

Preliminary estimates of potential areas for seaweed farming along the Indian coast

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Abstract

India has enormous potential for seaweed mariculture; however, mass scale commercial farming of seaweeds is yet to take off successfully in the country. R&D efforts over the years have resulted in techno-scientific improvements in farming technologies such as floating rafts, net-tubes, long-lines, and cage based IMTA systems for seaweed culture. However, a few challenges remain, particular in identifying potential sites, its demarcation and developing suitable and sustainable spatial plans for seaweed farming on a country-wide, commercial perspective. In view of the emerging importance of seaweed mariculture and policy thrust by the Government of India, an all India preliminary site selection survey suitable for seaweed farming was conducted by ICAR-CMFRI along all maritime states of India. From this survey a total of 23,970 ha area were identified as potential seaweed farming along the Indian coast. In the present article, we present details of the suitable sites and its demarcation on a preliminary spatial map for facilitating the imminent expansion and effective adoption of seaweed farming in the country.

Keywords: GIS, mariculture, seaweed, site selection, spatial mapping

Introduction

Seaweeds are marine macroalgae which provide a variety of food products, phycocolloids (alginates, agars, and carrageenans), fodder and bio-fertilizers. Global seaweed production during 2018 was 32.4 million t (wet weight) with a first sale value estimation of 13.3 billion USD (FAO, 2020). Globally, seaweed farming has expanded

rapidly due to its ever increasing demand and in India it is one of the best diversified-livelihood options for coastal fishers (Narayankumar and Krishnan, 2011). Various studies have been carried out on the potential of seaweed farming in India along with the available resource along various maritime states of India (Rao and Mantri 2006, Tandel *et al.*, 2016). These studies indicated that the major commercially important seaweed

species in India are *Gracilaria edulis*, *Gelidiella acerosa* and *Kappaphycus alvarezii* in red algae and *Sargassum wightii*, *Turbinaria conoides* and *Cystoseira* spp. in brown algae. Besides some of the green algae like *Ulva lactuca*, *Enteromorpha* sp., *Caulerpa* spp. which can be used for human consumption and can be part of the regular diet for nutritional security. However, the pace of seaweed farming in India has been constrained due to inadequate marine spatial plans which needs a systematic site selection process. In this context, ICAR-Central Marine Fisheries Research Institute (CMFRI) initiated a preliminary survey all along the coastal regions of the country for identifying potential seaweed farming areas. Initial assessments on the potential areas for seaweed farming were conducted through informal surveys during field visits by scientific and technical personnel along with the information collected from local fishers through personal interactions.

Site selection plays an important role in the success of any sustained commercial farming activity. It significantly influences the economic returns and viability of the farming system. In the same manner seaweed farming also needs best suitable farming sites for successful operation. Although Divu *et al.*, (2020) developed a novel GIS based site suitability model for mariculture in territorial waters of the country, the candidates for their model were marine finfish and shellfish species and the model could not cover seaweeds. Thus this preliminary survey was conducted as a first step towards getting baseline data for future development of spatial models

and spatial plans for seaweed mariculture in India. Site suitability was worked out for all maritime states along the Indian coast. The methodology and criteria for the site suitability are mentioned below.

Criteria used for identifying the potential seaweed farming sites:

- Nearshore area within 1000 m distance from the lowest low tide line
- Intertidal and sub-tidal zones with rocky or sandy bottom
- Previous existence of seaweed farming activity (if any along the coast)
- Seaweed collection from natural seaweed beds (if existing)
- Sheltered area with adequate current and tidal exchange
- Area with moderate wave action
- Area free from silt deposits
- Area away from freshwater runoff and domestic or agro-industrial effluents discharge
- Area away from fishing harbor/landing centre
- Non-hindrance for existing fishing and other allied activities
- Optimum basic water quality parameters: Salinity (28-38 ppt), Sea Surface Temperature (26-31°C), pH (6.5-8.5) and Transparency (2-6 m).

