to stable operation of the secondary process.

Use of fresh water: Securing fresh water necessary for extraction of useful components and treatment of wastewater after the process should be investigated in advance from the viewpoint of environmental and social considerations.

Residue treatment: Appropriate treatment of residues (scientifically stable) after extraction of useful components should be considered for agricultural use or use as biomass energy.

Items to be examined for Adaptation of the Technology

【Technology Adaptability】Content of useful ingredients in sargassum (alginic acid, marine polyphenols, etc.)

【Market】Needs, market prices, and competitive environment in and around the target countries.

【Local partners】Primary processors/sales agents, recipients of residues (agricultural use, energy use)

【Acceptability】Relevant laws and regulations, target regions

【Value Chain】Primary processors, distributors, composters/organic waste processors, verification of potential customers

【Profitability study】Cost/sales analysis

Possible Local Counterparts

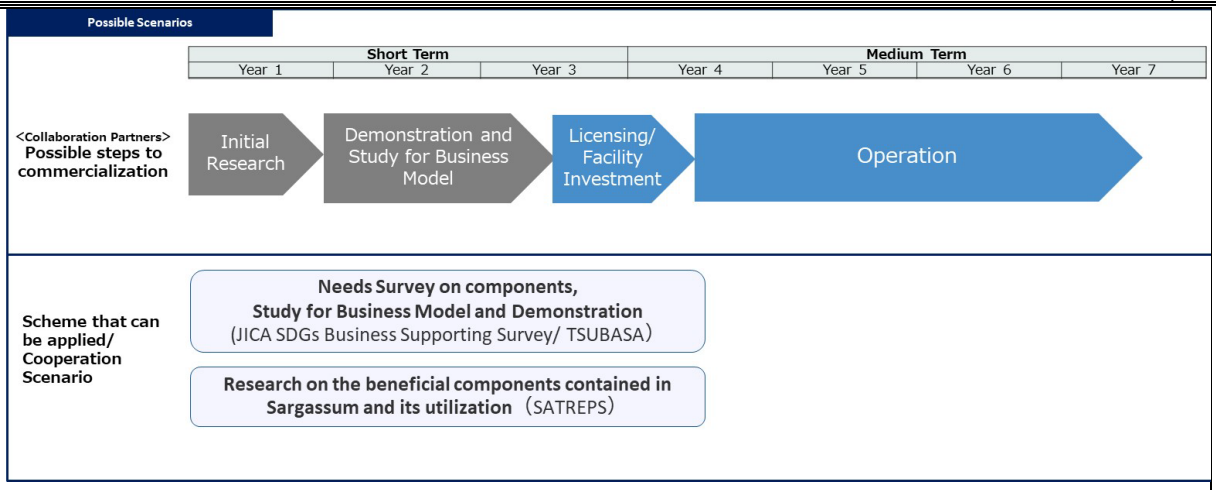
- Ministry of Environment and Natural Resources (for marine environment, waste management, etc.)
- Local Government (responsible for collecting sargassum and waste management)

Other Key Stakeholders

- Industries that use useful ingredients as raw materials (food processing, cosmetics processing, pharmaceutical manufacturing, etc.)
- Companies receiving residues (agricultural use, energy use)

Proposed Cooperation Scenarios

Needs assessment and business demonstration for the extraction of sargassum-derived components (JICA Small and Medium Enterprises, SDGs Business Support Program, TSUBASA, SDGs Business Support Type, SATREPS): Conduct local needs assessment and selection of cooperation partners, etc., and study business models. For large companies, FS/demonstration by SDG business support type can be considered. For research institutions, SATREPS could be implemented as a framework that includes commercialization with private companies.



Source: JICA Survey Team

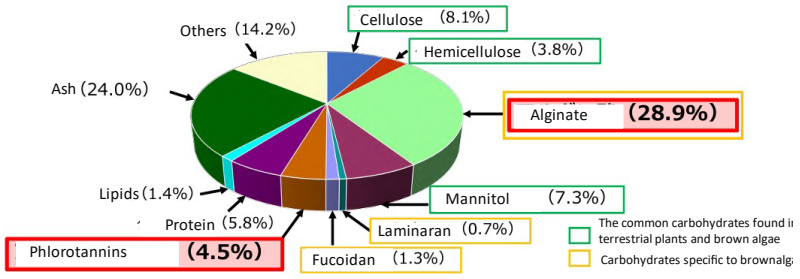
Figure 5.10 Possible Timeline and Cooperation Scenarios of the Cooperation Approach III

Cooperation Approach IV : (Long-term development) Extraction of High Value-added Components and Bioethanol Production for Biorefinery

Background

From Research and Development to Social Implementation of Macroalgae's Bio-Refinery: In Japan, foundational technology research and development is underway for the complete utilization of macroalgae. This includes the extraction of valuable components (functional ingredients, resin materials), ethanol production using specific yeast, and the cascading utilization of residues (mainly ash content) in agriculture. Efforts are being made towards the creation of a comprehensive bio-refinery. Additionally, macroalgae are known to absorb approximately 10 times more CO_2 than terrestrial plants, holding expectations for both environmental restoration and material production.

Establishment of High-Value Component Extraction Technology: Macroalgae contain diverse valuable components (refer to Figure 5.11), and practical extraction of alginate and fucoidan has already been achieved. For phlorotannins, Mie University has successfully developed an extraction method from brown algae in the family Sargassaceae, known as Marine Polyphenols ※, and industrial-level production is now possible. Marine Polyphenols are known for their antioxidant and anti-glycation activities, and they are currently used in components of ingestible sunscreens. Due to their wide



Source：FY 2021 NEDO Exploratory Research Program / Energy and Environment Leading Technology Exploratory Research Program "Development of Fundamental Technology for the Complete Utilization of Large Seaweeds" - Presentation Material by Professor Shibata of Mie University, October 2022.

Figure 5.11 Components in the Fucales, Brown Macroalgae

range of potential applications in functional foods, pharmaceuticals, and cosmetics, further research and development are underway for their commercialization.

Development of Ethanol Production Technology: Macroalgae contain a high proportion of polysaccharides, and research and development are ongoing to convert all polysaccharide components into ethanol. Currently, the team from Kyoto University and others has developed genetically modified yeast and demonstrated ethanol fermentation on a bench scale. Macroalgae as a raw material for bioethanol are attracting attention due to their high CO_2 fixation rate, simple ethanol production process (fermentation by yeast), and minimal competition with food. Moreover, the residue (mainly ash content) after ethanol production can be used as a soil conditioner, enabling the complete utilization of seaweed through cascade utilization.

Utilization as Blue Carbon: Utilizing the cultivation technology of macroalgae, the comprehensive long-term business model for the utilization of sargassum can be considered, focusing on CO_2 fixation and stable supply achieved by the growth rate of sargassum.

※Marine polyphenols are substances registered as trademarks by Mie University. They have a chemical structure completely different from the polyphenols found in terrestrial plants and exhibit excellent physiological functions such as antioxidant, anti-glycation, and anti-inflammatory activities.

Overall Goal of the Approach

A comprehensive initiative aimed at creating a bio-refinery through the complete utilization of macroalgae, constructing a platform that allows for seamless efforts. This includes the extraction of valuable components from sargassum (such as marine polyphenols), manufacturing functional foods and healthcare products utilizing these components, and producing bioethanol. The goal is to contribute to human health, energy security, and the realization of carbon offset through blue carbon.

Key Points for Sargassum Utilization

Long-term development of research and development stage technologies: Some technologies are at the research and development stage, and their deployment will depend on progress in domestic demonstration experiments and industrial-level implementation.

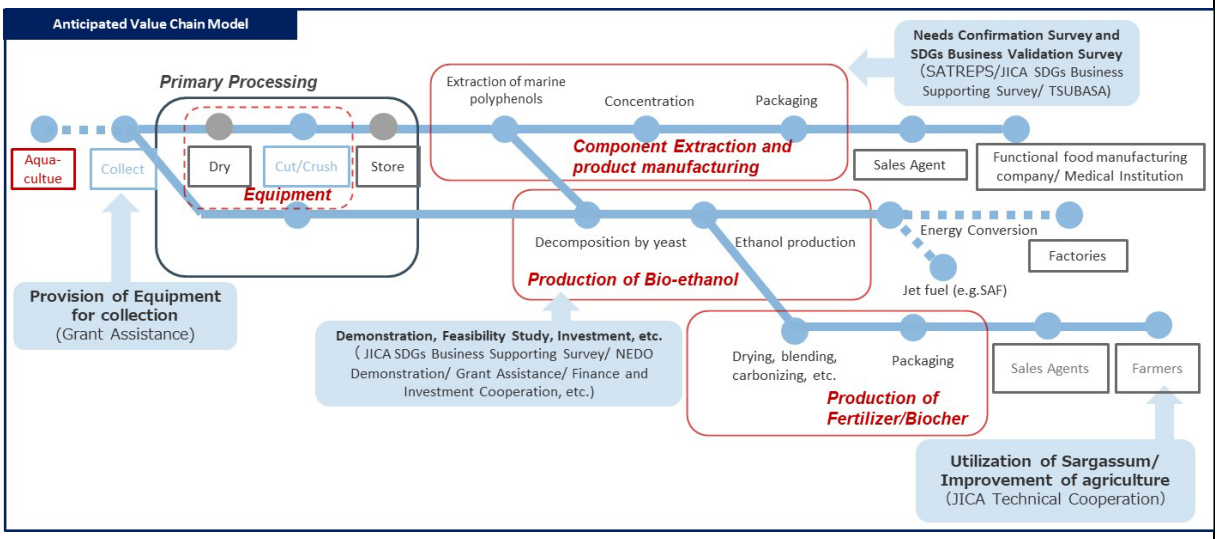
Reduction of production costs: Reduction of primary processing costs, consideration of processes that reduce energy use in the drying process

Selection of target sites: This approach is a proposal that combines Japan's advantage in various utilization technologies. It is useful to organize the location conditions from a comprehensive perspective, considering the transportation of sargassum from the collection and primary processing stages to various manufacturing processes and energy supply destinations.

Anticipated Value Chain

In the case of extraction of useful components, the processing is after the primary processing, while in the case of direct conversion to energy, the washing and drying processes are not necessary. Depending

on local demand, energy conversion after production of bioethanol will be considered. Residue will be used as seaweed fertilizer after drying. Possible introduction of aquaculture technology to secure a stable supply of sargassum in future.



Source: JICA Survey Team

Figure 5.12 Anticipated Value Chain (Cooperation Approach IV)

Prerequisites for Utilization

Compositional analysis and market research: The percentage of high value-added components such as bio-polyphenols contained in sargassum will be analyzed to estimate the scale of commercialization and to determine whether cleaning is required. In addition, energy conversion methods after production of bioethanol will be determined through a survey of energy demand.

Use of fresh water: Securing fresh water necessary for extraction of useful components and treatment of wastewater after the process should be investigated in advance from the perspective of environmental and social considerations.

System for social implementation through collaboration between research institutions and private companies: A system for collaboration with private companies responsible for social implementation should be established in advance to ensure social implementation smoothly from the research and development phase and to accelerate the process.

Items to be examined for Adaptation of the Technology

【Technology Adaptability】 Survey of sargassum components (including useful components, arsenic/heavy metals, and salts), and the availability of raw materials for ethanol conversion.

【Market】The needs for functional foods, pharmaceuticals, energy, and fertilizers in the target country and its surrounding areas

【Local partners】Primary processing and sales agents

【Acceptability】Relevant laws and regulations, degree of cooperation from local governments, target regions

【Value Chain】Involvement of primary processing/agents, verification of potential customers, and trading companies responsible for technology transfer

【Profitability study】Cost/sales analysis

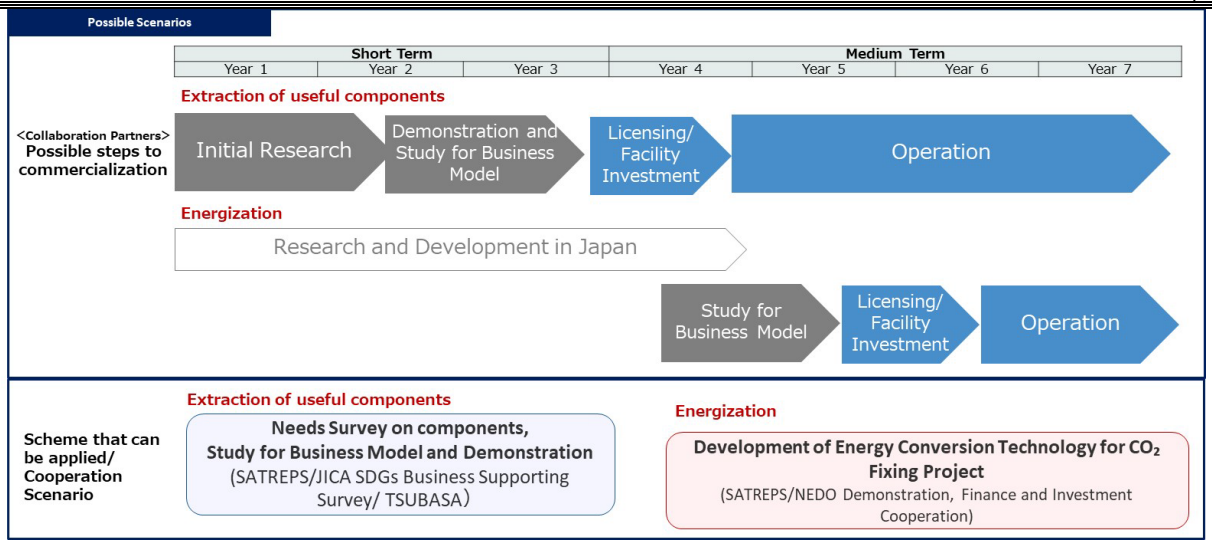
Possible Local Counterparts	**Other Key Stakeholders**
- Ministry of Health, Labour and Welfare (Licensing and approval of pharmaceutical products)) - Ministry of Energy - Ministry of Agriculture, Forestry and Fisheries - Ministry of Environment and Natural Resources (for marine environment, waste management, etc.) - Local Government (responsible for collecting sargassum and waste management)	- Local research institutes (extraction of useful components from seaweed) - Industries that use useful ingredients as raw materials (food processing, cosmetics processing, pharmaceutical manufacturing, etc.)

Proposed Cooperation Scenarios

Needs assessment and business demonstration for the utilization of useful components contained in sargassum (SATREPS / JICA SDG Business Supporting Survey): For the extraction of useful components, SATREPS can be applied for research and development or the JICA's scheme of the SDG Business Supporting Survey will be available for investigation on local partners, markets, study on the business model and implementation of demonstration, followed by commercialization in the private sector.

Project for the development of energy conversion technology for CO2-fixing macroalgae (sargassum) (SATREPS/NEDO Demonstration, JICA's Financing and Investment Cooperation, or private sector's investment and loan): SATREPS can be applied for implementation of comprehensive research and development for the energy conversion of sargassum. The utilization of NEDO's scheme for international demonstrations※ can be considered to be applied. For the commercialization, options such as JICA's Financing and Investment Cooperation or private fund can be examined.

※ International Demonstration Project on Japan's Technologies for Decarbonization and Energy Transition, https://www.nedo.go.jp/english/activities/activities_AT1_00175.html



Source: JICA Survey Team

Figure 5.13 Possible Timeline and Cooperation Scenarios of the Cooperation Approach IV

Cooperation Approach V : Promotion of Utilization by Providing Equipment for Collection and Primary Processing

Background

Source: CIIMAR
Collection by local residents in Mexico

In Central America and the Caribbean region, the collection of sargassum is currently being carried out by local government agencies, the hotel industries, some private companies (such as bio-stimulant manufacturing companies), and residents, but it is not sufficient. While some collection activities take place along the coast using boats, the majority involve the manual collection of beached sargassum on the shores. However, beachside collection of beached sargassum has been criticized for issues such as foul odor, hydrogen sulfide gas emissions, beach erosion, and ecological impacts, while the collection at sea before it reaches the shore is not widely utilized due to cost-related challenges.

For the development of utilization in agriculture (Cooperation Approach I) and the component extraction processes (Cooperation Approach III-IV), reliable raw material sourcing is essential. Hence, the collection and primary processing (cleaning, reduction of arsenic (if possible), drying, cutting/shredding) of sargassum are crucial steps. To avoid inefficient internalization of each process by individual businesses, it is effective to establish centralized processing facilities for primary processing in key regions. In this regard, the technologies possessed by Japanese companies related to sargassum collection (both on land and at sea), drying, cutting, and shredding could be provided through the Grant Assistance by the Ministry of Foreign Affairs of Japan. Considering that full processing of all collected sargassum may be challenging, appropriate intermediate

processing, such as reduction or incineration, and proper disposal methods like landfilling, should be implemented for the sargassum that cannot be utilized.

Overall Goal of the Approach

To mitigate the impact of sargassum on the local environment and promote its utilization, efficient at-sea collection of sargassum by providing silt fences and waste collection vessels, facility development for the primary processing and provision of equipment and technical support for proper treatment will be conducted.

Key Points for Sargassum Utilization

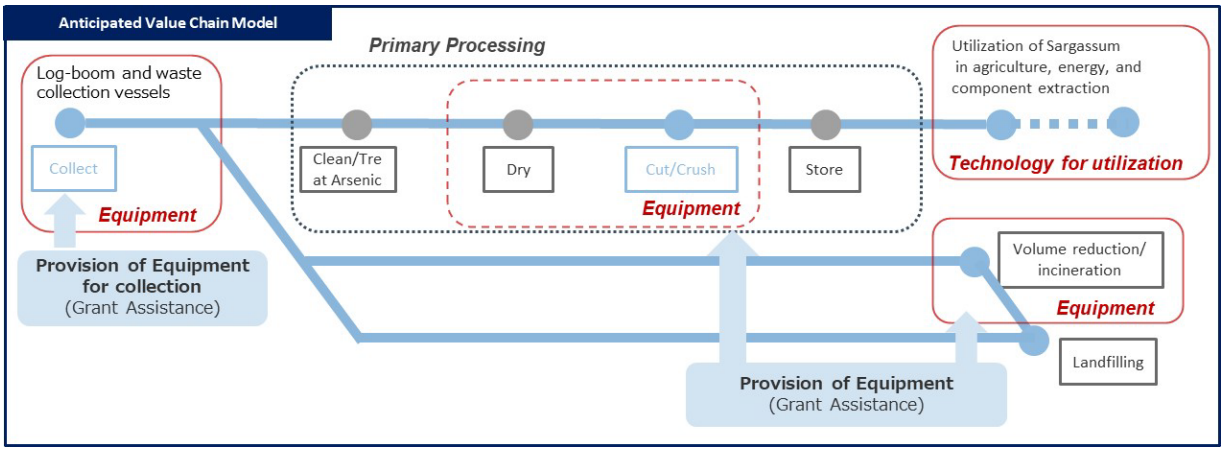
Selection of priority sites for sargassum collection and primary processing: The influx of sargassum has been observed across a wide range of the Caribbean Sea coastal areas. Among these areas, the collection of sargassum in regions where its impact on tourism, fisheries, and local livelihoods is significant, are considered to be prioritized areas. Currently, there is often a situation where the collected sargassum is disposed of in the nearby area, creating a need for a streamlined process for both collection and primary processing. To address this, it is crucial to establish a comprehensive process, especially in areas with existing infrastructure like developed fishing ports, allowing for the efficient offloading of sargassum from the sea and the installation of primary processing facilities.

Consideration of efficient drying process: The utilization methods for sargassum may involve technologies that eliminate the need for a drying process. However, from the perspective of raw material storage, the drying process for sargassum is necessary as a primary processing step for the majority of utilization methods. On the other hand, drying requires a substantial amount of energy, so considerations regarding energy balance and economic efficiency necessitate the exploration of cost-effective and energy-efficient methods such as sun drying. Investigations and assessments are needed to explore the feasibility of sun drying, including whether there are suitable regions with dry climates and vast land for sun drying. Efficient methods for the primary processing, particularly the drying process, require careful research and consideration.

Anticipated Value Chain

Collection and primary processing: Aim to promote the utilization of sargassum through collection and primary processing. Consider options, collaboration with local companies that are engaged in primary processing, option for in-house processing within each project, etc. Equipment for lifting sargassum ashore and facilities for primary processing near the lifting point are required. In this sense, it may be possible to consider local fishing associations taking on the responsibility for the collection and primary processing of sargassum.

Intermediate Processing (volume reduction, etc.) and Landfill: Given the difficulty of processing the entire amount of sargassum in the utilization of sargassum, it is essential to explore the adaptability of Japanese technologies for intermediate processing (volume reduction, incineration) and final disposal (proper landfill). Among these, organic waste reduction technologies are considered highly applicable to



sargassum.

Source: JICA Survey Team

Figure 5.14 Anticipated Value Chain (Cooperation Approach V)

Prerequisites for Utilization

Securing budget and human resources for appropriate operation and maintenance of equipment of local government agencies: Regarding the procured equipment, whether it is possible to establish an operation and maintenance management system, including budget and human resources.

Collaboration with local government agencies and stakeholders: Assessing the feasibility of establishing a collaborative framework with local government and other stakeholders (Fishing industry associations, hotel industry, etc.) for the collection and primary processing of sargassum.

Items to be examined for Adaptation of the Technology

Cooperation and collaboration with local stakeholders: Cooperation and collaboration with local stakeholders, including relevant government agencies and port authorities, are crucial for the offshore collection of sargassum. This involves setting up log boom with heavy machinery, removal during hurricanes, operation of vessels for transporting sargassum, and the maintenance of facilities for onshore handling. Furthermore, it is desirable to conduct the primary processing of sargassum in locations near the collection sites. It is essential to assess whether a collaborative framework with local stakeholders for the collection and primary processing can be established or how cooperation can be facilitated within the existing collection system.

Possible Local Counterparts	**Other Key Stakeholders**
- Ministry of Agriculture, Forestry and Fisheries (Fisheries Affairs)	- Fishermen's Association - Surrounding residents

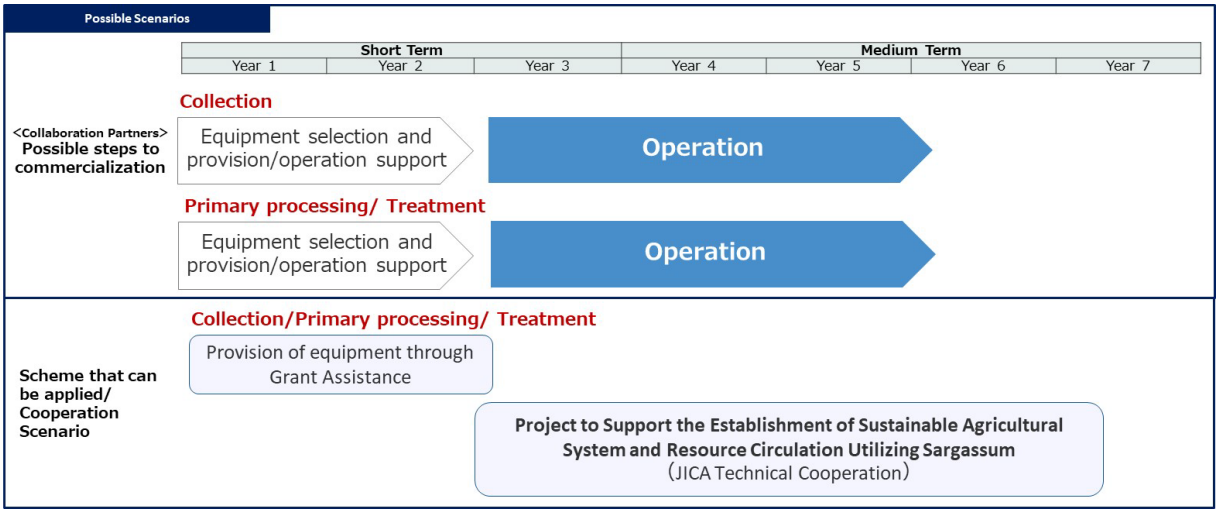
- Ministry of Environment and Natural Resources (for marine environment, waste management, etc.) - Local Government (responsible for collecting sargassum and waste management)	- Private companies (primary processing, fertilizer production, distributors)

Proposed Cooperation Scenario

Utilization of the Grant Assistance from the Ministry of Foreign Affairs of Japan: Provision of equipment for offshore and onshore collection of sargassum and equipment for primary processing facilities.

Establishing the collection and primary processing processes concurrently or before the introduction of sargassum utilization technologies will contribute to fostering utilization activities.

Lateral support through JICA Technical Cooperation Project: As one component of the proposed Technology Cooperation Project for utilization in agriculture, provide technical support for the sargassum collection and primary processing under the jurisdiction of the local government.



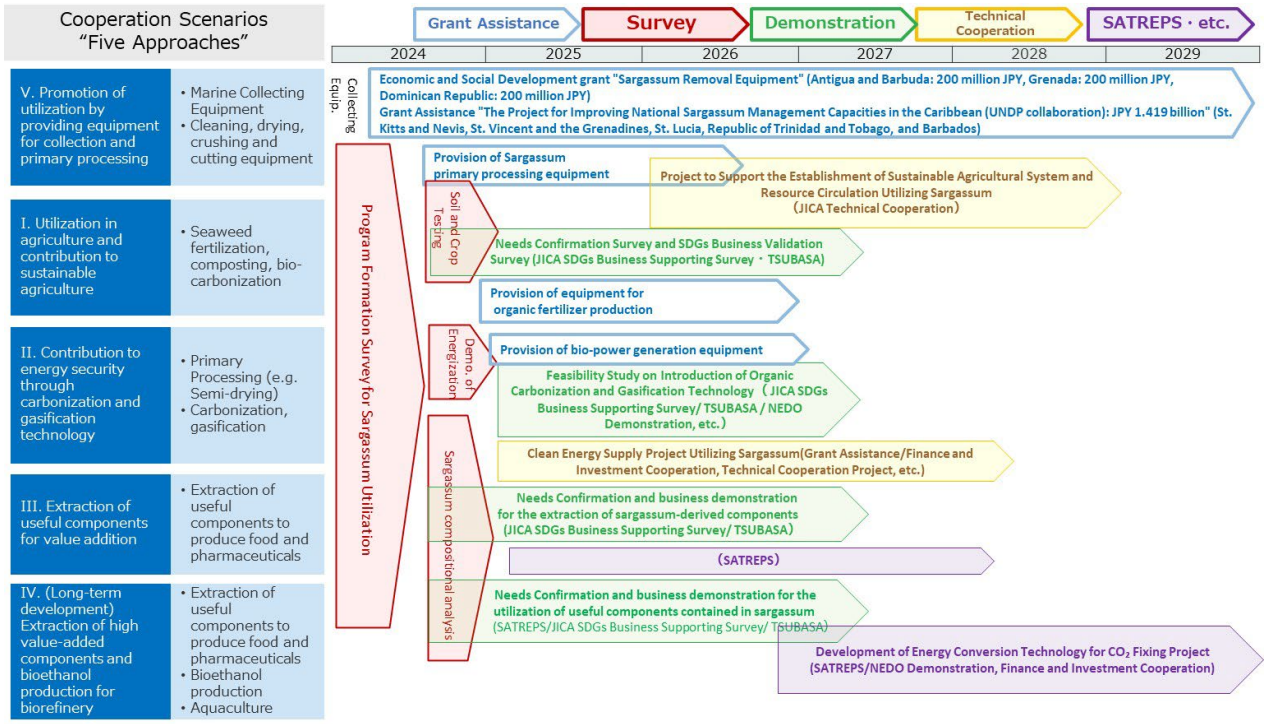
Source: JICA Survey Team

Figure 5.15 Possible Timeline and Cooperation Scenarios of the Cooperation Approach V

(2) Overall Concept of Proposed Cooperation Scenarios

Based on the above five approaches, the overall concept of proposed future cooperation scenarios is summarized in Figure 5.16 for each support scheme. Japan's support for Central America and the Caribbean region in relation to sargassum is already underway in the Dominican Republic, Grenada, and other countries through the Ministry of Foreign Affairs of Japan's Grant Assistance "Economic and Social Development Program" for the provision of sargassum removal equipment. In order to realize the deployment of technologies in Japan for utilization of sargassum, it is necessary to first draw a roadmap for a comprehensive cooperation scenario based on the local situation. For this purpose, the implementation of a program formulation survey on the utilization of sargassum is considered to be useful.

The program formulation survey will identify priority areas for sargassum removal, conduct local surveys on stakeholders, local needs and market trends related to the utilization technology, and value chain development including local partners for business development, and then determine how Japan's utilization and appropriate treatment technology can be applied to these areas. It is necessary to organize how it is beneficial to apply Japanese utilization and appropriate treatment technologies. Based on these arrangements, it is important to (1) consider a comprehensive cooperation program including deployment of collection and primary processing equipment, and (2) conduct specific considerations regarding the priority approaches, and propose details such as the introduction areas, possible schemes, timeline, and methods for collaboration with local stakeholders. When proposing in detail the priority approach, the key points for sargassum utilization, preconditions for utilization, and items to be confirmed for adaptation, as indicated in "(1) Five Cooperative Approaches", should be organized through field surveys. It is desirable to plan the comprehensive cooperation program aimed at contributing to the effective resolution of the sargassum issue by combining the Grant Assistance for provision of equipment for collection and primary processing, and technical assistance to the government authorities through the Technical Cooperation Project, and also to propose supportive schemes such as TSUBASA and JICA SDGs Business Supporting Survey to the private companies and research institutes that possess adaptable technologies based on their business development potential.



Source: JICA Survey Team

Figure 5.16 Overall Concept of Proposed Cooperation Scenarios

6. Online of Seminars held in the JICA Survey

Based on the survey results, the first seminar was held in January 2024 for Japanese private companies, research institutes and universities, and the second seminar was held in February 2024 for JICA officials. (For details, refer 1.4 Survey Policy (4) Holding Online Seminars).

(1) First Online Seminar

In the first online seminar, from among the relevant Japanese institutions organized in "3.2 Collection and organization of information on the results of seaweed utilization and research in Japan" and based on the initial survey conducted in "3.3 Japanese Technology that can be Adapted for Use in Sargassum", invitations were sent to a total of 91 companies and institutions, of which 18 companies and institutions participated.

Figure 6.1 shows an overview of the first online seminar.

First Online Seminar

【Date & Time】
Thursday, January 11, 2024, 10:00-11:30 (90 minutes)

【Target Participants】
Japanese private sectors, research institutes, and other interested organizations as indicated in the long list.

【Number of participating related organizations】
18 of Japanese related private companies and research institutions

Agenda

Time	Contents	Presenters
10:00	Opening Remarks	JICA Central America and the Caribbean Division
10:10	Overview of the survey and the sargassum problem in Central America and the Caribbean region	JICA Survey Team
10:25	Japanese technology expected to be adapted	JICA Survey Team
10:40	Image of cooperation approaches and JICA's support scheme	JICA Central America and the Caribbean Division
11:00	Introduction of the support scheme of the Ministry of Foreign Affairs of Japan	Ministry of Foreign Affairs of Japan
11:10	Q & A session	Participants
11:25	Closing Remarks	JICA Central America and the Caribbean Division
11:30	Adjournment	

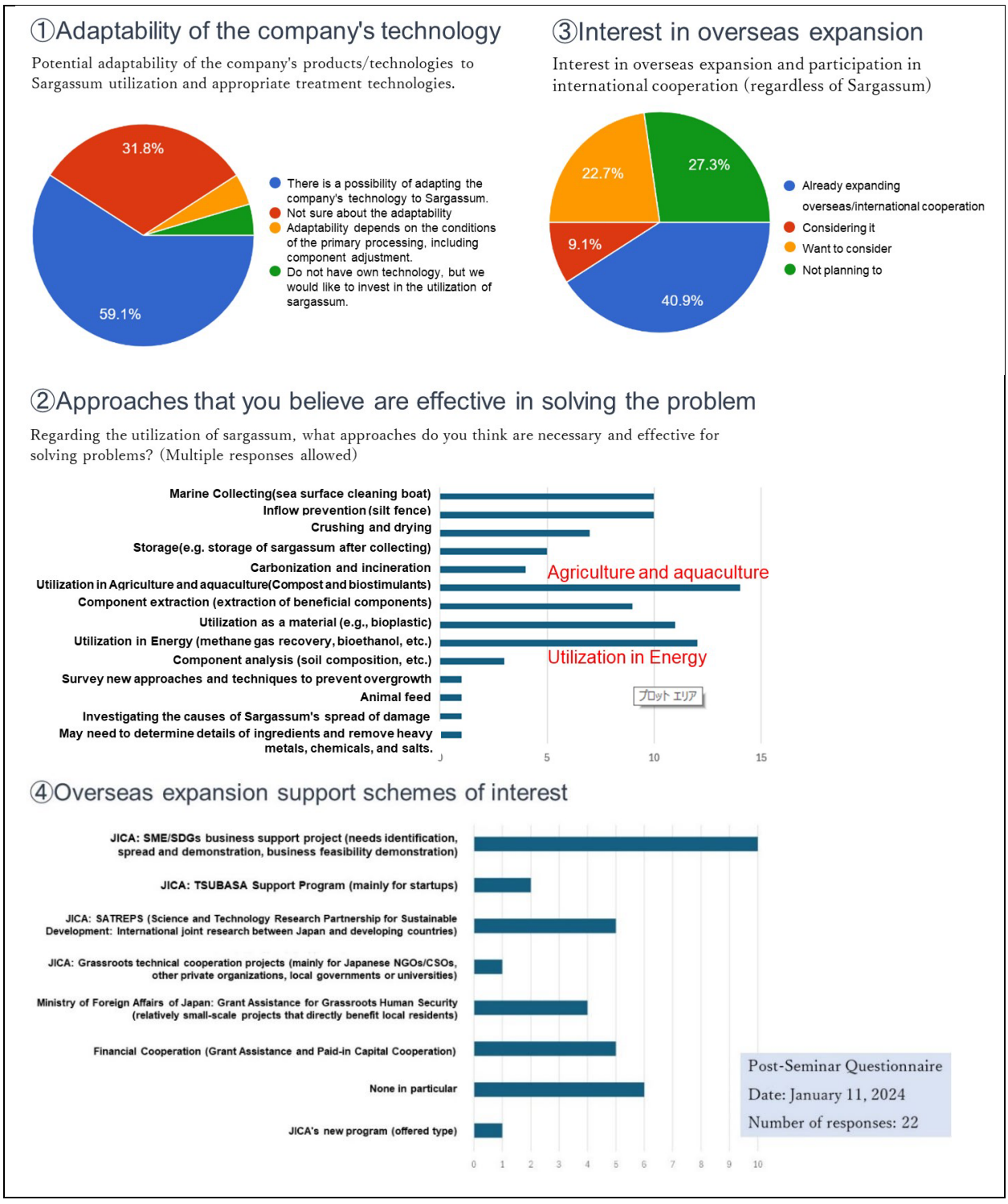
Sources : JICA Survey Team

Figure 6.1 Overview of the First Online Seminar

An online questionnaire survey was also conducted among participating companies and research institutes to confirm their interest in sargassum utilization and their intention to expand overseas (Refer to Figure 6.2). The seminar was attended by participants from various fields of utilization, and about 60% of the related institutions responded that they "think their technology has potential to be adapted to sargassum". Also, regarding interest in overseas expansion, about 70% of the respondents answered that they are already expanding overseas or that they are interested in doing so. Regarding support schemes, there was a high level of interest in JICA's SDGs Business Support Survey, SATREPS, and the Ministry of Foreign Affairs' Grant Assistance.

Table 6.1 shows the main comments and questions obtained from the questionnaire. Particularly common were matters related to primary processing (washing, drying, crushing/shredding, and storage) at the site

and matters related to the composition and amount of sargassum generated. It was also confirmed that the ability to stably secure it as a raw material at a low cost was important from the perspective of business continuity.



Sources : JICA Survey Team

Figure 6.2 Overview of Questinnaire Survey Result

Table 6.1 Main Comments and Questions from Participants in the First Online Seminar

Main Comments and Questions
【In reviewing adaptability】 - want a sample of sargassum for demonstration in Japan. - want the results of compositional analysis and sodium content data. - want to know the difference in content among the three types of sargassum.
【About Primary Processing】 - What are your thoughts on drying methods for sargassum? - Status of local commercialization of primary processing (dehydration, drying, etc.) - Supply (price and quantity) of sargassum after primary processing (drying, grinding) - Status of implementation of arsenic removal
【Others】 - It would be helpful if materials which explain the sequence of commercialization of the utilization of sargassum (e.g., past cases) were provided.

Sources : JICA Survey Team

(2) Second Online Seminar

Figure 6.3 shows an overview of the second online seminar. It was conducted to explain the survey results including interviews survey, and proposed cooperation scenarios, and to exchange opinions with internal stakeholders of JICA and relevant personnel from the Ministry of Foreign Affairs of Japan. It was noted that , the participants were limited due to the inclusion of confidential information from related private companies and research institutions.

Second Online Seminar

【Date & Time】
Wednesday, February 21, 2024, 8:00-9:30 (90 minutes)

【Target Participants】
Internal stakeholders of JICA, relevant department of Ministry of Foreign Affairs of Japan

Agenda

Time	Contents	Presenters
8:00-	Opening Remarks	JICA Central America and the Caribbean Division
8:05-	Survey Results and Proposed Cooperation Scenarios for the Utilization of Sargassum	JICA Survey Team
8:40-	Proposal for "offer-based Cooperation	JICA Central America and the Caribbean Division
8:50-	Q & A session／Comments from Internal stakeholders of JICA and the Ministry of Foreign Affairs	—
9:25-	Closing Remarks	JICA Central America and the Caribbean Division
9:30	Adjournment	

Sources : JICA Survey Team

Figure 6.3 Overview of the Second Online Seminar

7. Direction of Cooperation and Recommendations

As mentioned earlier, the direction of collaboration outlined in the JICA Survey was considered based on information obtained from desk study and interviews. The considerations include: (1) An assessment of the adaptability of various utilization and proper processing technologies in Japan to sargassum, considering technical, socio-economic, and business model aspects, and (2) the organization of the superiority of individual private companies and research institutions that could be potential cooperation partners in terms of technology and corporate orientation. Based on the results, five cooperation approaches are detailed in Chapter 5. The directions of cooperation and recommendations are summarized below.

【Promotion of Adaptation of Technologies in Japan through Analysis and Demonstration Experiments on Sargassum】 Through the JICA Survey, **some adaptable technologies in Japan were confirmed for the utilization of sargassum** in agriculture such as composting, biochar, fertilizer production, for extraction of useful components such as alginate and marine polyphenols, and in energy such as bioethanol. However, since the three types of sargassum, which are Sargassum fluitans III, Sargassum natans I, and Sargassum natans VIII, identified locally are not present in Japan, it is essential to first **examine their adaptability through component analysis including useful components, arsenic, and heavy metal content and verification through demonstration experiments** for practical adaptation. This was one of the points emphasized by various private companies and research institutions in the interviews. As a possible future collaboration, for example, as a first step, obtaining sargassum samples from the local area, conducting research on the extraction and analysis of useful components of sargassum at public research institutions, and sharing the results with Japanese companies and research institutions would be beneficial for companies to consider the next steps in adapting utilization technology.