Considering the above-mentioned criteria, preliminary identification of the potential sites for seaweed farming along the Indian coast was made. The potential area and

Table 1. Potential seaweed farming sites along Indian coast

State	No. of locations identified	Preliminary demarcation of potential sites (in ha)
Gujarat	9	10316
Diu	5	700
Maharashtra	12	2724
Goa	4	120
Karnataka	14	1579
Kerala	7	80
Lakshadweep Islands	11	213
Total West Coast	62	15,732
Tamil Nadu	187	5048
Andhra Pradesh	49	1215
Odisha	14	1525
West Bengal	5	450
Total East Coast	255	8238
Total (All India)	317	23,970

production potential will vary from site to site depending on the local climatic conditions and number of farming cycles in a year.

State-wise potential area available for seaweed farming

The geo-morphology and demography of India's coastline is diverse and distinct. Each maritime state

has its individual advantages and disadvantages with respect to seaweed farming. Since this study was a preliminary assessment, broader arrays of biological and environmental parameters have been taken as site selection criteria. The information is represented as the name of the village/site, name of the district, its location with latitude and longitude and approximate area available for seaweed farming in hectare (ha).

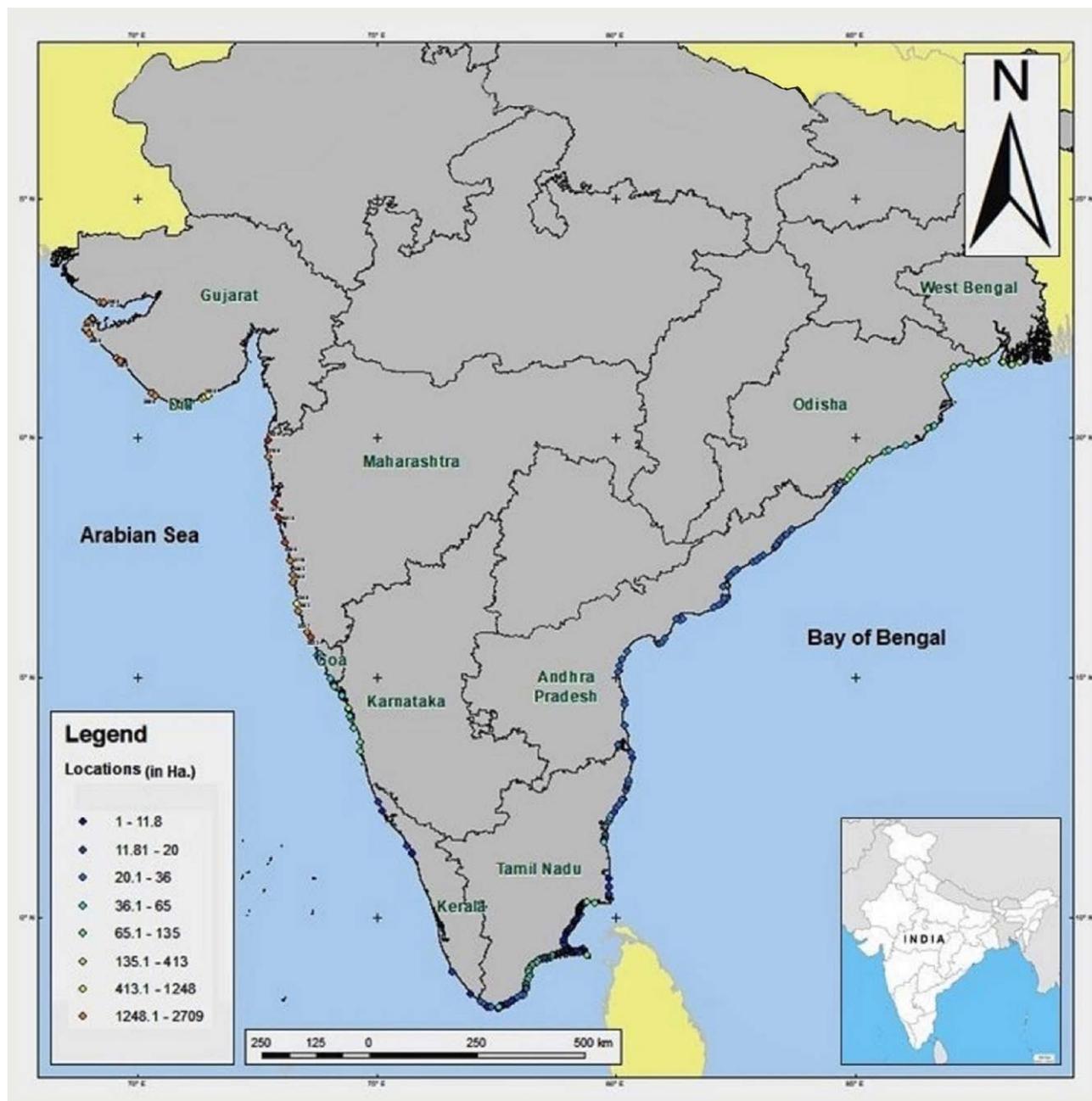


Fig 1. Potential seaweed farming locations in various maritime states of India

Table 2. Potential areas for seaweed farming in Gujarat

Name of the location	GPS Coordinates (D.M.S)	Total available area (in ha) (approx.)
Kutchh District		
Mandvi	22°50'12.6"N, 69°12'17.4"E	1500
Total available area for Kutchh District		1500
Dwarka District		
Dwarka	22°15'33.1"N, 68°55'26.4"E	2000
Okha	22°29'13.7"N, 69° 2'39.4"E	2000
Total available area for Dwarka District		4000
Amreli District		
Jafrabad	20°50'19.8"N, 71°20'38.1"E	616
Total available area for Amreli District		616
Gir-Somnath District		
Madhwad-Site 1	20°41'31.5"N, 70°50'44.2"E	300