【Establishment of Primary Processing Steps and Ensuring Raw Material Procurement Network for Promoting Sargassum Utilization】 To promote the utilization of sargassum, a reliable supply of sargassum as a cost-effective raw material in stable quantities and quality is essential. Therefore, **the presence of local partners who can carry out collection and primary processing steps (cleaning, arsenic reduction, drying, crushing, etc.) anticipating secondary processes and provide sargassum as a raw material** is crucial. The JICA Survey confirmed the existence of private companies in Central America and the Caribbean region engaged in the collection, primary processing, and sale of sargassum as a raw material. However, since the current collection activities for sargassum as a raw material are minimal, the supply chain for sargassum as a raw material is considered fragile. Therefore, **through collaboration with local government agencies, providing equipment for sargassum collection (silt fences and water surface cleaning boats) and equipment for primary processing (shredders, etc.) using the Grant Assistance can contribute to the development of the primary processing steps for sargassum, promoting its utilization**. Even if the entire collected sargassum is not utilized, conducting simple primary processing near the landing points can be effective to reduce transportation costs to the final disposal site

for sargassum, containing approximately 80% moisture. (Note: From the perspective of storing sargassum as a raw material, the drying process is often essential, and sun drying is considered a cost-effective drying process where possible.) In terms of collection and primary processing, it is **beneficial to collaborate not only with local government agencies but also with local communities, fishermen, hotel operators, and local businesses**. In addition, since the amount of sargassum inflow has been observed to fluctuate seasonally and yearly, it is considered that the establishment of a system that enables procurement of other organic materials that can be substituted or mixed as raw materials when the amount of sargassum supplied is insufficient will contribute to further promotion of its introduction.

【Expectations and Support for the Expansion of Businesses Using Sargassum as a Raw Material by Japanese Companies】 Global seaweed markets are estimated with the potential to grow by an additional USD 11.8 billion by 2030[19], and have been expanding in areas such as fertilizers, animal feeds, functional foods, cosmetics, and pharmaceuticals. Seaweeds, including brown algae such as sargassum, contain unique useful components such as alginate and marine polyphenols, holding potential value in the business market. The interviews under the JICA Survey also confirmed interest in importing sargassum as a raw material, given certain conditions. Thus, there is an expectation for Japanese companies to import sargassum as a raw material, expand their business activities, and establish distribution channels through trading companies. As support for the activities of Japanese companies, it is considered useful to provide schemes such as TSUBASA and JICA's SDGs Business Supporting Survey for discovering local partners, as well as to provide equipment for collection and primary processing using the Grant Assistance as mentioned earlier. Additionally, it is also expected to implement on-site visits as missions for small and medium-sized enterprises and startups in Japan which have a high interest in utilizing sargassum.

【Immediate-effect Utilization in Agriculture: Promotion of Organic Fertilizer Utilization through Manufacturing of Fertilizers and Soil Improvers derived from Sargassum】 In Japan, the utilization of seaweed in agriculture has been a traditional method for a long time as established technology. Given the simple processing steps and a certain expected consumption of raw materials, the adaptability of utilizing sargassum for manufacturing fertilizers and soil improvers is relatively high. The use of organic fertilizers and soil improvers derived from seaweed, is **expected to contribute to increased productivity in farmland and reducing dependence on imported chemical fertilizers**. While the local manufacturing and sales activities of biostimulants have been observed, there is a certain expectation for local acceptance. By **concurrently establishing cultivation techniques utilizing organic fertilizers and supporting outreach activities to local farmers through the Technical Cooperation Project**, it is expected to secure a market for organic fertilizers and/or soil improvement agents derived from sargassum and to have a positive ripple effect on agricultural production.

[19] The World Bank, "Global Seaweed -New and Emerging Markets report-", 2023

【Creation of Clean Energy through the Utilization of Sargassum as Biomass Fuel】 Regarding the utilization of sargassum as a raw material for biomass energy, technologies such as the extraction of bioethanol from large algae (at the demonstration stage) and gasification technology using organic waste (at the implementation start stage) obtained from the interview survey are considered useful for processing large amounts of sargassum. Biomass energy creation is expected to **contribute to reducing the import and use of fossil fuels, ensuring energy security, promoting climate change measures, and strengthening the economy of the target country**. However, for the local adaptation of the technology, preliminary surveys including demonstrations and feasibility studies, and the establishment of on-site implementation structures, as well as necessary facility investments on a certain scale, are required. Therefore, a smooth deployment is desired, starting from the formation of projects in the F/S stage with public support from JICA and other official schemes, coordination with local government agencies, and financial support for equipment provision.

【Comprehensive Approach for Connecting Dots, Expanding the Ripple Effect to Areas】 Leveraging the supply of sargassum collection equipment through the Grant Assistance, it is effective **to establish a sustainable utilization system by supporting a comprehensive approach connecting the "dots" of sargassum collection to the primary processing steps and then to utilization process as a raw material**. The outputs generated from various utilization process are expected to contribute to the agricultural activities and energy usage in local economy, serving as a tangible support to the community. In this sense, for the next survey, it is considered useful for establish a sustainable utilization system to conduct a program formation survey in the target country to gather information on the current situation, management, countermeasures, stakeholders, etc., related to sargassum, and **proposing a comprehensive approach method considering the overall flow of sargassum from collection points until there is a ripple effect caused by products derived from sargassum to areas**.

Attachments

Attachment 1 List of local companies related to the utilization of Sargassum

Attachment 2 Summary of the first online seminar materials

Attachment 1

List of local companies related to the utilization of Sargassum

Attachment 1: List of local companies related to the utilization of Sargassum

A long list of local companies involved in primary processing and each field of utilization obtained from the desk research is organized in the table below.

（1） Collecting and Preprocessing

Table 1 Companies and Institutions Related to Collection to Preprocessing

No. Source	Use area	Name of organization /institution	Country	Contact links	Additional Information
1-1 a, c	Inflow Prevention・Collecting	AlgaeNova	República Dominicana	Sr. Manolo Despradel m.despradel@algeanova.com https://algeanova.com/	AlgaeNova's goal is to implement sustainable solutions to improve the consequences of pollution by sargassum, and is working on the manufacture of inflow containment barriers and collectiong from the sea using boats and ships.
1-2 a	Collecting	Aventura Boats	República Dominicana	Sr. Lucas Guessard info@aventuraboats.com https://aventuraboats.com	A company that designs and manufactures tourist boats located in Lupellón, Puerto Plata Province. is currently in the process of designing and manufacturing a prototype Sargassum collecting boat.
1-3 a, c	Collecting・Blue Economy	SOS Carbon	República Dominicana	Sr. Andrés Bisonó andres@soscarbon.com https://soscarbon.com/	A spin-off from the Department of Mechanical Engineering at the Massachusetts Institute of Technology (MIT), the company was founded with the technology to isolate Sargassum in deep water for carbon offsets. The company has also developed a littoral collecting module (LCM), which collects the sargassum in a net before coming ashore and can be installed on any type of ship.
1-4 a	Inflow Preventing・Collecting	Beach Trotters,	España	Sr. Seran Mercadé info@beach-trotters.com https://en.beach-trotters.com/	The Spanish company offers solutions for the containment and removal of sargassum in the sea and on beaches, including the "Mursargaz" underwater net barrier, the "Algatros" and "Captor" boats for collecting sargassum at sea, and the "Scarbat" beach cleaning machine to remove sargassum and prevent erosion. and other products.
1-5 a	Collecting・Remove	BeachTech	Alemania	Sr. Mahhias Pfitzer mahhias.pfitzer@beach-tech.com https://www.beach-tech.com/	The company specializes in the manufacture of professional beach cleaners. The product portfolio includes self-propelled, tractor-towed, and small pedestrian beach cleaners.
1-6 a	Collecting・Remove	DESMI	Dinamarca	Sr. Rolando Chávez roc@desmi.com www.desmi.com	A special mesh-like floating barrier technology called MESH BOOM moves the Sargassum to a specific location, where it is removed by a small device called SEA TURTLE or TRI TURTLE. They can be moved up to 250 meters

No. Source	Use area	Name of organization /institution	Country	Contact links	Additional Information
					to sand-free beaches. It is not affected by weather conditions (no waves or currents).
1-7 a	Collecting・Remove	NEAT SAND	Estados Unidos	Sr. Alejandro Quintás aquintas@neatsand.com https://www.neatsand.com/	Specializes in the removal and disinfection of biohazards and sargassum from beaches, resorts, and sports fields. Provides services to contain sargassum with barriers, recover sargassum from the sea, remove sargassum from beaches, and minimize erosion due to

a: Gran Caribe-UE Cenferencia_Sargazo_25JUL23
b: Sargassum Uses Guide_Sargassum Information HUB_2020.10
c: EU Blue Economy Report 2023, Phyconomy Seaweed Organizations Database https://phyconomy.net/database/

(2) Utilization in Agriculture and Aquaculture

Table 2 Companies and Research Institutes for Utilization of Agricultural and Aquatic Products

No. Source	Use area	End product / service	Name of organization /institution/project	Country	Contact links	Additional Information
2-1 b	Agricultural – Animal husbandry	Animal feed supplement for goats & sargassumbased charcoal	Awganic Inputs / Integral Recyclers Limited	Jamaica	Daveian Morrison, Founder & CEO 876 383 5286 / 876 323 8682 awganicinputs@gmail.com	This young entrepreneur is developing innovative sargassum based products such as a blended goat feed and charcoal. His feed is made from a mix of sargassum (up to 30%) and locally available organic agro-processing wastes (feed has a 30% protein content). In collaboration with local goat farmers, he has been testing the feed as to whether goats' would accept the scent of this new feed. Since the feed has been well received by the goats, he is now starting clinical trials. https://www.facebook.com/awganic/ https://www.facebook.com/integralrecyclers/
2-2 b		Research - AC & biochar	PYROSAR project	Guadeloupe, Martinique (France &	Prof. Sarra Gaspard, project coordinator sarra.gaspard@univ-antilles.fr	Valorisation of sargassum by pyrolysis and application for food safety. Holistic approach to sargassum valorisation including developing bioelicitors, biostimulants and other agricultural

No. Source	Use area	End product / service	Name of organization /institution/project	Country	Contact links	Additional Information
				collaborators		products, products and by-products by bio refinery, eco-materials and panels from ashes and particles, activated carbon, gelling agents, anticorrosive dyes
2-3 b		Research - Compost & animal feed	SARGWA Consortium, INRA & Université des Antilles	Guadeloupe (France)	—	Physicochemical analysis of sargassum composition (heavy metals, pesticides, hydrocarbons, biochemicals and biocides) for valorisation in agriculture (direct spreading, compost and animal feed).
2-4 b		Research - Animal feed	Instituto Nacional de Ciencias Médicas y Nutrición Salvador Zubirán (INCMNSZ), Department of Animal Nutrition	Mexico	Silvia Carrillo Domínguez silvia.carrillod@incmnsz.mx	Research on use of natural non-traditional ingredients, including sargassum, for animal feeds (chicken and small ruminants), compositional analysis of eggs and meat to see impact of feed and evaluation of nutritional feed strategies to reduce the risk of fatty liver disease in animals. https://www.incmnsz.mx/Investigacion/investigador.jsp?id=83&idep=3
2-5 b, c	Agricultural Crop production	Biostimulant - Super Seaweed	Red Diamond Compost	Barbados	Joshua Forte, Founder & CEO 246 549 1594 info@reddiammondcompost.com	Developing several organic agricultural amendments including plant biostimulants made with different plant-based materials, including sargassum. http://www.reddiamondcompost.com/en/
2-6 b,c		Biostimulant - Total Plant Tonic	Algas Organics	St. Lucia	Johanan Dujon, Founder & CEO, 758 461 5019 johanan@algasorganics.com	A pioneer in developing sargassum based plant biostimulant and is well-known for the innovative project throughout the Caribbean. commercializing the first plant improver made 100% from Sargassum natans and S. fluitans seeds, as well as processing over 1 million pounds of exotic seaweed annually and exporting plant improvers to 10 countries. https://www.algasorganics.com/
2-7 b, c		Compost	Holdex Environnement	Martinique (France)	Mike Bernus, Director 0596 50 36 58 mb@holdexenvironnement.com	The company has commercialised several organic-based products for agriculture (soil amendments - mulch, fertilizers, biochar), including a sargassum-based compost (co-composting).

No. Source	Use area	End product / service	Name of organization /institution/project	Country	Contact links	Additional Information
						https://www.martinique2030.com/non-classe/holdexenvironnement-une-solution-de-valorisation-des-sargasses-100-martiniquaise
2-8 b, c		Fertilizer, mulch, cosmetics & paper	Salgax Biotecnología Marina Aplicada	Mexico	Mauricio Gómez 52 999 285 4541 / 52 999 374 3214 /52 999 371 5107 salgaxventas@salgax.com	Developing several sargassum-based products such as fertilizers, mulch, cosmetics and paper.
2-9 b, c		Compost, mulch & bioplastic	AlgaeNova	Dominican Republic	Manolo Despradel, General Manager 809 959 2070 algeanovard@gmail.com www.algeanova.com-	Producing a compost made of 60% sargassum and 40% river tamarind, which takes approximately 70 days to mature and also a 100% sargassum mulch. In collaboration with Bionova, who has developed single-use plates made with 50% sargassum and 50% cassava, which is fully compostable (no industrial composting required) within 30 days https://www.facebook.com/algeanovard
2-10 b		Compost (in development)	SUEZ	Guadeloupe (France)	Stéphane Dupuy, General Director for Sita Espérance Stephane.dupuy@suez.com	SUEZ is a long-standing company specialized in water and waste management, where they place a focus on innovative, intelligent and sustainable management of resources. They promote circular economies that ensure recycling and valorisation of materials.
2-11 b		Fertilizer	Sargasso Organics	Barbados	Roett's Garage 246 426 0547 roettsgarage@gmail.com	This recent company is commercialising sargassum-based fertilizer, available island wide.
2-12 b, c		Fertilizer (Alquifert), alginate & fucoidans	Alquimar	Mexico	Luis Masía Nebot, Founder 998 310 1231 info@alquimar.com.mx	This active company is developing several seaweed-based products, including sargassum. They are commercializing fertilizers and fucoidan extract, and will soon add alginate extracts to their end products. https://alquimar.com.mx/nosotros
2-13 b, c		Fertilizer & paper products	Dianco México	México	Hector Romero 55 2731 3841 hromero@medialectica.com	Dianco is in the process of establishing a sargassum processing plant to produce a sargassum-based fertilizer and paper products. www.diancomexico.com

No. Source	Use area	End product / service	Name of organization /institution/project	Country	Contact links	Additional Information
2-14 b, c		Compost	Beacon Farms & University College of the Cayman Islands (UCCI)	Cayman Islands	Granger Haugh, Chairman / Sasha Appleby, Agricultural Production Unit 345 326 4426 / 345 324 2991 grangerhaugh@gmail.com	Nonprofit organization, offering housing and employment for people in recovery from drug and alcohol use. In collaboration with researchers at the UCCI, exploring the potential of sargassum for use as a compostable soil additive. www.beaconfarmscayman.org
2-15 b		Compost & coastal restoration	Moon Palace Resort	Mexico	Antonio Ortiz, Environmental Manager Info@palaceresorts.com	Collecting sargassum from their 2-km long beach for several years and have been processing it into compost and used on the hotel grounds. Actively involved in restoring their coastal area and enhancing the growth of plants to prevent further beach erosion, using sargassum.
2-16 b		Research - Mulch, fertilizer, bioelicitor	University of the West Indies	Barbados, Trinidad & Tobago	Dr. Francis Lopez, Dept. of Biological and Chemical Sciences, Barbados (mulch & fertilizer) francis.lopez@cavehill.uwi.edu Prof. Jayaraj Jayaraman, Dept. of Life Sciences, Trinidad (bio-elicitors, nanopesticides & biocontrol) Jayaraj.Jayaraman@sta.uwi.edu	Several ongoing projects to research the potential of using sargassum in agricultural applications.
2-17 b		Research - Practical field application	Institut Technique Tropical (IT2)	Guadeloupe &Martinique(France)	David Dural, Director 0596 42 43 54 d.dural@it2.fr	Agronomic and toxicological analyses of effects resulting from application of pelagic sargassum compost and direct field spreading. http://www.it2.fr/
2-18 B		Research - Agriculture	SAVE project	Martinique (France)	Stéphane Pacaud, project coordinator stephane.pacaud@univ-lorraine.fr	Sargassum agricultural valorisation and energy production.
2-19 B		Research - Biopesticides	SAVE-C project	Martinique (France)	Valérie Stiger, project coordinator Valerie.Stiger@univ-brest.fr	Valorisation of sargassum in agriculture (biopesticides) and as a biomaterial (cardboard).
2-20 B		Research - Compost & analysis	ECO3SAR project	Guadeloupe (France)	Dr. Pascal Jean Lopez, project coordinator 33 1 40 79 37 02 Pascal-jean.lopez@mchn.fr	Compositional analysis of sargassum and through co-composting (project in collaboration with Holdex Environnement).
2-21 B		Research - Fertilizer, animal feed &	Amadéite Group	Guadeloupe (France)	—	Pilot project in collaboration with ADEME, to determine the potential of sargassum for improving plant, animal and human health through the optimization of compound extraction.

No. Source	Use area	End product / service	Name of organization /institution/project	Country	Contact links	Additional Information
		analysis				
2-22 B		Research - Mushroom substrate	Centro de Investigación Científica de Yucatán (CICY), Colegio Postgraduados, Puebla Campus & Universidad Popular Autónoma del Estado de Puebla (UPAEP)	Mexico	Dr. Alfonso Larqué Saavedra, CICY larque@cicy.mx Dr. Daniel Claudio Martínez Carrera, UPAEP dcarrera@colpos.mx	Ongoing research on the use of sargassum as growth substrate for mushroom cultivation. https://www.foroconsultivo.org.mx/eventos_realizados/RP_hongos_14_01_2019/1_hongos_comestibles.pdf
2-23 C		Plant & soil nutrition	Bionema	UK	—	Manufacturer and distributor of biostimulants using Sargassum. https://bionema.com/
2-24 c		Foams	Bloom Sustainable Materials	USA	—	Recovery of sargassum on land and production of shoe soles containing sargassum by mixing with rubber. https://www.linkedin.com/posts/bloom-materials_a-seaweed-blob-twice-the-width-of-the-us-activity-7049488638853668864-XGNV/
2-25 C		Plant & soil nutrition,HABs,Personal care	Carbonwave (formerly C-Combinator)	USA	—	Manufacturer of Sargassum-derived fertilizers and cosmetics. https://carbonwave.com/
2-26 C		Plant & soil nutrition	Grogenics	Saint Kitts and Nevis	—	Recovery, conversion to compost, application of sargassum, and credit under the Gold Standard. https://www.grogenicssg.com/
2-27 a		Composting	UTV AG	Alemania	Sr. Thomas Schlien thomas@utvag.de https://kompostanlagen.de	UTV AG's composting technology is suitable for composting almost all types of organic waste, including sargassum, due to its pressure-vented, oxygen-controlled membrane cover. The technology effectively reduces odors and emissions and is modular and scalable from 1,000 to 1 million tons per year. It

No. Source	Use area	End product / service	Name of organization /institution/project	Country	Contact links	Additional Information
						has more than 70 factories in more than 20 countries in all climatic zones of the world.

a: Gran Caribe-UE Cenferencia_Sargazo_25JUL23

b: Sargassum Uses Guide_Sargassum Information HUB_2020.10

c: EU Blue Economy Report 2023, Phyconomy Seaweed Organizations Database https://phyconomy.net/database/

(3) Component Extraction

Table 3 Companies and Research Institutes for Component Extraction and Utilization

No. Source	Use area	End product / service	Name of organization /institution	Country	Contact links	Additional Information
3-1 b	Alginates	Alginates	Grupo Metco	Mexico	Hector Alvarez clientes@metco.com.mx	Grupo Metco has over 25 years working in the development of food supplements and sweeteners. They are currently researching the extraction of alginates from sargassum and other seaweeds. They are also elaborating construction blocks made with sugarcane bagasse and sargassum.
3-2 b, c		Alginate, fucoidans & fertilizer (Alquifert)	Alquimar	Mexico	Luis Masía Nebot, Founder 998 310 1231 info@alquimar.com.mx	This active company is developing several seaweed-based products, including sargassum. They are commercializing fertilizers and fucoidan extract, and will soon add alginate extracts to their end products. https://alquimar.com.mx/nosotros/
3-3 b		Alginate extracts	University of the West Indies	Barbados, Trinidad & Jamaica	Dr. Srinivasa Popuri, Dept. of Biological and Chemical Sciences, Barbados (bioethanol) srinivasa.popuri@cavehill.uwi.edu Dr. Bidyut Mohapatra, Dept. of Biological and Chemical Sciences, Barbados (nanobiocatalytic alginate lyase) bidyut.mohapatra@cavehill.uwi.edu	Several researchers across the three campuses in the Caribbean are working on different studies to evaluate the potential use of sargassum alginate extracts for several applications.

No. Source	Use area	End product / service	Name of organization /institution	Country	Contact links	Additional Information
					Prof. Jayaraj Jayaraman, Dept. of Life Sciences, Trinidad (bio-elicitors, nanopesticides & biocontrol) Jayaraj.Jayaraman@sta.uwi.edu Dr. Keeran Ward, Dept. of Chemical Engineering, Trinidad (thin film composite - biodegradable water container) keeran.ward@sta.uwi.edu Dr. Howard Reid, Mona Institute of Applied Science mias@uwimona.edu.jm	
3-4 b		Alginate extracts	Nexo project, Tecnológico de Monterrey	Mexico	Dr. Jesús Antonio Jáuregui Jáuregui, Bioengineering jesusjauregui@tec.mx	A group of students are extracting alginates and fucoidans from the cell walls of sargassum to determine potential uses in bath gels, creams and other cosmetics.
3-5 b	Antifouling	Research - Antifouling properties	CORSAIR project	Guadeloupe	Christophe Roos, project coordinator christophe.roos@univ-antilles.fr	Research on the impact of chemical products extracted from sargassum and the characterization of natural molecules with antifouling properties.
3-6 b		Research - Anticorrosive dyes	SARGOOD project	Guadeloupe & collaborators	Marie-Ange Arsène, project coordinator maarsene@univ-ag.fr	Holistic approach to sargassum valorisation including developing bioelicitors, biostimulants and other agricultural products, products and by-products by bio refinery, eco-materials and panels from ashes and particles, activated carbon, gelling agents, anticorrosive dyes

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c: EU Blue Economy Report 2023, Phyconomy Seaweed Organizations Database https://phyconomy.net/database/

(4) Utilization in Energy

Table 4 Companies and Research Institutes for Utilization in Energy

No. Source	Use area	End product / service	Name of organization /institution	Country	Contact links	Additional Information
4-1 b	Biofuels	Biogas & digestate	EnergyAlgae	Dominican Republic	Ygdal Ach, CEO, Y.A. MAOF Holding Management Ltd.	Pilot Project in Punta Cana to experiment five small-scale anaerobic digestors, using sargassum and organic waste as

No. Source	Use area	End product / service	Name of organization /institution	Country	Contact links	Additional Information
					972 3 7798825 / 972 50 2626749 ygdal@yamaof.co.il Dr. Shmuel Brenner, Project Manager shmuel4212@gmail.com Franklyn Holguin Hache, Universidad APEC fholguinhache@adm.unapec.edu.do	feedstock. Results will be used as a basis to develop a of a larger 1 MW co-digestion model biogas facility. https://www.energy-algae.com/
4-2 b		Biogas & digestate	Fickert & Winterling Maschinenbau (FWM) - BiogasTiger	Germany	Karen Guerrero, Regional Manager 593 998 038 333 Karen.guerrero@fwe.energy	Will be installing anaerobic digestors at hotel facilities in Mexico shortly, using sargassum in co-digestion with other hotel wastes.
4-3 b		Biogas & digestate	Mécaméto	France	Guillaume Brillat, Manager 06 22 53 23 02 Contact@mecameto.com	Dry methanation technology. Methanization container using a dry process, continuous, modular and portable.
4-4 b		Biogas	BJP Renov	Guadeloupe (France)		Pilot project to determine the potential of sargassum for biogas production.
4-5 b		Biogas, Bioenergy & digestate	Blue Caribbean Energy Solutions (Damen & Maris Group)	Netherlands	Lennart Koning, Business Development, Damen 31 0630 30 46 41 Lennart.koning@damen.com Ruben van Maris, Managing Director, Maris Group 31 06 515 09 430 ruben@maris-projects.nl	Consortium of both companies is looking to branch out in the Caribbean to implement their holistic solution including harvesting, preprocessing, transport and anaerobic digestion (two-step process) of sargassum. Production of biogas via (1) low temperature anaerobic digestion and (2) high temperature anaerobic thermal reactor. https://www.damen.com/en/news/2019/10/damen_partners_with_maris_to_consider_seaweed_solution
4-6 b		Bioenergy, activated carbon, biochar	Num SMO Technologies (NST)	Guadeloupe (France)	Franck Saint-Martin info@smo-process.com contact@smo-process.com	Active-SMO is a Solar microwave procedure, based on solar pyrolysis and gasification. The mobile and versatile unit can generate electricity, activated carbon, carbon powder and biochar. https://www.youtube.com/watch?v=L7zUqutlubc
4-7 b		Bioenergy	Microsystemfuel Srl / Green	France (St. Barts) & Italy	Maurizio Coni, General Director Green Engineering S.A.S. +590 690 290956	This collaboration has developed a prototype based on low CO2 emission auto-combustor to transform biomass into electrical energy, where bio-seaweed pellets are treated with

No. Source	Use area	End product / service	Name of organization /institution	Country	Contact links	Additional Information
			Engineering S.A.S. / Garbage Service Srl / The Pelikan System		greenengineering@gmail.com	spontaneous combustion. This open circuit gasification allows the production of syngas, the synthesis gas generated by the combustion of biomass.
4-8 b		Biogas	Biogen Biotechnologies Inc.	Barbados	Mark Hill, Director biogengas.barbados@gmail.com markhill@thinkdesignbarbados.org	Biogen produces bio-methane and bioCNG for transport fuel in Barbados. The team has been exploring the potential of sargassum for anaerobic co-digestion to produce bio-methane. https://www.facebook.com/biogengas/
4-9 b		Biopellets & bioplastic	Energryn / Solesyto	Mexico	Andres Muñoz, Founder & CEO info@energryn.com https://www.energryn.com/nosotros.html	The team is investigating the use of sargassum to produce blended bio-pellets used in boilers at local hotels and bioplastic products, including water heaters, plates and cups.
4-10 b		Bioenergy, bioplastic, compost & soil amendments	GARAS project (Groupe CAïALI, La SARA & Holdex Environnement)	French Guiana, Guadeloupe, Martinique (France)	La SARA: information.comrse@sara.mq Groupe CAÏALI: 0596 57 10 23 Holdex: Mike Bernus, Director 0596 50 36 58 mb@holdexenvironnement.com https://www.sara-antilles-guyane.com/le-projet/garas/ https://www.caiali.fr/	GARAS project is an industrial consortium of three companies, where SARA, a major refinery business in the region, is investigating the potential use of sargassum to develop a thermoconversion process (e.g. pyrolysis) to produce biofuel, CAÏALI Group is looking at the potential of sargassum for bioplastic (extrusion tests with composite materials from PVC/PE and sargassum powder), and Holdex Environnement will focus on the valorisation of sargassum through composting. https://www.martinique2030.com/non-classe/holdexenvironnement-une-solution-de-valorisation-des-sargasses-100-martiniquaise
4-11 b		Bioenergy & activated carbon	Transporte Maritima Mexicana (TMM)	Mexico	Jesus Davis businessdevelopment@tmm.com.mx	This very expansive company offering services of maritime transport, logistics, and storage, is researching the possibilities of producing electricity and activated carbon with sargassum and other organic waste (municipal & cruise ships) using a sublimation process.
4-12 b		Research - Biogas, bioethanol	University of the West Indies	Barbados & Trinidad	Dr. Legena Henry, Dept. of Computer Science, Math & Physics, Barbados & Dr. Renique Murray, Dept. of	Researchers at Cave Hill & St. Augustine campuses are investigating the potential use of sargassum to produce biogas and ethanol.

No. Source	Use area	End product / service	Name of organization /institution	Country	Contact links	Additional Information
					Mechanical and Manufacturing Eng. (anaerobic digestion - biogas) legena.henry@cavehill.uwi.edu Dr. Srinivasa Popuri, Dept. of Biological and Chemical Sciences, Barbados (bioethanol) srinivasa.popuri@cavehill.uwi.edu Dr. Nikolai Holder, Barbados (Biogas) nikolai.holder@gmail.com	
4-13 b		Research - Effect of salt on anaerobic digestion, digestate	SAVE project	France, Martinique & collaborators	Stéphane Pacaud, project coordinator stephane.pacaud@univ-lorraine.fr	Sargassum agricultural valorisation and energy production (anaerobic digestion).
4-14 b		Research - Biogas pretreatment	Centro de Investigación Científica de Yucatán (CICY)	Mexico	Dr. Raúl Tapia Tussell rtapia@cicy.mx	The team has developed a prototype methodology (patent pending) that involves mixing sargassum with a locally sourced fungus, able to degrade lignin, and a bacterial inoculum as a pretreatment to produce methane. https://www.cienciamx.com/index.php/centros-deinvestigacion/centros-publicos-de-investigacion/23708-cientificos-del-cicy-producen-biogas-a-partir-de-sargazo
4-15 b		Research - Biogas	ESETA, Greenaffair & INRA	Guadeloupe (France)	—	Recipient of Ademe grant in 2016 for a pilot sargassum methanization trial.
4-16 b		Research - Biopellets	Ecodec	Guadeloupe (France)	—	Recipient of Ademe grant in 2016 for a pilot trial to evaluate sargassum's potential as a fuel to power a biomass boiler.
4-17 b		Research - Biooil	University Exeter & University of Bath	UK	Dr. Mike Allen, Plymouth Marine Laboratory mije@pml.ac.uk	This team has been developing a method to pre-process sargassum on an industrial scale by fractionation, which can then go through a hydrothermal liquefaction to produce liquid bio-oil. This end-product can be further processed into fuel and fertilizer precursor.

No. Source	Use area	End product / service	Name of organization /institution	Country	Contact links	Additional Information
4-18 c		Energy,HABs Biofuel	Nopalimex	Mexico	—	Obtained patent for biogasification. Considering building a plant in Quintana Roo. http://www.nopalimexgasyenergia.com/
4-19 c		Biofuel	Rum and Sargassum	Barbados	—	Co-digestion of three major waste products: seaweed from Sargassum, wastewater from rum distilleries, and blackberry sheep manure from Barbados, as a substitute for gasoline. https://rumandsargassum.com/
4-20 a		Biofuel	Convertrash RD	República Dominicana	Sr. Miguel Barceló miguel.barcelo@convertrash.com	The company owns and produces a patented technology to produce CDRN, a standardized waste-derived fuel with less than 5% moisture, less than 3 mm particle size, and a calorific value greater than trinitrotoluene (TNT), from any raw material, including sargassum. The company also holds patents for converting solid waste and sargassum into electricity and biodiesel. https://www.convertrash.com/

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b: Sargassum Uses Guide_Sargassum Information HUB_2020.10

c: EU Blue Economy Report 2023, Phyconomy Seaweed Organizations Database https://phyconomy.net/database/

(5) Utilization as a material

Table 5 Companies and Research Institutes for Utilization as a material

No. Source	Use area	End product / service	Name of organization /institution	Country	Contact links	Additional Information
5-1 b, c	Bioplastics	Bioplastics - Microcapsules	Algopack	France & collaborators in Guadeloupe/ Martinique	David Coti, Founder contact@algopack.com	Experts developing bioplastics with brown algae in France. They are collaborating with researchers and businesses in Guadeloupe and Martinique to develop a sargassum-based bioplastic. Recipient of a grant from Ademe in 2016 to evaluate the feasibility of producing sargassum-based bioplastics in collaboration with Novundi Group. https://www.ouest-france.fr/bretagne/ille-et-vilaine/saintmalo-algopack-transforme-les-sargasses-en-plastique-6078218

No. Source	Use area	End product / service	Name of organization /institution	Country	Contact links	Additional Information
5-2 b, c		Bioplastics	Le Floch Depollution	France	Pauline Morvan contact@leflochdepollution.com http://leflochdepollution.com	The team is currently testing to develop two different grades of bioplastics: (1) 30% sargassum and 70% thermoplastic resins and (2) 40% sargassum and 60% polylactic acid.
5-3 b, c		Bioplastics	Abaplas	Mexico	Marco Moreno Sandoval, CEO 33 35 77 22 11 marco@abaplas.com http://abaplas.com/	Producing plastic and bioplastic products for 15 years. Currently testing to produce a bioplastic made of 30% sargassum and 70% plastic for use in different applications, including ecological housing and train tracks.
5-4 B		Research - Bioplastics	University of the West Indies	Barbados & Trinidad	Dr. Srinivasa Popuri, Dept. of Biological and Chemical Sciences, Barbados srinivasa.popuri@cavehill.uwi.edu Kerri-Ann Bovell, UWI Cave Hill student kerri-ann.bovell@mycavehill.uwi.edu Dr. Keeran Ward, Dept. of Chemical Engineering, Trinidad (thin film composite - biodegradable water container) keeran.ward@sta.uwi.edu	Researchers at both Cave Hill and St. Augustine campuses are exploring sargassum for use in the manufacture of bioplastics.
5-5 b		Research bioplastics	Clemson University & Rochester Institute of Technology	USA	William Scott Whiteside, Dept. of Food, Nutrition and Packaging Sciences, Clemson University wwhtsd@clemson.edu	Researchers at both institutes working together on development of nanocomposite films using *Sargassum natans*
6-1 b	Bioremediation & purification	Activated carbon	NBC / TECMALAB	French Guiana & Dominican Republic	Nicolas Brehm, Founder & Director 594 05 94 29 07 70 / 809 817 7764 06 94 43 36 00 Nicolas.brehm@nbcsarl.com	In collaboration with research teams in French Guiana, Guadeloupe and Dominican Republic, NBC and TECMALAB are working to develop and commercialise a sargassum-based activated carbon for use in water and wastewater treatment and air purification applications.
6-2 b		Research – Activated carbon, biochar & energy storage	University des Antilles, COVACHIMM2E laboratory	Guadeloupe, Martinique (France)	Prof. Sarra Gaspard sarra.gaspard@univ-antilles.fr	The team is researching the potential of sargassum to produce activated carbon for soil remediation, pesticide sequestration in animals, water treatment and energy storage (electrodes for supercapacitors) applications.
6-3 b		Research - Activated	Instituto Tecnológico	Dominican Republic	Dr. Ulises Jauregui ulises.jauregui@intec.edu.do	Sargassum-based activated carbon for water treatment and other applications.

No. Source	Use area	End product / service	Name of organization /institution	Country	Contact links	Additional Information
		Carbon	de Santo Domingo (INTEC)			
6-4 b		Research - Purification & bioremediation, biofilters	Center for Applied Physics and Advanced Technology (CFATA), Autonomous Univ of Mexico (UNAM)	Mexico	Dr. Miriam Rocio Esteves Gonzalez miries@fata.unam.mx www.fata.unam.mx/Academicos/Dra-MiriamEsteves	Has developed filters using sargassum for bioremediation, removing contaminants such as metals, sulphates and pigments (phenolic compounds) from water. Also promising results in trials to treat the acidic, sulphur-rich lixiviates of sargassum.
6-5 b		Research - Purification & bioremediation, biofilters/ membranes	University of the West Indies	Trinidad, Barbados	Dr. Keeran Ward, Dept. of Chemical Engineering, Trinidad (biofilter membranes) keeran.ward@sta.uwi.edu Dr. Srinivasa Popuri, Dept. of Biological and Chemical Sciences, Barbados (wastewater treatment) srinivasa.popuri@cavehill.uwi.edu	Sargassum polymers to create membranes for use as biofilters in the remediation of heavy metals in wastewaters.
6-6 b		Research - Activated carbon	SARGOOD project	Guadeloupe & collaborators	Marie-Ange Arsène, project coordinator maarsene@univ-ag.fr	Holistic approach to sargassum valorisation including developing bioelicitors, biostimulants and other agricultural products, products and by-products by bio refinery, eco-materials and panels from ashes and particles, activated carbon, gelling agents, anticorrosive dyes
7-1 b	Clothing, footwear & accessories	Shoes	Renovare Ocean	Mexico	Jorge Castro Ramos, CEO Renovare.r@gmail.com	Third generation shoemaker, this company is making eco-friendly shoes using recycled plastic bottles, biodegradable resins and sargassum seaweed in their 'Ocean Ova' shoe line.
7-2 b	Construction material	Bricks	Blue Green	Mexico	Omar Vázquez Sánchez, Founder, CEO Blue Green +52 984 175 0536 https://www.facebook.com/bluegreenmx/	Omar built the first sargassum house in 2015, when he invented SargaBlocks, which are construction blocks made of sargassum and organic waste. Since then, he has been making thousands of blocks and improved his production method and equipment. Innovation and success at its best.
7-3 b		Particleboard	Diseño y Decorativos	Mexico	Saúl Duarte Méndez, Director 0152 331 980 4711	The industrial designer has developed a sargassum-based conglomerate board that can be used in several construction and furniture applications.