Madhwad-Site 2	20°41'59.1"N, 70°51'43.2"E	200
Madhwad-Site 3	20°41'10.7"N, 70°50'16.0"E	200
Veraval	20°55'54.6"N, 70°18'53.7"E	2000
Total available area for Gir-Somnath District		2700
Porbandar District		
Porbandar	21°38'53.1"N, 69°34'4.8"E	1500
Total available area for Porbandar District		1500
Total available area in Gujarat		10316

Table 3. Potential areas for seaweed farming in in Diu (UT)

Name of the location	GPS Coordinates (D.M.S)	Total available area (in ha) (approx.)
Simar	20°44'46"N, 71° 5'12 "E	200
Navbundar-Site 1	20°43'35"N, 71° 2'24"E	50
Navbundar-Site 2	20°43'49"N, 71° 3'55"E	50
Chakrathirth coast	20°42'4"N, 70°56'21 "E	300
Vanakbara coast	20°41'41"N, 70°53'39"E	100
Total Area available in Diu		700

Table 4. Potential areas for seaweed farming in in Maharashtra

Name of the location	GPS Coordinates (D.M.S)	Total available area (in ha) (approx.)
Palghar District		
Dhanu	19° 57' 36" N, 72° 43' 48" E	10267
Kelva	19° 36' 36" N, 72° 43' 48" E	2709
Total available area for Palghar District		12976
Raigad District		
Alibaug	18° 38' 60" N, 72° 51' 36" E	12198
Murud	18° 19' 48" N, 72° 57' 36" E	9415
Total available area for Raigad District		21613
Ratnagiri District		
Harnai	17° 48' 36" N, 73° 5' 24" E	5200
Guhaghar	17° 25' 48" N, 73° 11' 24" E	2116
Ganpatiphule	17° 8' 24" N, 73° 15' 36" E	1583

Name of the location	GPS Coordinates (D.M.S)	Total available area (in ha) (approx.)
Total available area for Ratnagiri District		8899
Sindhudurg District		
Vijaydurg	16° 33' 0'' N, 73° 19' 48'' E	1248
Devgad	16° 22' 12'' N, 73° 22' 12'' E	1663
Achara	16° 59' 24'' N, 73° 26' 24'' E	2200
Shriramwadi	15° 56' 24'' N, 73° 32' 60'' E	2347
Vengurla	15° 50' 24'' N, 73° 37' 48'' E	3533
Total available area for Sindhudurg District		10991
Total area available in Maharashtra		54479*
Area accounted for present purpose (5%)		2724

*Since it is preliminary assessment only 5% of the suitability taken in to account for immediate support