No. Source	Use area	End product / service	Name of organization /institution	Country	Contact links	Additional Information
			del Caribe Maya		caribemayadiseno@gmail.com	
7-4 b		Particleboard, biogas	Biogen Biotechnologies Inc.	Barbados	Mark Hill, Director biogengas.barbados@gmail.com markhill@thinkdesignbarbados.org	Biogen has been exploring the potential of sargassum for the development of particleboards. https://www.facebook.com/biogengas/
7-5 b		Bioasphalt, paper products	The Marine Box	Martinique	Christophe Germé & Priscilla Lambert, Founders. Jérôme Siniamin, CEO 596 696 17 93 70 / 569 696 30 47 07 j.siniamin@themarinebox.com c.germe@themarinebox.com	These young entrepreneurs are leading a French start-up and researching the possibility of using sargassum for different biomaterials, including paper and cardboard products, such as coffins, and bioasphalt. http://themarinebox.com/
7-6 b		Research - Ecomaterials	SARGOOD project	Guadeloupe & collaborators	Marie-Ange Arsène, project coordinator maarsene@univ-ag.fr	Holistic approach to sargassum valorisation including developing bioelicitors, biostimulants and other agricultural products, products and by-products by bio refinery, eco-materials and panels from ashes and particles, activated carbon, gelling agents, anticorrosive dyes.
7-7 b	Cosmetics	Soaps	Oasis Laboratory	Barbados	Kemar Codrington & Mikhail Eversley, Founders, CEOs 246 264 9543 sustainable@oasislaboratory.com	These two young entrepreneurs have been developing a sargassum skincare line. https://www.facebook.com/OasisLaboratory/
7-8 b		Hair care products, fertilizers, mulch & paper	Salgax Biotecnología Marina Aplicada	Mexico	Mauricio Gómez 52 999 285 4541 / 52 999 374 3214 / 52 999 371 5107 salgaxventas@salgax.com https://salgax.com	The team of young entrepreneurs are developing several sargassum-based products such as fertilizers, mulch, cosmetics and paper.
7-9 b	Electrochemical industry	Research - Electrodes	SARtrib project	Guadeloupe & collaborators	Thierry Cesaire, project coordinator thierry.cesaire@univ-antilles.fr	Valorisation of vacuum pyrolysis by-products of sargassum for use as lithium battery electrodes, supercapacitors, new generation lubricants, solvents and adhesives.
7-10 b, c		Research - Energy storage, activated carbon & biochar	University des Antilles, COVACHIMM2E laboratory	Guadeloupe, Martinique (France) & collaborators	Prof. Sarra Gaspard sarra.gaspard@univ-antilles.fr	The team is researching the potential of sargassum activated carbon for soil remediation, pesticide sequestration in animals, water treatment and energy storage (electrodes for supercapacitors) applications. http://www.univ-ag.fr/recherche/structures-derecherche/covachim-m2e-connaissance-valorisation-chimie-desmateriaux
7-11 b	Environmental restoration	Dune restoration	Texas A&M University	USA	Dr. Jens Figlus, Dept. of Ocean Engineering	Extensive research carried out by Texas A&M University, to determine the use of sargassum in coastal erosion prevention and restoration of sand dune

No. Source	Use area	End product / service	Name of organization /institution	Country	Contact links	Additional Information
					409 741 4317 figlusj@tamu.edu	ecosystems. Sargassum bales were tested to protect dunes from erosion and promote plant growth
7-12 b		Dune restoration	Walkers Institute for Regenerative Research Education and Design(WIRRED)	Barbados	Kiesha Farnum, Managing Director 246 622 4097 info@wirred.org http://walkersreserve.com/wirred1/ https://www.facebook.com/wirredbarbados	WIRRED is a not-for-profit think tank, research centre and consultancy dedicated to the study of climate-smart agricultural practices. Amongst their several ongoing projects, they are researching potential techniques for dune restoration and enhancing coastal plant growth.
7-13 b		Coastal restoration & compost	Moon Palace Resort	Mexico	Antonio Ortiz, Environmental Manager Info@palaceresorts.com	Moon Palace resort has been collecting sargassum from their 2-km long beach for several years and have been processing it into compost and used on the hotel grounds. They have been actively involved in restoring their coastal area and enhancing the growth of plants to prevent further beach erosion, using sargassum.
7-14 b		Carbon sequestration	Sargassum Ocean Sequestration of Carbon project (SOS Carbon)	Dominican Republic	Andrés Bisonó León & Luke Gray 833 767 2726 (SOS CRBN) Sales@soscarbon.com https://soscarbon.com/	This Boston-based engineering team and partners in Dominican Republic have developed a system to pump and effectively sink sargassum into the deep ocean before it impacts the coastlines.
7-15 b		Construction, HABs	Sargacreto (Dakatso)	Mexico	https://sargacreto.com.mx/	Manufacturing "SARGACRETO®," a concrete made from Sargassum
8-1 b	Food	Food	Tomfoodery Kitchen	Cayman Islands	Thomas Tennant, Chef	A chef in the Cayman Islands has experimented with the use of sargassum as an ingredient in different dishes.
8-2 b		Beer	Texas A&M University & Galveston Island Brewery	USA		In 2015, students and researchers from Texas A&M University, in collaboration with Galveston Island Brewery, have tested producing a craft beer using sargassum. https://www.houstonpublicmedia.org/articles/news/2015/04/02/58969/how-galveston-researchers-are-putting-seaweed-to-use/
8-3 b	Lubricants, surfactants &adhesives	Research	SARtrib project	Guadeloupe (France) & collaborators	Thierry Cesaire, project coordinator thierry.cesaire@univ-antilles.fr	Valorisation of vacuum pyrolysis by-products of sargassum for use as lithium battery electrodes, supercapacitors, new generation lubricants, solvents and adhesives.
8-4 b	Paper and cardboard products	Paper products	Sargánico	Mexico	Victoria Morfín, Founder & CEO 998 296 9700 ext 112 hola@sarganico.mx	This young entrepreneur has developed several high quality sargassum-based paper products such as notebooks, agendas, folders, business cards and many more. https://sarganico.mx/

No. Source	Use area	End product / service	Name of organization /institution	Country	Contact links	Additional Information
8-5 b		Paper products & bioasphalt	The Marine Box	Martinique (France)	Christophe Germé & Priscilla Lambert, Founders Jérôme Siniamin, CEO 596 696 17 93 70 / 569 696 30 47 07 j.siniamin@themarinebox.com c.germe@themarinebox.com	These young entrepreneurs are leading a French start-up and researching the possibility of using sargassum for different biomaterials, including paper and cardboard products, such as coffins, and bioasphalt. http://themarinebox.com/
8-6 b, c		Paper products	Sargasse Project	France (St. Barts), Guadalupe	Pierre-Antoine Guibout, Founder & CEO sargassesproject@gmail.com	Sargasse Project has been developing paper products made with 100% sargassum and is looking to scale-up the business. http://sargasseproject.com/
8-7 b		Paper products	Golden Tide Project	Curaçao	Wouter Osterholt http://www.wouterosterholt.com/golden-tide/golden-tide	This artist started the project Golden Tide, which consisted in making sargassum-based paper for use as painting canvas. Paintings skeletal remains were depicted, representing fauna killed by sargassum influx. Proceeds of sales were donated to Amazon Watch.
8-8 b, c		Cardboard boxes	Sargazbox	Mexico	sargazbox@gmail.com	Developing cardboard boxes with sargassum cellulose. https://www.facebook.com/Sargazbox/
8-9 b		Paper, fertilizer, mulch & cosmetics	Salgax Biotecnología Marina Aplicada	Mexico	Mauricio Gómez 52 999 285 4541 / 52 999 374 3214 / 52 999 371 5107 salgaxventas@salgax.com https://salgax.com	The team of young entrepreneurs are developing several sargassum-based products such as fertilizers, mulch, cosmetics and paper.
8-10 b		Research - Cardboard	SAVE-C project	Martinique & collaborators	Valérie Stiger, project coordinator Valerie.Stiger@univ-brest.fr	Valorisation of sargassum in agriculture (biopesticides) and as a biomaterial (cardboard).
8-11 b, c		Fertilizer & paper products	Dianco México	Mexico	Hector Romero 55 2731 3841 hromero@medialectica.com www.diancomexico.com	Dianco is in the process of establishing a sargassum processing plant to produce a sargassum-based fertilizer and paper products. https://www.elfinanciero.com.mx/tv/la-nota-dura/sargazo-nodejara-de-llegar-es-consecuencia-del-cambio-climatico-dianco
8-12 b	Pharmaceuticals & biomedical	Research	SARGSCREEN project	Martinique (France) & collaborators	Azaria Remion, project coordinator azaria.remion@gmail.com	Determining pharmacological potentials of sargassum extracts against non-communicable diseases common and widespread across the Caribbean.

No. Source	Use area	End product / service	Name of organization /institution	Country	Contact links	Additional Information
8-13 b		Research	University of the West Indies	Jamaica & Trinidad	Prof. Rupika Delgoda, Natural Research Institute (anticancer properties of sargassum extracts) npi@uwimona.edu.jm Dr. Winklet Gallimore, Dept. of Chemistry (bioactive compounds) Winklet.gallimore@uwimona.edu.jm Dr. Frederick Boyd, Dept. of Life Sciences (medical botany & antimicrobial properties) Frederick.boyd@uwimona.edu.jm Dr. Jayaraj Jayaraman (Dept. of Life Sciences) Jayaraj.Jayaraman@sta.uwi.edu	Several ongoing projects at UWI researching the potential of sargassum in pharmaceutical and biomedical applications.

a: Gran Caribe-UE Cenferencia_Sargazo_25JUL23

b: Sargassum Uses Guide_Sargassum Information HUB_2020.10

c: EU Blue Economy Report 2023, Phyconomy Seaweed Organizations Database https://phyconomy.net/database/

(6) Others

Table 6 Companies and Research Institutes for Utilization as Others

No. Source	Use area	End product / service	Name of organization /institution	Country	Contact links	Additional Information
9-1 b	General research	Research - Commercial value	Polytechnic University of Quintana Roo (UPQRoo)	Mexico	Jorge Cantó, Lead Researcher canto@corrosionyproteccion.com https://www.raconteur.net/sustainability/sustainable-business-2020/sargassum-seaweed-business	Funded by the Consejo Nacional de Ciencia y Tecnología (CONACYT) of Mexico, this research project focuses on determining potential commercial value of sargassum through interviews with local stakeholders, analysis of compounds and determining the impact indicator value for each potential use.
9-2 b		Research	Instituto de Ciencias del Mar y	Mexico	Dr. Brigitta van Tussenbroek vantuss@cmarl.unam.mx	Assessment of eco-toxological impact of sargassum leachates and particulate organic matter (POM) on marine organisms and ecosystems

No. Source	Use area	End product / service	Name of organization /institution	Country	Contact links	Additional Information
			Limnologia, Universidad Nacional Autonoma de Mexico			https://www.icmyl.unam.mx/puerto_morelos/en/node/24
9-3 b		Research	University of Greenwich	UK	Dr. John Milledge jj.milledge@gre.ac.uk	Renown algae biotechnology researcher with interest in macroalgae value chains for hydrocarbon fuel, energy balance of bioenergy and algal production processes and many more. Dr. Milledge has published on these topics with regards to sargassum.
9-4 b		Primary processing	Thalasso As	Mexico & Norway	Paulina Zanela & Frode Stolen Sønstebø 52 55 22 20 6751 paulinazanela@gmail.com frodesonstebo@gmail.com	This project is supported by Norway's Foreign Affairs in Mexico. The team is currently carrying out research for coastal harvesting and containment and offshore harvesting and primary processing of sargassum.
9-5 b, c		Research	Fearless Fund	USA	Alyson Myers 202 297 9743 Alysonmyers1@gmail.com www.fearlessfund.org	Fearless Fund is a non-profit dedicated to healthy ocean ecosystems, is supported by the US DOE ARPA-E to produce macroalgae at energy scale. They are looking to efficiently intercept the biomass before it beaches to repurpose the carbon for long term sequestration or conversion to carbon neutral energy. This includes building products, cement and various forms of energy.
9-6 b		Research – Biomass (sargassum + organic waste), nanocarbons and extracts	Tecnológico Nacional de México /IT de Cancún	México	Prof. J. Ysmael Verde Gómez, Graduate Studies and Research Department, TecNM/ITdeCancun jose.vg@cancun.tecnm.mx Dr. Ana María Valenzuela-Muñiz, Graduate Studies and Research Department, TecNM/ITdeCancun ana.vm@cancun.tecnm.mx	The research group is performing fundamental studies on the properties of sargassum to generate new knowledge towards future sustainable applications such as: biofuels, nanocarbons for energy and environmental applications, and extracts.
9-7 c		Carbon sequestration,HABs	Climate Cleanup	Netherlands		Project for utilizaiton of sargassum (creating a carbon sink, making fuel, building block, etc.) https://climatecleanup.org/sargassum/

No. Source	Use area	End product / service	Name of organization /institution	Country	Contact links	Additional Information
9-8 a		Investigation of the pollution risk by sargassum	NBC SARL	Francia	Sr. Nicolas Brehm nicolas.brehm@nbcsarl.com https://nbcsarl.com/	A consulting firm specializing in environmental impact studies, with expertise in the water sector, including drinking water and wastewater treatment, NBC is currently conducting a study of Sargassum for OEG (French Guiana Water Authority), investigating the risk of pollution if it washes ashore in large quantities and the decomposition process to make it economically valuable. He is working on the following projects.

a: Gran Caribe-UE Cenferencia_Sargazo_25JUL23

b: Sargassum Uses Guide_Sargassum Information HUB_2020.10

c: EU Blue Economy Report 2023, Phyconomy Seaweed Organizations Database https://phyconomy.net/database/

Attachment 2

Summary of the first online seminar materials

中米・カリブ海域
海藻類【サルガッサム】
利活用に向けたWebセミナー

主催：独立行政法人国際協力機構(JICA)

2023.1.11　10:00-11:30

日本工営株式会社

本Webセミナーのプログラム

時間	内容	発表者
10:00	開会挨拶	JICA中米・カリブ課
10:10	本調査概要 及び 中米カリブにおけるサルガッサム問題	JICA調査団
10:25	適応が期待される本邦技術	JICA調査団
10:40	事業化イメージ、支援スキーム	JICA中米・カリブ課
11:00	外務省の支援スキームのご紹介	外務省
11:15	質疑応答	参加者
11:25	閉会挨拶	JICA中米・カリブ課
11:30	閉会	

最後にwebアンケート調査をさせていただきたく、何卒ご協力お願い申し上げます。

本調査概要

本調査概要

中米カリブ地域（広域）
カリブ海沿岸におけるサルガッサムの利活用を目的とした本邦技術に係る基礎調査

目的	サルガッサムが漂着する地域の観光・漁業等への影響を改善するために、 サルガッサムの利活用に係る技術や製品、関連研究に係る情報を収集・整理し、 これらの技術を活用したサルガッサムの利活用に関する協力の可能性を整理・検討すること。
調査概要	机上調査、聞き取り調査、オンラインセミナーの開催を通じて、将来的な開発パートナーとなりうる機関の検討・整理を行い、今後のサルガッサム課題の利活用に関する協力シナリオ策定方針を作成する
調査期間	2023年11月下旬～2024年3月上旬
実施体制	JICA中南米部中米・カリブ課、中米・カリブ地域JICA現地事務所 JICA調査団：日本工営株式会社

本調査概要　- 調査の流れ -

2023.11下旬～12下旬

第１段階：机上調査
①サルガッサム全体調査
②海藻類の利活用調査
③サルガッサムの利活用調査
④有機廃棄物の利活用調査

2024.1.11
第1回 オンライン セミナー
Web アンケート
聞き取り先の選定

2024.1中旬～2上旬
第２段階：聞き取り調査・整理作業
サルガッサムの利活用に適応可能な日本の民間企業、研究機関・大学等への聞き取り調査

2024.1下旬～2中旬
将来的な開発パートナーとなりうる機関の検討・整理

中南米におけるサルガッサム問題

1.中米カリブ海でみられる浮遊性サルガッサムの現況
1.1 サルガッサムとは

綱 (Class)	目 (Order)	科 (Family)	属 (Genus)	種（Species）
Chlorophyccae（緑藻綱）				
Phaeophyceae（褐藻綱）				
	Fucales（ヒバマタ目）			
		Sargassaceae（ホンダワラ科）		
			Sargassum（ホンダワラ属）	
				Sargassum fluitans III Sargassum natans I Sargassum natans VIII
Rhodophyceae（紅藻綱）				

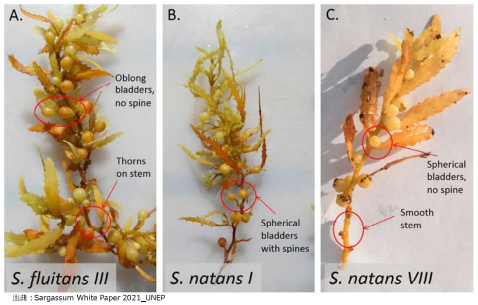
大型藻類におけるサルガッサムの分類

サルガッサム（ホンダワラ属）の特徴

- 褐色大型藻類に分類、ホンダワラ科ホンダワラ属
- 温帯・熱帯の海洋に300種以上
- 日本では、アカモク、ホンダワラ、ヒジキ※がこれにあたる

※ヒジキはホンダワラ科に分類されているが、英名にSargassumが付くケース（海藻海草標本図鑑、国立科学博物館）と、付かないケース（学研生物図鑑）がある。後者ではヒジキをヒジキ属、としてホンダワラ属と分類している。

1.中米カリブ海でみられる浮遊性サルガッサムの現況
1.1 サルガッサムとは



出典：Sargassum White Paper 2021_UNEP

中米・カリブ地域特有のサルガッサム

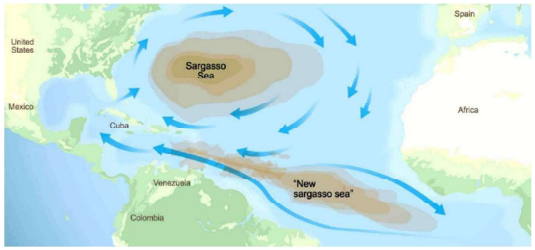
本セミナーで対象とするサルガッサム

- 大西洋赤道域の遠洋性（自由浮遊性）サルガッサム
- 2種または3種が混在
- 全深海性：海底に付着せずに浮遊してライフサイクル全体を過ごす唯一の種

※ヒジキはホンダワラ科に分類されているが、英名にSargassumが付くケース（海藻海草標本図鑑、国立科学博物館）と、付かないケース（学研生物図鑑）がある。後者ではヒジキをヒジキ属、としてホンダワラ属と分類している。

1.中米カリブ海でみられる浮遊性サルガッサムの現況
1.2 サルガッサムの漂流海域・増加

NIPPON KOEI



出典：*Cleaner Oceans Foundation, "New Sargasso Seas"*

- 大西洋の種で、フロートを有し、浮遊した状態で生息、表面風を受けながら海流で運ばれる
- 北大西洋で自然に発生し、循環海流によって大量に含まれ、サルガッソー海にて形成される
- 絶熱帯大西洋のギニア湾とブラジル北岸（アマゾン川・オリノコ川等）からの栄養塩の流入がサルガッサム増加の原因と言われている

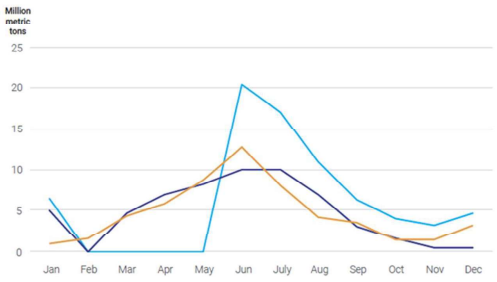
1.中米カリブ海でみられる浮遊性サルガッサムの現況
1.3 サルガッサムの役割、現況

NIPPON KOEI

- サルガッサムの本来の役割は、滅危惧種を含む多様な動植物の生息地、産卵場所、隠れ場所やえさ場など
- 2011年以降大量発生を繰り返す。中南米・カリブ地域の沿岸部に不定期に大量漂着
- 漂着した藻は腐敗しやすく、悪臭による環境汚染を引き起こしている他、観光業や漁業へも影響し、同地域の社会経済に打撃を与えている

1.中米カリブ海でみられる浮遊性サルガッサムの現況
1.4 中米・カリブ地域におけるサルガッサムの漂着時期、量

NIPPON KOEI



2018	6.4M	-	-	-	-	20.4M	17M	11M	6.3M	4M	3.2M	4.7M
2019	5M	-	4.7M	7.0M	8.2M	10M	10M	7M	3M	1.5M	0.5M	0.4M
2020	1M	1.6M	4.3M	5.8M	8.7M	12.7M	8.0M	4.2M	3.5M	1.4M	1.4M	3.2M

出典：Sargassum White Paper 2021, UNEP

- 年によって発生量にばらつきはあるが、概ね春先から増加し夏以降減少
- 4年前と比較して20%増の2,400万トンを超える漂着量(2022年)
- 爆発的繁殖は今後も続くと予想

2.サルガッサムによる現地の被害
2.1 サルガッサムによる影響

NIPPON KOEI

社会経済への影響
メキシコでは観光客が35%減少（2018年）

観光分野
- 悪臭　・遊泳阻害　・回収費用負担
- 景観悪化→旅行キャンセル

水産分野
- 漁業の阻害（地引網、漁業フロート）
- 漁獲量の減少→漁師の収入減

公衆衛生
- 呼吸器疾患、吐き気、頭痛、目の炎症
- 発疹、炎症

海事
- 航行阻害　・舵等の船体への引っ掛かり

地元住民
- 観光ビジネスの売上減少
- 硫化水素による腐食（電子機器、ボート）

環境・生態系への影響
メキシコでは藻場の大量枯死が発生

- 海洋の低酸素状態→サンゴ礁・海洋生物生育悪化
- ウミガメ等の海洋生物の行動の阻害
- 漂着後の腐敗→温室効果ガスの発生
- 海岸浸食、外来生物の流入

2.サルガッサムによる現地の被害
2.2 漂着した浮遊性サルガッサム（メキシコの様子）

NIPPON KOEI


カンクン（2019年4月）


トゥルム（2019年4月）


プエルト モレロス（2019年4月）


カルメン ビーチ（2019年5月）

2.サルガッサムによる現地の被害

NIPPON KOEI

カリブ諸国の様々な国では、サルガッサムの流入に対し国家非常事態を宣言


Cancún: 22 de junio de 2018
出典： Porfirio Alvarez Torres


Micoud, St. Lucia 2021.09.21
出典：調査団

3.中米・カリブにおけるサルガッサムの対応状況
3.1 サルガッサムに対する取り組み

NIPPON KOEI

サルガッサムによる影響を改善するための取り組みとして、サルガッサムの流入モニタリング、回収、処理の段階で対応されている。

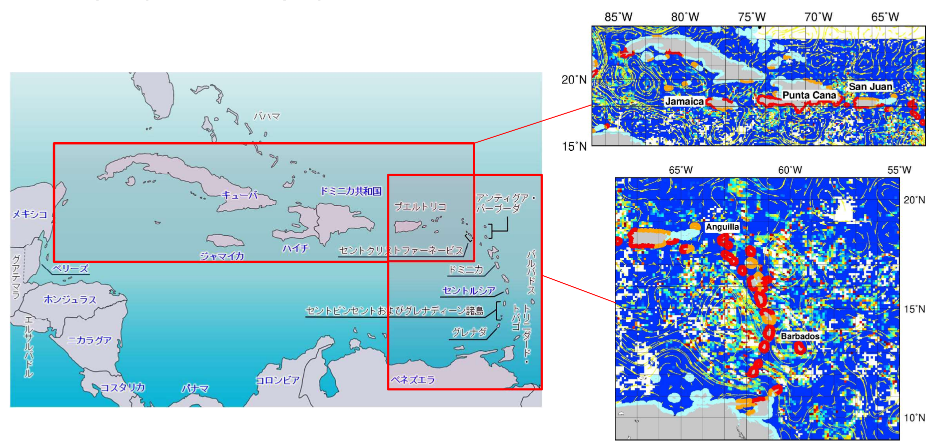
取り組み	取り組みの現状	取り組みに係る問題点
モニタリング	衛星・ドローンや海流予測を用いたサルガッサムの流入予測	雲やサハラ砂漠の塵、水蒸気などのノイズや海流により高精度の予測が困難、各国関係者からのアクセス、データの利活用、予防・対応措置が不十分 実際には市民や観光客による写真の投稿により、サルガッサムの漂着を把握
流入予防	海上へのフロート設置 作業船の稼働	水深や海岸の状況次第では機能せず、高価、投入・メンテ費用 ハリケーンに備えて要撤去
回収	バックホウなどの重機による回収 手作業による回収	回収にかかる人件費、重機、トラックのレンタル費用が高価 重機による回収は、砂浜保護の観点から進んで実施されておらず、回収が遅延 回収しきれず堆積したサルガッサムが悪臭を放ち、回収作業が中断 観光地では作業日当が支払われて除去されているが、漁村や一般集落では除去に係るインセンティブがなく除去が進まない
処理	埋立地へ埋立 農地への散布	運搬費用の負担 ベリーズにて採取したサンプルから高いヒ素の値が検知されたことから、廃棄方法や利活用に懸念

出典：Fact-finding survey regarding the influx and impacts of Sargassum seaweed in the Caribbean region：final report(2019),北米・中南米（広域）With/Post COVID-19 禍下における強靭な社会共創のための人材及びインフラ開発に係る情報収集・確認調査 ファイナルレポート(2023)を基に調査団作成

3.中米・カリブにおけるサルガッサムの対応状況
3.2 モニタリング

NIPPON KOEI

米国海洋大気庁 (NOAA) と南フロリダ大学 (USF)によるサルガッサム漂着モニタリングツール（2023年8月）



出典：Experimental Weekly Sargassum Inundation Risk (SIR v1.3) https://cwcgom.aoml.noaa.gov/SIR/index.php?dtrange=SIR_20230515#

3.中米・カリブにおけるサルガッサムの対応状況
3.3 流入予防

写真出典：AlgaeNova社ウェブサイト

ドミニカ共和国でのAlgeaNova社によるログブーム
（7キロのバリア、海上での回収）

写真出典：DESMI社ウェブサイト

DESMI社（デンマーク）のMESH BOOM

写真出典：SOS Carbon社動画

SOS Carbon社は、低コストで騒音や生態系への影響が少ない装置を開発。
観光業界や地元住民との協働で取り組んでいる。

3.中米・カリブにおけるサルガッサムの対応状況
3.4 回収

写真出典：CIIMAR

手動による回収（メキシコ）

写真出典：CIIMAR

吸引での回収（メキシコ）

写真出典：UFHEC, Playa Guayacanes, El Nuevo Diario (June 9th 2023)

重機を用いた回収（ドミニカ共和国）

4.サルガッサムの利活用状況
4.1 中米カリブ地域でのサルガッサムの利活用：農業・漁業

利活用方法	概要・具体的事例	開発ステージ*
たい肥化	• AlgaeNova 社やSOS Carbon 社（ドミニカ共和国）はサルガッサムの洋上回収からたい肥製造まで実装	研究開発～社会実装 
バイオスティミュラント	• CRFM（CARICOM の漁業関連組織）がニュージーランドからの支援にて、サルガッサムからの液肥を実施 • セントルシアのスタートアップAlgas Organics 社が、現地のサルガッサムを活用したバイオスティミュラントを製造販売（重金属の除去も対応）	研究開発～社会実装 
家畜飼料の製造	• 研究開発が多いが、Awganic Inputs 社（ジャマイカ）はサルガッサムを主原料としたサプリメント飼料（ヤギ用）を商品化	研究開発～社会実装

*"開発ステージ"は、【研究開発（基礎研究～応用研究まで）】技術の研究～開発段階、【実証実験】普及に向けた調整段階、【社会実装】得られた研究成果をもとに社会に普及させる段階、で示す。

4.サルガッサムの利活用状況
4.2中米カリブ地域でのサルガッサムの利活用：エネルギー

利活用方法	概要・具体的事例	開発ステージ*
ﾊﾞｲｵｴﾀﾉｰﾙ・ﾃﾞｨｰｾﾞﾙ生成	• 研究機関によるポテンシャル確認・生成方法にかかる研究段階	研究開発（基礎研究）
バイオガス回収	• 他の有機物と混合したバイオガス回収計画やパイロット事業がドミニカ共和国、メキシコ、バルバドス等で実施中。 • FWM 社（ドイツ）はホテルへの小規模施設の設置を計画中。 • ベリーズで政府主導のバイオ燃料製造パイロット事業（一般ごみ及びサルガッサム）を開発中（Variodin（ドイツ）と連携）	実証実験
バイオ炭の生成	• メキシコ等でのポテンシャル確認・生成方法にかかる研究段階	基礎研究

*"開発ステージ"は、【研究開発（基礎研究～応用研究まで）】技術の研究～開発段階、【実証実験】普及に向けた調整段階、【社会実装】得られた研究成果をもとに社会に普及させる段階、で示す。

4.サルガッサムの利活用状況
4.3中米カリブ地域でのサルガッサムの利活用：材料（プラスチック・建設資材）

利活用方法	概要・具体的事例	開発ステージ*
ブリックや建設ﾎﾞｰﾄﾞの製造	• メキシコではサルガッサムを原料としたブリックや建設ボードが開発中	（小規模）社会実装
バイオプラスチックの製造	• バイオプラスチック製造メーカーや大学・研究機関が研究開発を実施中。 • Abaplas（メキシコ）はサルガッサムを原料（30%）にする手法をテスト中 • ドミニカではサルガッサムとキャッサバを原料とした使い捨て皿を開発中	研究開発～実証実験  サルガッサムとキャッサバの使い捨てプラスチック
紙製品の製造	• スタートアップが環境にやさしい製品として売り出し中（メキシコ、キュラソー等） • Sargasse Project（フランス）は、商用レベルへの紙製品実用化に向けた研究を実施中	研究開発～（小規模）社会実装

*“開発ステージ”は、【研究開発（基礎研究～応用研究まで）】技術の研究～開発段階、【実証実験】普及に向けた調整段階、【社会実装】得られた研究成果をもとに社会に普及させる段階、で示す。

4.サルガッサムの利活用状況
4.4 カリブ地域でのサルガッサムの利活用：成分抽出

利活用方法	概要・具体的事例	開発ステージ*
医薬品の製造	• 西インド諸島大学で複数の研究プロジェクトが進行中	研究開発
化粧品の製造	• スタートアップがサルガッサムを利用したスキンケアを開発中	研究開発  サルガッサムを使用した石鹸

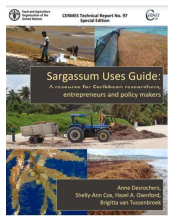
*“開発ステージ”は、【研究開発（基礎研究～応用研究まで）】技術の研究～開発段階、【実証実験】普及に向けた調整段階、【社会実装】得られた研究成果をもとに社会に普及させる段階、で示す。

参考資料

1. United Nations Environment Programme, “**Sargassum White Paper**” 2021
https://www.unep.org/cep/resources/publication/sargassum-white-paper-turning-crisis-opportunity

2. Food and Agriculture Organization of the United Nations,
“**Sargassum Users Guide: A resource for Caribbean researchers, entrepreneurs and policy makers**” 2020
https://sargassumhub.org/sargassum-uses-guide-now-available/

3. ”**Sargassum Information Hub**” operated by GEO Blue Planet in collaboration with several partners
https://sargassumhub.org/



課題解決に向けて適応が期待される技術

1. 本調査のステップ

課題解決に向けて適応が期待される本邦技術や研究（特に利活用分野）に係る情報収集

① 現地サルガッサム問題及び利活用の全体像・課題に係る情報を基に、適応が期待される技術項目の洗い出し

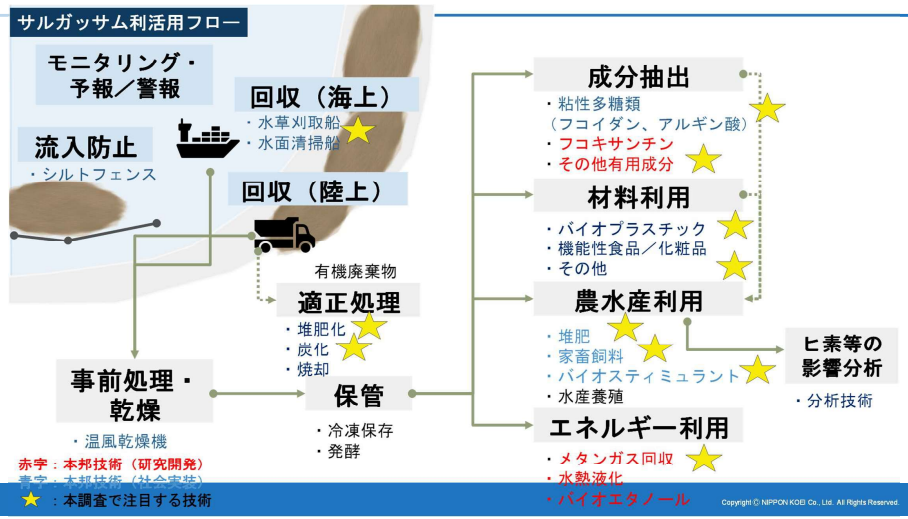
② ・各技術項目での研究開発・実装を行う民間企業、スタートアップ、研究機関の調査
・各技術項目の適応可能性に係る初期的検討
i. 科学技術面、ii. 社会経済面、iii.ビジネスモデル面からの課題の整理（ボトルネックの確認）

・・・本セミナー

③ 企業・研究機関の皆様へのインタビュー
技術項目：サルガッサムへの適応可能性、技術要件や投入（施設、資材、コスト、人材等）、必要となる調査内容、各項目で整理された課題、等
個社：　中南米への事業展開への関心、懸念事項、現地パートナーの要件、等

本邦企業・技術を活用したサルガッサムの利活用に関する協力の可能性の検討

2. 適応可能性のある技術項目



3. サルガッサムの利活用に係る現地での主な課題

現地で確認されている利活用にかかる主な課題

1. 回収、洗浄、前処理に係るロジスティックと費用
2. 供給量・質が一定ではない
3. 様々な物質（重金属を含む）／生物の混在、除去
4. 海岸への漂流に係る傾向や予報の限界
5. 研究活動と社会実装への展開、各活動主体の横の連携

4.利活用：農水産利用

Pros ➡ **他の技術より安価に、簡単に利活用可能。成分抽出後の処理方法としても有効。化学肥料の高騰、食料安全保障の向上が期待される。**
Cons ➡ **ヒ素・重金属の土壌、農作物への影響は分析が必要。国によっては、国外での分析となる。回収後の乾燥、保管。**

	本邦技術適応の優位性／機会	適用に係る課題
農地への施用	• 日本では古来から実施 • 海水を流水で洗い流し、利用可能 • 最も安価に適用可能	• 土壌への混合方法次第で嫌気性となるため、農家へは要指導
バイオスティミュラント	• 注目度高く市場拡大中 • 漂着後のサルガッサムにも適応可能性あり	• 現地では欧州企業による取組先行
堆肥化技術 家畜飼料 養殖用飼料	• 国によっては市場あり	• 単一原料ではなく他の原料との配合の可能性あり • 海藻の前処理・保管にかかる場所やコスト

4.利活用：農水産利用
主要対象国の農業活動

主要対象国	農水産への利活用ポテンシャル/本邦技術適用にかかる事業環境	各国の農地面積状況
ドミニカ共和国	• 一年を通して農業が盛ん • 米やバナナの生産量が多い • 大学による研究、民間企業の参入が盛ん	• 国土面積は約484万haである。 • 約246万haが農地（国土の51%） • 日本の農地面積の約1.25倍
セントルシア	• 農業は小規模 • 小島のため島内のアクセス良好	• 国土面積は6.2万ha • 約1万haが農地（国土の16.3%） • 日本の農地面積の196分の1
ベリーズ	• 農地は散在傾向 • サトウキビやバナナの生産量が多い	• 国土面積は約230万ha • 約18万haが農地（国土の8%） • 日本の農地面積の約10分の1
ジャマイカ	• JICA有償資金協力を実施 • CARICOMへの拡大の期待大	• 国土面積は110万ha • 約42.3万haが農地（国土の38.5%） • 日本の農地面積の約5分の1
メキシコ	• 広大な農地面積 • 中米地域内での三角協力への期待大	• 19,700万ha • 約9,900万haが農地（国土の50%） • 日本の農地面積の約50倍
キューバ	• 特殊な経済政治システムに加え、米国経済制裁等による経済状況の悪化もあり、資機材の購入や搬入が難しく事業環境が厳しい	• 国土面積は約1000万ha • 約678万haが農地（国土の61.7%） • 日本の農地面積の約3.4倍
ホンジュラス	• コーヒー・バナナなど一次産品への依存度が高い • 汚職、治安悪化が懸念	• 国土面積は1125万ha • 360万haが農地（国土の32%） • 日本の農地面積の約1.8倍

出典：IDB, Extreme Outlier: The Pandemic's Unprecedented Shock to Tourism in Latin America and the Caribbean(2020)などの情報を基に作成
各国の農地面積状況はWorldbank.orgの情報を基に作成（https://data.worldbank.org/）

4.利活用：農水産利用
サルガッサム（乾燥）の成分事例

地域や時期により、ヒ素の含有量は大きく異なる

畑地での分解には比較的時間が必要

採取場所	Total As (ppm)	Org. As (ppm)	Inorg.As (ppm)	Cd (ppm)	Hg (ppm)	Pb (ppm)	Cr (ppm)	C/N比
メキシコ (2018-2019)	24-172 (ave.80)		-	<2	-	<2-3	<8	-
イギリス領ヴァージン諸島 (2016)	45	17.3	27.7	0.169	<0.005	0.32	-	-
マルティニーク島・グアドループ島 (2015-2016)	11.5-100.8	-	-	-	<0.1	<5.3-1.2	5.2-10.6	17-35
タークス・カイコス諸島 (2019)	123.69	-	-	<0.2-1.02	0.01	0.26	<0.3	16.08
ドミニカ共和国 (2015)	14-42	-	-	0.13	-	1-2	2-56	-

※東京都によるひじき（乾燥）に含まれるヒ素含有量は、34～117ppm（うち無機ヒ素は約75%）

各成分量や、C/N比は分析対象によって大きく異なるため、あくまで参考値としてご認識ください。

出典：Sargassum Use Guide

5. 利活用：材料利用

Pros → **高付加価値の可能性。**
Cons →**サルガッサムの回収、乾燥・事前処理、保管が課題。食品として加工する場合はヒ素・重金属の含有量分析や安全性確認が必須。**

	本邦技術適応の優位性／機会	適用に係る課題
バイオプラスチック	• 現地サルガッサムによる生分解性プラスチックの製造技術が報告済 • ごみ等が混合した状況から、純粋な海藻を抽出可能な技術 • 実用化にはコストが課題	• 現地でも大学等が研究開発中 • 製造コストが課題（既存プラスチックとの競合）
機能性食品	• 食文化を活かした海藻を原料としたサプリメントや粉末状食品（機能性食品）製造技術 • 中米・カリブでは確認されない • 予防医学の観点から世界的に市場は拡大	• 日本ではアカモク、モズク、コンブ等食用藻類が対象（中米のサルガッサムは食用されていない） • 安全性確認、現地の規制等
化粧品その他	• 化粧品、藻塩、可食性フィルムの製造販売等の技術 ※化粧品についてはスタートアップでの取り組みが確認されている	

5. 利活用：材料利用

中米のサルガッサムを活用した事例

Green Science Alliance

◆サルガッサム複合天然生分解性樹脂製スプーン

◆サルガッサムを加工し、押出機などを用いて、樹脂、樹脂成型品を作成

◆その他生分解性プラスチック製品、塗料、美容製品などへのサルガッサムの利用を検討

◆現地企業との協業

6. 利活用：成分抽出

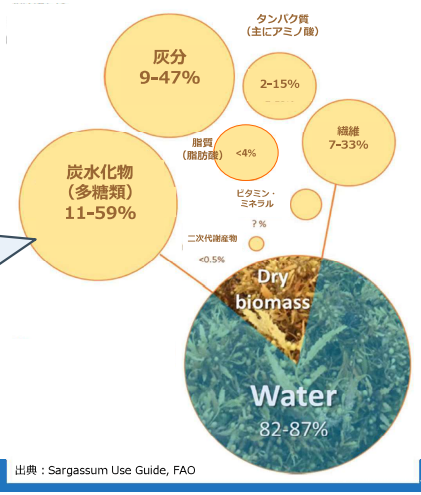
Pros ➡ **高付加価値の可能性。**
Cons ➡**サルガッサムの回収、乾燥・事前処理、保管が課題。食品として加工する場合はヒ素・重金属の含有量分析や安全性確認が必須。**

主な技術	本邦技術適応の優位性／機会	適用に係る課題
粘性多糖類の抽出（フコイダン、アルギン酸）	• 中米・カリブでは確認されない • 日本では複数社が製造・販売、その効用も確認済 • 安価な原料調達に期待	• フコイダンの抽出効率は未確認 • 回収・乾燥・保管技術やコスト • 安定した原料調達（季節変動）
その他有用成分の抽出	• 各海藻の有用成分の発見や抽出、商品化（機能性食品、化粧品、医薬品） • 健康増進、老化防止等の効用研究も	• 中米サルガッサムの含有成分と抽出効率

6. 利活用：成分抽出
成分抽出に係る研究結果事例

イギリス領ヴァージン諸島(2016)
サンプル：海岸漂着のサルガッサム
炭化水素（多糖類）含有割合

10.25%：マンニトール
12.6%：ラミナリン
15.55%：アルギン酸
6.19%：フコイダン



出典：Sargassum Use Guide, FAO

7. 利活用：エネルギー利用

Pros ➡ **大量の処理が可能。腐敗後のサルガッサムへの適応可能性あり。**
成分抽出後の処理方法としても有効。
エネルギー安全保障として、エネルギー利用への期待あり。

Cons ➡ **日本ではコストに見合わず社会実装されていない。**
一年を通した施設稼働のための原料確保が課題。
（その他有機廃棄物との混合での適応が可能か）

主な技術	本邦技術適応の優位性／機会	適用に係る課題
メタン発酵（バイオガス）	• 消化液は、土壌改良剤として農地利用可能 • 各国で計画が検討されている • 大学での研究事例あり	• サトウキビやトウモロコシなどの原料と比較し、食料と競合しない • サルガッサムへの適応は実証必要 • サトウキビなどのその他の農業残渣の活用可能性あり • 低脂質、複雑な多糖類によるエネルギー化の難しさがある（左図参照）
水熱液化（HTL）	• 中米・カリブでは確認されない	
バイオエタノール		

出典：Sargassum use guide. BLUE BIOECONOMY REPORT(2023)

7. 利活用：エネルギー利用
バイオエネルギーに係る動向

ベリーズ、サルガッサムのバイオ燃料化を示唆

ベリーズの首相は、自治体の固形廃棄物とサルガッサムを併せた燃料化に対し、ドイツの企業と5,000万ドルの契約を結ぶ計画であると述べている。

OCT 10, 2023

Belize hints at turning sargassum seaweed into biofuel

Belize has been reported to be developing a pilot project to convert sargassum seaweed into biofuel.