Table 5. Potential areas for seaweed farming in in Goa

Name of the location	GPS Coordinates (D.M.S)	Total available area (in ha) (approx.)
North Goa District		
Siridoa	15°25'49'' N, 73°52' 01'' E	7.5
	15°25'52'' N, 73°52' 04'' E	
Caranzalem	15° 27'36'' N, 73° 45' 52'' E	63
	15° 28'40'' N, 73° 48' 22'' E	
Total available area for North Goa District		70.5
South Goa District		
Baina	15° 23'43'' N, 73° 48' 13'' E	4
	15° 23'37'' N, 73° 48' 19'' E	
Talpona	14° 58'24'' N, 74° 02' 35'' E	45
	14° 58'56'' N, 74° 02' 20'' E	
Total available area for South Goa District		49
Total area available in Goa		120

Table 6. Potential areas for seaweed farming in Karnataka

Name of the location	GPS Coordinates (D.M.S)	Total available area (in ha) (approx.)
Uttara Kannada District		
Dhandebag-Kangiguda Island, Karwar	14° 53'19'' N, 74° 05' 59'' E	101
Baval-Kanga Island, Karwar	14° 51'56'' N, 74° 06' 29'' E	11
Harwada, Ankola	14° 42'50'' N, 74° 15' 49'' E	72
Belikeri, Ankola	14° 42' 14'' N, 74° 15' 54'' E	135
Gabit Keni, Ankola	14° 39' 46'' N, 74° 16' 41'' E	7
Belambar, Ankola	14° 38' 52'' N, 74° 16' 38'' E	244
Haldipur-Horbhag, Honnavar	14° 18' 44'' N, 74° 24' 53'' E	413
Manki 1, Honnavar	14° 11' 27'' N, 74° 28' 04'' E	50
Manki 2, Honnavar	14° 8' 29'' N, 74° 28' 43'' E	94
Navayatkeri, Murudeshwara (North)	14°11'85''N, 74°27'40'' E	52
Huddi Point South Bhatkal-Shiroor North)	14°56'85''N, 74°32'98''E	100
Total available area for Uttara Kannada District		1279

Name of the location	GPS Coordinates (D.M.S)	Total available area (in ha) (approx.)
Udupi District		
Navunda South	14°42'30"N 74°38'44"E	50
Kundapur	13°39'.62"N 74°39'25"E	120
Hoode	13°27'42"N 74°40'42"E	130
Total available area for Udupi District		300
Total Area available in Karnataka		1579

Table 7. Potential areas for seaweed farming in in Kerala

Name of the location	GPS Coordinates (D.M.S)	Total available area (in ha) (approx.)
Thiruvananthapuram District		
Vizhinjam	8°23'1.24" N, 76°57'36.67"E	10
Total available area for Thiruvananthapuram District		10
Kollam District		
Thirumallavaram	8°54'42"N, 76°38' 21"E.	20
Total available area for Kollam District		20
Kozhikode District		
Elathur	11°20'07.03" N, 75° 44'35" E	1
Puthiyappa	11°19'18.17" N, 75°44'24.65" E	7
Thikkodi	11°28' 46.1"N, 75°37' 28.8"E	20
Total available area for Kozhikode District		28
Kasargod District		
Padanna	12° 12'20.52" N; 75° 07'22.22" E	5
Bekal	12°23'43.8"N; 75°02'78"E	17
Total available area for Kasargod District		22
Total area available in Kerala		80

Table 8. Potential areas for seaweed farming in Tamil Nadu

Name of the location	GPS coordinates (D.M.S)	Total available area (ha) (approx.)
Ramanathapuram District (Palk Bay)		
Dhanushkodi (Pachapatti)	9°11'41.7"N, 79°24'18.9"E	90
Sangumal	9°17'40.1"N, 79°19'36.3"E	25
Olaikuda	9°19'01.2"N, 79°19'54.9"E	34
Mangadu	9°19'39.0"N, 79°18'55.1"E	22
Sambai	9°19'41.7"N, 79°18'46.0"E	30
Vadakadu	9°19'22.2"N, 79°17'59.8"E	30
Pillaikulam	9°19'15.3"N, 79°17'34.5"E	26
Ariyankundu	9°17'52.6"N, 79°16'19.1"E	23
Villoondi	9°17'33.9"N, 79°15'41.9"E	26
Manthoppu	9°17'30.4"N, 79°15'14.4"E	14
Victoria Nagar	9°17'32.2"N, 79°14'42.3"E	9.5
Naalupanai	9°17'32.3"N, 79°14'22.8"E	15

Name of the location	GPS coordinates (D.M.S)	Total available area (ha) (approx.)
Akkalmadam	9°17'31.7"N, 79°13'56.6"E	20
Pamban	9°17'29.1"N, 79°13'13.0"E	8
Thonithurai	9°17'02.0"N, 79°10'45.7"E	14
Meenavar colony	9°17'04.2"N, 79°10'26.6"E	6
T.Nagar	9°17'29.0"N, 79°08'40.9"E	15
Munaikadu	9°17'16.1"N, 79°07'59.8"E	40
Umayalpuram	9°17'15.5"N, 79°07'31.7"E	38
Vedalai	9°17'20.4"N, 79°06'18.0"E	24
Pillaimadam	9°17'41.9"N, 79°05'07.2"E	22
Pirappanvalasai	9°18'21.0"N, 79°03'15.3"E	16
Irumeni	9°19'21.4"N, 79°01'43.8"E	16
Uchipuli	9°19'59.3"N, 79°00'55.4"E	20
Attrangarai	9°21'03.7"N, 78°59'35.7"E	15.3
Alakankulam	9°21'51.8"N, 78°58'43.8"E	15.9
Panaikulam	9°22'40.7"N, 78°57'57.4"E	16
Puduvalasai	9°23'46.4"N, 78°56'55.9"E	19
Athiyuthu (Iranianvalasai)	9°24'27.2"N, 78°56'20.5"E	15
Palanivalasai	9°25'10.9"N, 78°55'46.2"E	9
Mudiveeranpattinam	9°26'46.1"N, 78°54'46.7"E	27
Devipattinam	9°29'17.4"N, 78°53'53.1"E	2
Thiruppalaikudi	9°32'12.1"N, 78°55'07.4"E	8
Karankadu	9°38'46.9"N, 78°57'57.0"E	8.5
Mullimunai	9°39'19.7"N, 78°58'13.5"E	9
Puthupattinam (K.K. Pattinam)	9°40'33.3"N, 78°58'29.9"E	12
Veerasangili Madam	9°41'13.6"N, 78°58'46.9"E	23
Soliyakudi	9°42'48.3"N, 78°59'56.9"E	15
Nambuthalai	9°43'44.1"N, 79°00'47.3"E	7.5
Thondi	9°45'02.5"N, 79°01'42.3"E	10.5
M.R.Pattinam	9°45'42.6"N, 79°02'11.4"E	12
P.V.Pattinam	9°45'59.7"N, 79°02'33.5"E	9.8
Narenthal	9°46'08.8"N, 79°03'02.8"E	13
Vattanam	9°47'09.5"N, 79°03'53.6"E	20
Dhamothirapattinam	9°47'38.2"N, 79°04'13.8"E	14
Pasipattinam	9°48'16.0"N, 79°04'45.4"E	12
Theerthandatnam	9°49'32.9"N, 79°05'22.8"E	8
S.P.Pattinam	9°50'07.7"N, 79°06'09.1"E	15
Total available area for Ramanathapuram District (Palk Bay)		900
Ramanathapuram District (Gulf of Mannar)		
Kunthukal	9°15'48.5"N, 79°13'16.0"E	20
Mandapam	9°16'34.1"N, 79°08'45.2"E	18