Prime Minister John Briceno said in a statement that a $50 million (€47 million) facility, the result of a public-private partnership with German company Variodin, would convert municipal solid waste and sargassum into diesel fuel replacements.

The facility could be scaled up with more financing, he said, adding that it would sign a power purchase agreement for energy generated from the plant.

"The sargassum seaweed invasion [is] causing economic, social and environmental wreckage across Belize and the Caribbean," a spokesman for the regional bloc CARICOM said.

"Removal is a vicious cycle of never-ending sargassum, a cycle that removes the seaweed but also the sand, causing further damage to the coastline.

"Research conducted shows that conversion of sargassum into the Belize energy mix is a viable solution to the problem," he concluded.

現地の民間企業及び大学との協業

イスラエルの企業と、現地のホテルや大学などで構成されたグループ（ドミニカ共和国）は、ホテルの食品廃棄物を原料とした小規模のバイオガスは圧電の実証を行った。

出典：Biofuel International (https://www.biofuels-news.com/news/belize-hints-at-turning-sargassum-seaweed-into-biofuel/)
Sargassum use guide

7. 利活用：エネルギー利用
現地でのエネルギー自給率

主要対象国	エネルギー供給の状況	エネルギー自給率	出典
ドミニカ共和国	• 一次エネルギーの89%を輸入している • エネルギー源の8割超が化石燃料であり、海外からの輸入に依存している • 再生可能エネルギーの割合は14%である	2015年：8 % 2020年：14 %	Dominican Republic_Central America and the Caribbean_RE_SP.pdf (irena.org)
セントルシア	• 一次エネルギーの108%を輸入している • エネルギー源の92%が石油由来であり、海外からの輸入に依存している • 再生可能エネルギー（主にバイオ燃料）の割合は8%である	2015年：9 % 2020年：8 %	Saint Lucia_Central America and the Caribbean_RE_SP.pdf (irena.org)
ベリーズ	• 一次エネルギーの67%を輸入している • エネルギー源の約60%が石油由来である • 再生可能エネルギーの割合は41%であり、そのうち88%がバイオ燃料によるものである	2015年：56 % 2020年：43 %	Belize_Central America and the Caribbean_RE_SP.pdf (irena.org)
ジャマイカ	• 一次エネルギーの118%を輸入している • エネルギー源の88%が化石燃料であり、海外からの輸入に依存している • 再生可能絵エネルギーの割合は12%であり、そのうち84%がバイオ燃料によるものである	2015年：8 % 2020年：11 %	Jamaica_Central America and the Caribbean_RE_SP.pdf (irena.org)
メキシコ	• 一次エネルギーの57%を輸入している • エネルギー源の約9割が化石燃料である • 再生可能エネルギーの割合は11%であり、バイオ燃料をはじめ、地熱、太陽光、水力発電など多様な再生可能エネルギーを使用している	2015年：105 % 2020年：84 %	Mexico_North America_RE_SP.pdf (irena.org)
キューバ	• 一次エネルギーの62%を輸入している • エネルギー源の約9割が化石燃料である • 再生可能エネルギー（主にバイオ燃料）の割合は12%である	2015年：46 % 2020年：50 %	Cuba_Central America and the Caribbean_RE_SP.pdf (irena.org)
ホンジュラス	• 一次エネルギーの62%を輸入している • エネルギー源の53%が石油由来である • 再生可能エネルギーのの割合は47%であり、そのうち約70%がバイオ燃料によるものである	2015年：43 % 2020年：46 %	Honduras_Central America and the Caribbean_RE_SP.pdf (irena.org)

8. 利活用：ブルーエコノミー

Pros ➡ 温室効果ガス低減に貢献
カーボンクレジット化されれば、地元住民への還元の可能性あり

Cons ➡ 既存の方法論では、新規の藻場形成のみクレジット化の対象、未成熟市場
海底へ沈めた場合の自然環境への影響は不透明

主な技術	本邦技術適応の優位性／機会	適用に係る課題
ブルーカーボン	• 新規の藻場形成に対するGHG算定方法が公開されている • クレジット化方法論は、開発中 • 各国のファンドの関心が高い	• クレジット化を目指す場合は、新規方法論の申請や検証方法の確立が求められる。

9. 流入防止・回収技術

Pros ➡ 洋上回収により、漂着後の砂浜との混合や腐敗、海岸線の侵食等が防止可能
成分抽出などの利活用に適した状態での回収が可能

Cons ➡ 洋上での大規模回収は、サルガッサムが本来保有する生態系維持機能を損なう恐れがある

主な技術	本邦技術適応の優位性／機会	適用に係る課題
流入防止網	• 現地ニーズが高い	• 既に現地企業や欧州企業が網を設置している • 網に滞留したサルガッサムの回収
水面清掃船	• 水草（ホテイアオイ等）の刈取回収船や湾岸でのごみ回収船 • 設計から製造まで	• 回収キャパシティ • 限定的な運転

10. 適正処理

Pros ➡ 即時の適正処理が可能
Cons ➡ 埋立時の土地利用、炭化・焼却の場合は環境基準への適合

主な技術	本邦技術適応の優位性／機会	適用に係る課題
埋立	• 日本に漂着した海藻類は、産業廃棄物として処理、または埋め立て（EM菌を撒いている事例有）	• 直接埋立だと嫌気性となるので、適切な埋立方法や、散布方法についての指導は必要 • 運搬に係るトラック、埋立地は必要
飼料化、堆肥化（有機廃棄物）	• 乾燥機、破砕機、焼却などの処理装置の活用が期待される	• サルガッサムの含水比は80%-90%ほどと高い • 脱水、乾燥、洗浄などの前処理の要否
炭化	• 炭化物は土壌改良剤やエネルギー利用可能	

11. まとめ

- 科学技術面：本邦技術適応性
- 社会経済面：有効性、現地への受け入れ可能性、波及効果・インパクト、法規制等
- ビジネスモデル面：市場、ビジネスモデル、事業性、経済性
- ボトルネック？

民間企業や研究機関の皆様が有する各分野の技術や研究

× JICA等の協力スキーム

サルガッサムの付加価値の創造

- 民間企業・研究機関の新たな事業展開
- 本邦技術の海外展開
- 観光業や漁業への影響の緩和
- 環境への負荷軽減（海岸浸食等）
- 気候変動への貢献
- エネルギー安全保障への貢献
- 食料安全保障への貢献

NIPPON KOEI

本日はWebセミナーへご参加いただき、誠にありがとうございました。

ウェブアンケートのご協力を何卒宜しくお願い致します。

https://forms.gle/pqoWUUaxfE6HRV648

アンケートの最後に、本日のプレゼン資料の電子データのダウンロード用URLがございますので、合わせてご活用くださいませ。

サルガッサム利活用に係るセミナー

2024年1月11日（木）
独立行政法人 国際協力機構（JICA）
中南米部中米・カリブ課　秋山　慎太郎
Akiyama.Shintaro@jica.go.jp

目次

1．中南米地域の特徴

中南米地域の特徴

（マクロ面）
- 市場としての魅力：ASEANと同じ人口、経済規模1.7倍
- 日本とのつながり：資源と日系社会の存在
- 高い所得水準（卒業）：JICAにとって次世代協力のモデル
- 新型コロナウィルスの影響：深刻な感染状況と経済成長への影響
- 財政制約：財政赤字の拡大、平常時は低い円借款借入意欲
- 民間資金（投資・海外送金）の存在感：低いODA地位
- 短期政権によるポピュリズムの蔓延：政策の非持続性
- 大きい貧困格差：開発ニーズの存在
- 治安問題：投資環境整備・事業実施におけるボトルネック

（事業実施面）
- 言語・文化の類似性：域内展開・南南協力の下地
- 日本社会の関心の低さ：ODAサポートの推進力不足（案件形成、認知度、無償案件の不調不落等）

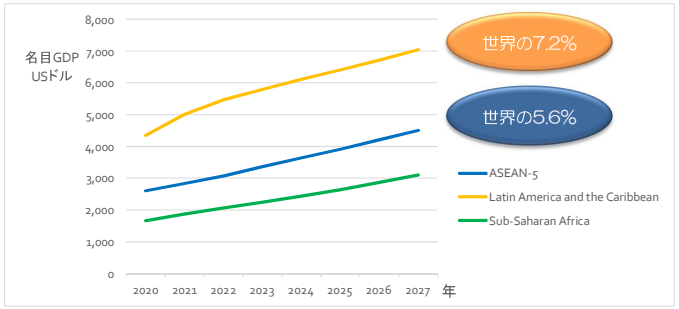
市場としての魅力

4

ASEANに匹敵する人口規模

出所 世界銀行, UN
2022年度データ

ASEANの1.7倍の経済規模（GDP）



出所 2022 IMF
2022年以降は推計

日系社会

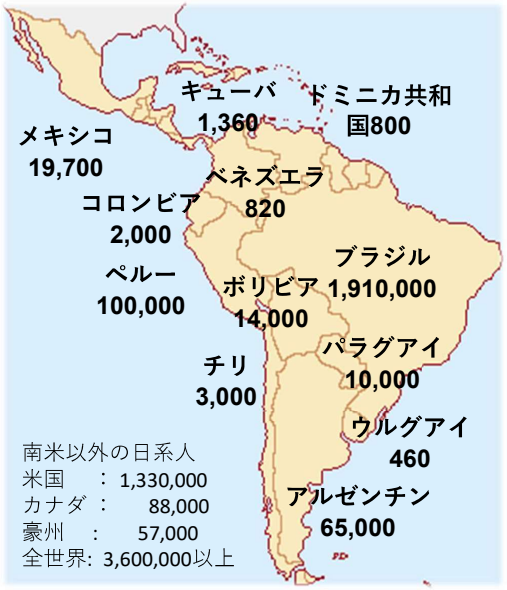
5

中南米の推定日系人総数

約213万人

中南米への送り出し総数

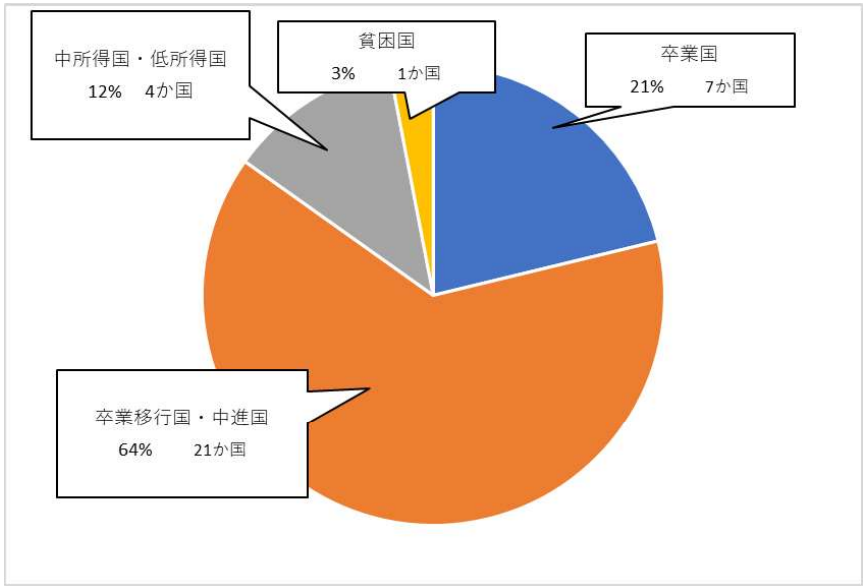
約34万9千人



高い所得水準（所得分類シェア）

6

中南米地域内（計33か国）の85%の国が中進国以上。



中南米主要国の経済成長域内比較

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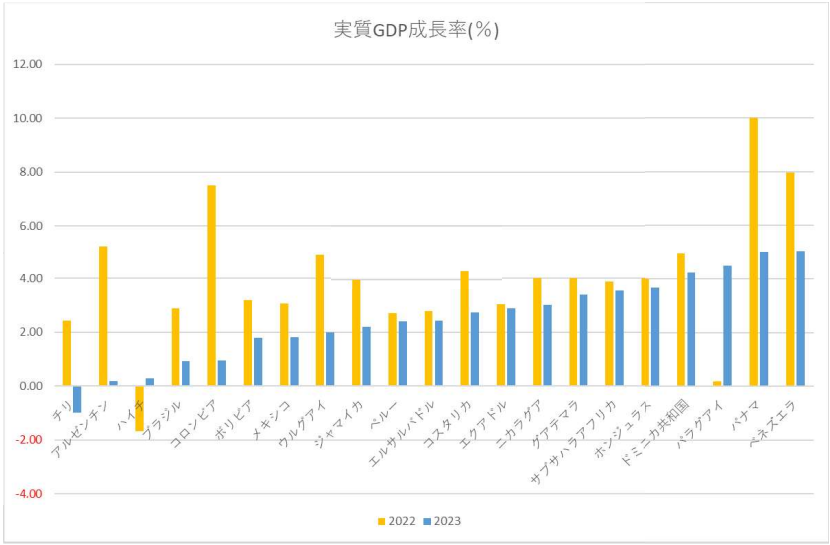

（IMF）

インフレ率の比較

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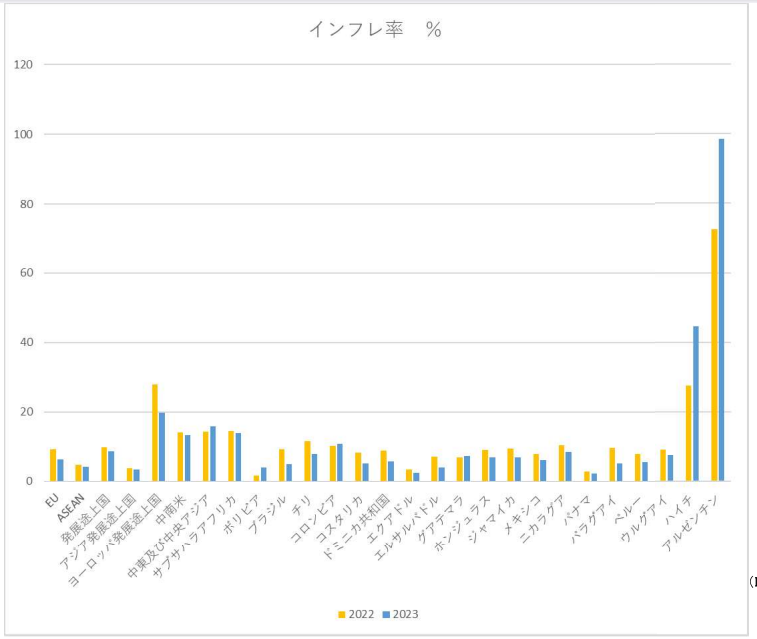
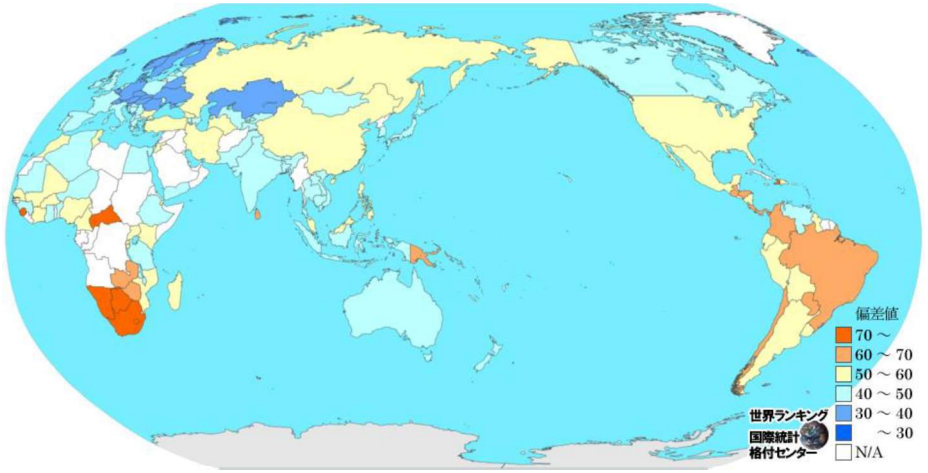


（IMF）

大きい貧困格差（ジニ係数）

9

地域的に中南米とアフリカ南部でジニ係数が高い。
（黄色→赤色と格差が大きくなる）



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2．中南米地域の協力動向

2．中南米地域の協力動向

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- <u>中南米はJICAにとって次世代協力のモデル</u>
  ⇒協力アセットの活用：協働による効果的な貢献、親日国の維持・関係強化、研修員同窓会のネットワーク
  ⇒他アクターとの協働：民間企業連携・海外投融資、日系社会連携、IDB連携（質高インフラ・保健・防災）、TSUBASAプログラム（IDB Labとの共催、スタートアップ支援）日米連携
  ⇒日本と共に解決：防災、高齢化社会、DX、海プラ

- <u>日系社会連携</u>
  ⇒国内の外国人人材活用への応用
  ⇒資料館ネットワーキング
  ⇒ビジネス連携（調査団派遣→中小企業支援スキーム）

米州開発銀行(IDB)との連携

12

- 第4次協調融資枠組み（CORE）として、Cooperation for Economic Recovery and Social Inclusionに改名して、グループ全体と2021年3月にMOC調印。
- IDBとは80年代から協調。CORE枠組みは2012年から。
- 現在、**約30億ドルを承諾済**。
- IDB LabとTSUBASAオープンイノベーションチャレンジ開始。
- 2022年12月にSIB（ソーシャル・インパクト・ボンド）にかかる勉強会を開催。

	旧CORE	新CORE
円借款等承諾額の目標額	30億ドル	30億ドル
対象期間	～2021年4月	～2026年3月
ソブリン／非ソブリン	ソブリンのみ IDB Investとは別途MOU	非ソブリンもCOREに統合し、 IDB Lab、IDB-Investも対象に
対象分野	電力・水・運輸 （省エネ・再生可能エネ）	ソブリン：質高インフラ全般、防災、保健 非ソブリン：JICA海外投融資の対象分野