Name of the location	GPS coordinates (D.M.S)	Total available area (ha) (approx.)
Vedalai	9°15'37.4"N, 79°05'29.7"E	30
Seeniappa Dharga	9°15'40.0"N, 79°04'03.8"E	24
Nochioorani	9°16'00.8"N, 79°02'05.8"E	19
Manankudi	9°16'16.8"N, 79°00'25.1"E	16
Pudumadam	9°16'24.4"N, 78°59'03.4"E	25
Valangapuri	9°16'22.5"N, 78°58'01.0"E	12.5
Vellarioodai	9°16'20.3"N, 78°57'24.7"E	15
Thalai Thoppu	9°16'13.8"N, 78°56'42.0"E	20
Inthira Nagar	9°15'45.4"N, 78°55'15.1"E	12
Munthal (Periyapattinam)	9°15'08.1"N, 78°54'41.6"E	13
Pudhukudiyiruppu (Periyapattinam)	9°15'08.5"N, 78°53'47.7"E	10
Thoppuvalasai	9°15'16.8"N, 78°53'16.4"E	15
Velayuthapuram	9°15'20.7"N, 78°52'55.6"E	13.5
Kalimankundu	9°15'14.5"N, 78°51'58.5"E	10
Sethukarai	9°14'54.4"N, 78°50'41.4"E	8.5
Kanjirangudi (Pakkirappa Dharga)	9°14'33.4"N, 78°49'42.7"E	14
Sengalaneerodai	9°14'13.3"N, 78°48'44.8"E	25
Keelakarai	9°13'26.5"N, 78°46'32.8"E	22
Bharathinagar	9°12'59.6"N, 78°45'26.6"E	25
Mangaleswari Nagar	9°12'41.3"N, 78°44'05.2"E	28
Earanthurai	9°12'24.6"N, 78°43'31.0"E	26
Erwadi	9°11'59.8"N, 78°43'15.8"E	18.5
Sadaimuniyanvalasai	9°11'27.8"N, 78°42'37.3"E	16
P.M. Valasai	9°11'35.9"N, 78°41'52.8"E	36
Adancheri	9°11'39.1"N, 78°39'48.8"E	28
Valinokkam	9°09'13.6"N, 78°37'41.8"E	88
Keelamundhal	9°08'26.6"N, 78°35'26.4"E	30
Melamundhal	9°07'59.7"N, 78°34'12.6"E	31
Mariyur	9°08'12.4"N, 78°32'31.0"E	34
Oppilan	9°08'04.3"N, 78°30'41.9"E	29.5
Mookaiyur	9°07'39.0"N, 78°28'38.6"E	30
Naripaiyur	9°07'06.7"N, 78°25'51.8"E	24
Kannirajapuram	9°06'19.3"N, 78°24'08.8"E	28.5
Rochma Nagar	9°05'47.3"N, 78°23'23.5"E	35
Total available area for Ramanathapuram District (Gulf of Mannar)		850
Total available area for Ramanathapuram District (Palk Bay & Gulf of Mannar)		1750
Pudukottai District (Palk Bay)		
Muthukuda	9°52'30.8"N, 79°07'07.5"E	7.2
Arasanagaripattinam	9°53'37"N, 79°07'38"E	35
Mimisal	9°54'42"N, 79°08'50"E	22

Name of the location	GPS coordinates (D.M.S)	Total available area (ha) (approx.)
Gopalapattinam	9°55'26"N, 79°09'10"E	15
Palakkudi	9°56'37"N, 79°10'06"E	18.5
Kallivayal (Muthanenthal)	9°57'12"N, 79°10'37"E	17.6
Jagathapattinam	9°57'58"N, 79°11'24"E	10.4
Kottaipattinam	9°58'40"N, 79°12'02"E	15.5
Odavimadam	9°59'15"N, 79°12'30"E	16.6
Pudukkudi	10°00'03"N, 79°13'14"E	14
Aathipattinam	10°00'26"N, 79°13'36"E	12.4
Ammapattinam	10°00'54.3"N, 79°13'59.8"E	14
Avudaiarpattinam	10°01'13"N, 79°14'22"E	19
Sangupattinam (Rajathoppu)	10°01'51.7"N, 79°15'05.4"E	5.5
Kodiyakarai (Manamelkudi)	10°02'05"N, 79°15'30"E	23
Muthurajapuram (Manamelkudi)	10°02'23.7"N, 79°15'49.6"E	22
Seetharamanpattinam	10°04'29"N, 79°14'11"E	10
Krishnajipattinam	10°05'48"N, 79°13'38"E	12
P.R.Pattinam	10°06'08.3"N, 79°13'39.7"E	10.3
Total available area for Pudukottai District		300
Thanjavur District (Palk Bay)		
Ganeshapuram	10°08'14.0"N, 79°13'43.4"E	7.1
Somanathapattinam	10°09'30.8"N, 79°14'25.7"E	7.5
Mandhiripattinam	10°10'18.4"N, 79°14'24.6"E	9
Senthalaipattinam	10°11'12"N, 79°14'55"E	14
Adaikathevan	10°12'00.3"N, 79°15'56.3"E	8.5
Karankuda	10°14'17.0"N, 79°16'18.6"E	9.2
Sethubavachathiram	10°15'08"N, 79°17'11"E	12
Pillayarthal	10°15'26"N, 79°17'30"E	17
Manora	10°15'55"N, 79°18'9.999"E	10.5
Chinnamanai	10°16'08"N, 79°18'38"E	2.2
Mallipattinam	10°16'50"N, 79°19'27"E	20
Pudhupattinam	10°17'11.2"N, 79°20'15.0"E	26
Kollukadu	10°17'30.3"N, 79°21'46.8"E	34
Athiramapattinam	10°18'59"N, 79°23'46"E	73
Total available area for Thanjavur District		250
Thiruvarur District (Palk Bay)		
Thondiyakadu	10°23'23"N, 79°34'46"E	100
Total available area for Thiruvarur District		100
Nagapattinam District (Palk Bay)		
Maniyantheevu	10°21'37.4"N, 79°52'27.8"E	28
Arcottuthurai	10°23'53"N, 79°52'09"E	40
Periyakuthagai	10°24'50"N, 79°52'01"E	54
Pushpavanam	10°27'22"N, 79°51'50"E	74