（参考）外務省地域別重点課題

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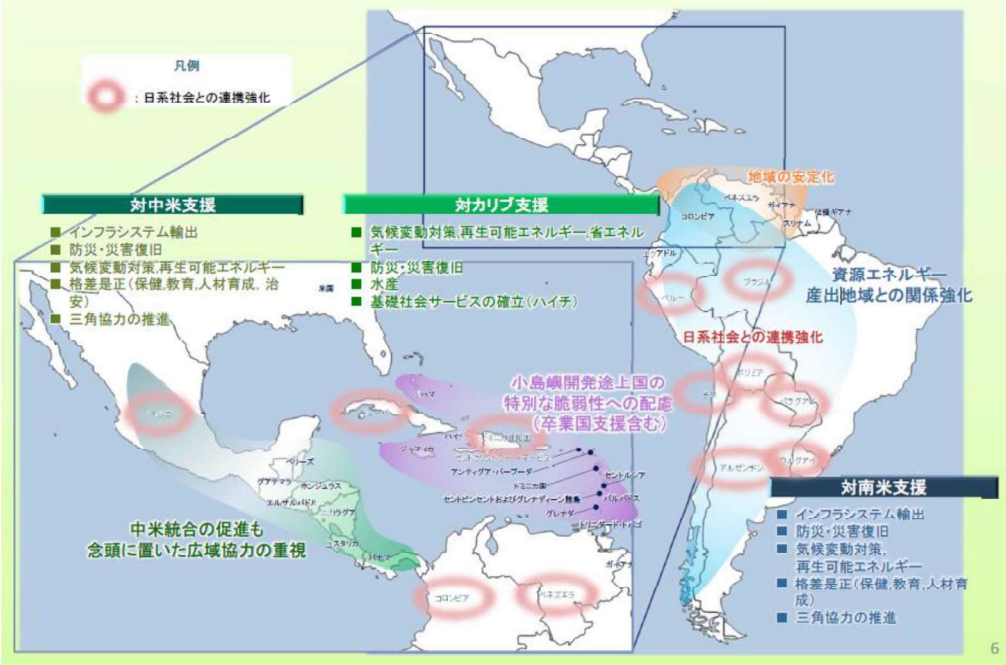


地域戦略

14

中米
●日本企業の海外展開との連携。
●中米移民の根本原因である貧困、治安、災害等の課題への取組を後押しする案件及び米国との連携。
●気候変動・防災分野での支援
●ウィズ・コロナ、ポスト・コロナ経済復興支援
●中米物流ロジスティックス支援
●中米統合機構（SICA）、日本メキシコ・パートナーシップ・プログラム（JMPP）等を活用した三角協力。
●CORE、海外投融資。

カリブ諸国
●複数の国が広域的に裨益する案件を追求。
●小島嶼国特有の脆弱性に対応するため、ODA卒業後も一人当たり所得水準とは異なる観点から支援。
●ウィズ・コロナ、ポスト・コロナ経済復興支援。
●気候変動、環境・防災、水産分野の支援を重視。
●CORE、海外投融資。

2024年　日カリブ交流年

JAPAN CARICOM FRIENDSHIP YEAR2024

2024年は、日・カリコム（カリブ共同体）事務レベル協議開始後30年が経過した年であるとともに、日本とジャマイカ及びトリニダード・トバゴ共和国との国交樹立60周年にもあたる。

これを記念し、2024年を「日・カリブ交流年2024」とし、**日本とカリブ共同体（カリコム）諸国の交流を深めることを目的とした記念事業を日本及びカリコム諸国で実施する。**

（外務省HP内「日カリブ交流年2024」より）

2025年　日・中米交流年

2025年は中米5カ国と日本の外交90周年を迎えます。

参考：2015年 日・中米交流年

- 2015年に，日本は中米5カ国（グアテマラ，エルサルバドル，ホンジュラス，ニカラグア，コスタリカ）と外交関係を樹立してから80周年を迎えました。日本と中米統合機構（SICA）（注）は，この佳節にあたり2015年を「日・中米交流年」と定め，政治，経済，文化等様々な分野で交流事業を実施することで合意し，年間を通じて多くの記念行事が開催されました。

（注）中米統合機構（SICA）：中米統合機構（SICA：Sistema de la Integración Centroamericana）は，中米地域の経済社会統合を図り，平和・自由・民主主義・開発を達成することを目的に1991年に創設された組織です。加盟国は，グアテマラ，エルサルバドル，ホンジュラス，ニカラグア，コスタリカ，パナマ，ベリーズ，ドミニカ共和国です。事務局はエルサルバドルに置かれています。

（外務省HP内「2015年日・中米交流年」より）

3．JICAの協力スキーム

相手国からの要請と採択が必要な事業

- ◆技術協力
  - ➢専門家派遣、研修員受入
  - ➢科学技術協力
- ◆無償資金協力
  - ➢一般無償
- ◆有償資金協力
  - ➢円借款
  - ➢海外投融資

科学技術協力（SATREPS)

目的

1．日本と開発途上国との国際科学技術協力の強化

2．地球規模課題の解決と科学技術水準の向上につながる新たな知見や技術の獲得、これらを通じたイノベーションの創出

3．キャパシティ・ディベロップメント（国際共同研究を通じた開発途上国の自立的研究開発能力の向上と課題解決に資する持続的活動体制の構築、また、地球の未来を担う日本と途上国の人材育成とネットワークの形成）

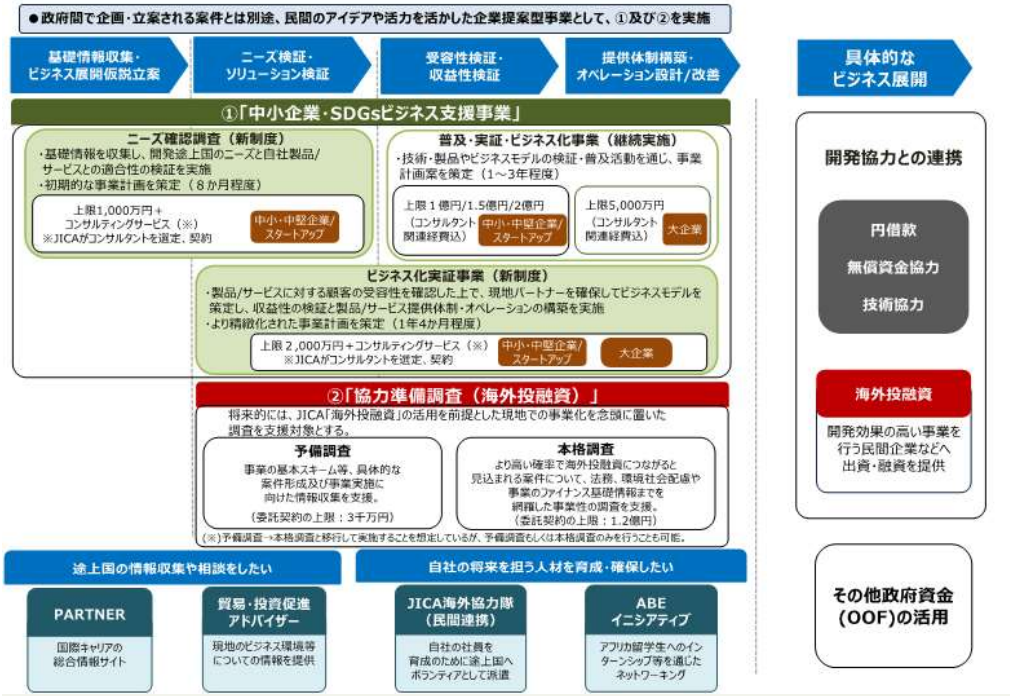
科学技術協力事業概要について－JICA

科学技術協力（SATREPS）

実施体制

◆ SATREPSは、開発途上国への技術協力を担うJICAと、大学等国内研究機関への研究支援を行う国立研究開発法人科学技術振興機構（以下、「JST」という。）及び国立研究開発法人日本医療研究開発機構（以下、「AMED」という。）が連携して事業を実施します。また、プロジェクトは、JST/AMEDによる公募にて選定された我が国の大学その他の研究機関の申請者（日本側研究代表者）が所属する機関（以下、「日本側研究代表者所属機関」という。）とJICAが連携し、ODA技術協力プロジェクトの枠組みにより共同で実施します。

分野	領域
環境・エネルギー分野	カーボンニュートラルの実現に向けた資源・エネルギーの持続可能な利用に関する研究
	地球規模の環境課題の解決に資する研究
生物資源分野	生物資源の持続可能な生産・利用に資する研究
防災分野	持続可能な社会を支える防災・減災に関する研究
感染症分野	開発途上国のニーズを踏まえた感染症対策研究



実施団体の提案に基づく事業

◆草の根技術協力事業

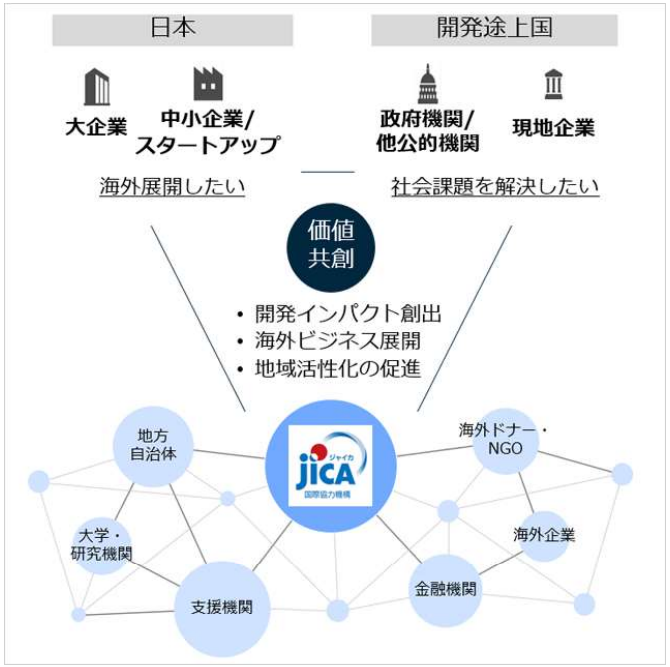
- ➢草の根協力支援型
- ➢草の根パートナー型
- ➢地域活性型

◆中小企業・SDGsビジネス支援事業

- ➢ニーズ確認調査
- ➢普及・実証・ビジネス化事業
- ➢ビジネス化実証事業

◆Tsubasa

中小企業・SDGsビジネス支援事業について



TSUBASA事業

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- TSUBASA（Transformational Start Ups' Business Acceleration for the SDGs Agenda）は、SDGs達成に貢献しうる革新的なアイデアやビジネスモデル、テクノロジーを有する日本のスタートアップ企業と共に、中南米・カリブ地域での新たな開発協力の形を創る取り組みです。

- 50年以上に渡る中南米・カリブ地域各国における事業の中で築いてきたネットワークや知見を持つJICAと、米州開発銀行（Inter-American Development Bank：IDB）のイノベーションラボであるIDB Labが連携し、日本のスタートアップ企業による、中南米・カリブ地域における開発課題に取り組む事業（地域格差、森林減少や環境保全、水資源管理、保健・医療へのアクセス等）の展開を支援します。

TSUBASA事業

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- TSUBASA スタートアップ連携促進調査

TSUBASA事業

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- TSUBASA 支援プログラム

事業実施体制

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事業実施体制

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カリブ地域

3事務所、3支所

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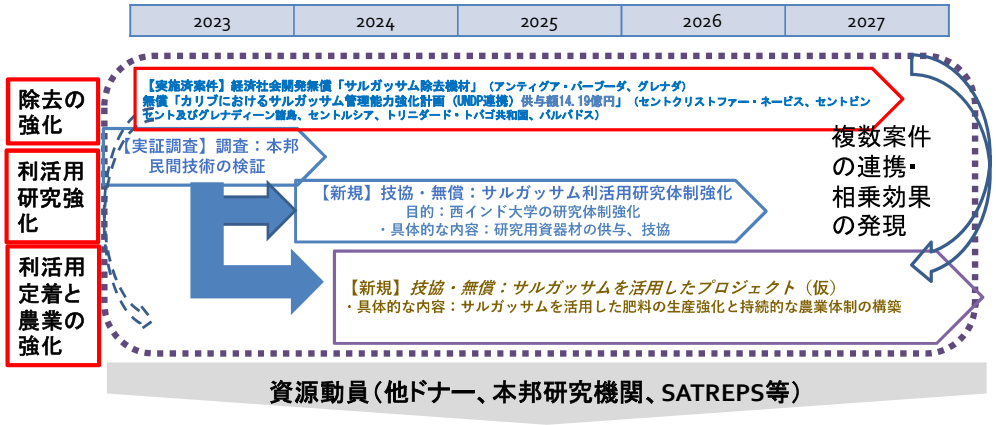
4．事業化イメージ

東カリブ地域（セントルシア、バルバドス、ベリーズ）×気候変動（サルガッサム）

開発目標：カリブ地域「強靭な社会基盤の整備」（気候変動対策プログラム）

- 目標：東カリブ地域におけるサルガッサムの利活用体制と持続的な農業の好循環を構築する。
- 開発シナリオ：サルガッサム除去機材、研究機材の供与と利活用促進及び知見の域内共有プラットフォームの構築を通じて、東カリブ地域におけるサルガッサム利活用体制が強化され、食料輸入の削減に繋がる。

（カリブ地域は2025年までに食料輸入25%減を目標としている。）



オファー型協力

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オファー型協力について

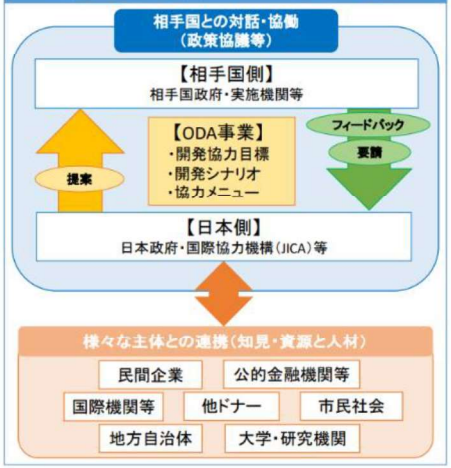
令和5年10月
外務省国際協力局

1. オファー型協力とは

- ✓ 対象国との対話・協働の場において、外交政策上、戦略的に取り組むべき分野の**開発協力目標**とそれを実現するための**開発シナリオ**（上記目標を達成する方法）と**協力メニュー**（上記目標を具体的に実施する案件の組み合わせ）を、我が国の強みを活かし、かつ、相手国にとっても魅力的な形で積極的に提案し、案件形成を行っていくもの。
- ✓ その際、**様々な主体（民間企業、公的金融機関、国際機関、他ドナー、市民社会、地方自治体、大学・研究機関、等）を開発のプラットフォームに巻き込んで連携**し、互いの強みを持ち寄り様々な協力を組み合わせることで、開発効果を最大化する。
- ✓ 開発途上国の課題解決と同時に、我が国の課題解決や経済成長にもつなげる。

注：公的金融機関等
国際協力銀行（JBIC）、日本貿易保険（NEXI）、海外交通・都市開発事業支援機構（JOIN）、海外通信・放送・郵便事業支援機構（JICT）、エネルギー・金属鉱物資源機構（JOGMEC）、日本貿易振興機構（JETRO）等

2. 開発のプラットフォームのイメージ図



外務省：オファー型協力について(mofa.go.jp)

オファー型協力

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3. 今後の具体的な流れ

戦略文書の公表

↓

対話・協働（提案とフィードバック）

対象国毎に①開発協力目標、②開発シナリオ、③協力メニューを提案（政策協議等）

様々な主体との連携

↓

開発シナリオの実施

- 我が国の外交政策を踏まえて、資源と人材を集中的に投下し、戦略的に取り組む分野を選定し、戦略文書（注）を策定して公表（2023年9月15日公表済み）。戦略文書は、分野別の①開発協力目標、②開発シナリオを含むものとする。
  （注）別紙：2023年9月に公表した戦略文書の重点分野
- 戦略文書に基づき、対象国毎にテーラーメードした上記①、②、及び③協力メニューを策定し、対象国に提案する。
- 対象国政府との対話を通じ、対象国のフィードバックを踏まえた上で、包括取決め等の作成等により協力の方向性を確認し、ニーズに応じて機動的にODAを投入する。これにより、案件実施の予見可能性を高め、様々な主体の案件参画を促す。
- 開発途上国の課題を解決すると同時に、日本の課題解決や日本の経済成長につなげる。

外務省：オファー型協力について(mofa.go.jp)

オファー型協力

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戦略文書（2023年9月）における重点分野

1. 気候変動への対応・GX
   - 発生と気候変動の関係
   - 資源としての活用と脱炭素化
2. 経済強靭化
   - サルガッサムと観光産業との関係
   - 農業生産性の向上
3. デジタル化の促進・DX

外務省「オファー型協力を通じて戦略的に取り組部分野と協力の進め方」（mofa.go.jp）

ご清聴ありがとうございました。

中米・カリブ課　5rtcc@jica.go.jp

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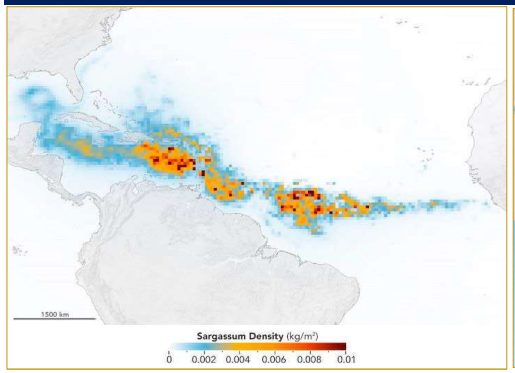
取扱注意

サルガッサム対策（支援の現状と今後）

2024年1月
国別開発協力第二課

サルガッサムの現状



◆ サルガッサム（ホンダワラ属の海藻）が近年大西洋とカリブ海の浜辺に大量に押し寄せ、過去10年で量や分布範囲が大幅増加。環境面のみならず水産・観光等経済面にも大きな影響。大繁殖の原因については、データが不足しており、ほとんど解明されていない。

◆ 2023年6月のサルガッサム・ベルト（西アフリカ～メキシコ湾）は推定600万トン、カリブ海に推定200万トン漂流していると推測（南フロリダ大学・NASA）。サルガッサムの発生は減少傾向にあるとされるが、見通しが難しく、引き続き注意が必要。

セントビンセント・グレナディーン諸島

https://optics.marine.usf.edu/projects/SaWS/pdf/Sargassum_outlook_2023_bulletin6_USF.pdf

1

サルガッサム対策（日本の支援）

2024年1月
国別開発協力第二課

①対アンティグア・バーブーダ無償資金協力
E/N署名：2020年11月30日
供与額：2億円
内容：サルガッサム海藻除去機材供与

②対グレナダ無償資金協力
E/N署名：2020年12月1日
供与額：2億円
内容：サルガッサム海藻除去機材供与

③対セントキッツ、セントビンセント、セントルシア、トリニダード・トバゴ、バルバドス無償資金協力
E/N署名：2022年2月18日
供与額：14.19億円
内容：対サルガッサム海藻除去のための機材供与、モニタリング及び除去能力の強化、情報共有ネットワークの構築（UNDP連携）

④対ドミニカ共和国無償資金協力
E/N署名：2023年12月14日
供与額：2億円
内容：サルガッサム海藻除去機材供与

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サルガッサム対策（今後に向けた検討）

2024年1月
国別開発協力第二課

サルガッサム対策支援の方向性

◆ サルガッサムは減少傾向にはあるが、引き続き漂流した大量のサルガッサムに苦しむ国も多い。

◆ サルガッサムは水産業のみならず、景観悪化、悪臭など放つため、観光業にも影響。そのため、サルガッサム対策にかかる我が国支援に対する謝意表明が寄せられ、外交成果が極めて高い。

◆ 2024年の外交日程に留意しつつ、**サルガッサムの回収・除去のみならず（「点」の支援）、回収したサルガッサムを有効活用していく「線」の支援方法を視野に入れた支援を検討していく**。

（参考）2024年外交日程等
・2024年は日・カリコム交流年。カリコム諸国関連の要人往来を調整中。
・第４回国連SIDs国際会議　2024年5月27日～30日（@アンティグア・バーブーダ）

想定支援案

◆ 本邦技術を活用したサルガッサム対策支援【仮】
現在「カリブ海沿岸におけるサルガッサムの利活用を目的とした本邦技術に係る基礎調査」を実施中。今後は、同調査にて確認された本邦企業の技術により、回収したサルガッサムの効率的な処理や有効活用の可能性を検討。

◆ その他のアイディアの可能性も検討
・現地研究体制強化？
・堆肥化、成分抽出による利用、バイオエネルギー化？

3