Name of the location	GPS coordinates (D.M.S)	Total available area (ha) (approx.)
Naluvethapathi	10°29'07"N, 79°51'46"E	20
Vizhunthamavadi	10°35'57"N, 79°51'23"E	18
Kameshwaram	10°37'27"N, 79°51'14"E	13
Sammanthan Pettai	10°47'31"N, 79°51'03"E	3
Total available area for Nagapattinam District		250
Tuticorin District (Gulf of Mannar)		
Vembar	9°05'00.10"N, 78°22'30.02"E	80
Periyasampuram	9°02'58.85"N, 78°20'09.03"E	50
Keelavaippar	9°00'02.62"N, 78°15'52.61"E	60
Sippikulam	8°58'57.09"N, 78°14'13.18"E	75
Pattinamaruthur	8°56'17.00"N, 78°11'39.86"E	80
Tharavaikkulam	8°53'34.34"N, 78°10'47.43"E	70
Vellapatti	8°51'48.48"N, 78°10'10.43"E	60
Mottagapuram	8°50'44.02"N, 78°10'02.60"E	40
Tuticorin Harbour Point	8°46'33.72"N, 78°12'07.72"E	80
Mullakaadu	8°44'25.90"N, 78°10'10.58"E	90
Palayakayal	8°41'31.85"N, 78°08'20.35"E	50
Punnakayal	8°36'41.49"N, 78°07'48.75"E	25
Kayalpattinam	8°33'58.69"N, 78°08'04.47"E	80
Veerapandiyapattinam	8°30'51.40"N, 78°07'28.11"E	60
Amali Nagar	8°29'25.15"N, 78°07'38.41"E	30
Alanthalai	8°25'47.12"N, 78°04'25.06"E	80
Kulasekarapattinam	8°23'39.30"N, 78° 3'30.58"E	40
Manapadu	8°22'31.01"N, 78° 3'51.76"E	65
Periyathalai	8° 21'34.63"E, 78° 1'41.60"E	35
Total available area for Tuticorin district		1150
Tirunelveli District		
Periyathalai	8°17'49.28"N, 77°55'40.18"E	35
Kootapanai	8°15'44.47"N, 77°51'51.38"E	15
Kooduthalai	8°14'59.18"N, 77°49'31.91"E	15
Uvari	8°13'26.16"N, 77°47'14.79"E	20
Idinthakarai	8°11'05.33"N, 77°45'27.38"E	15
Kuthenkuli	8°09'47.27"N, 77°41'21.49"E	15
Perumanal	8°09'28.75"N, 77°38'49.18"E	15
Kootapuli	8°08'46.97"N, 77°36'24.73"E	10
Thomaiyarpuram	8°08'19.50"N, 77°35'2.19"E	10
Total available area for Tirunelveli District		150
Kanyakumari District		
Thengapattinam	8°14'11.40"N, 77°10'14.61"E	30
Colachel	8°10'20.66"N, 77°15'12.65"E	30
Kadiapattinam	8° 7'53.28"N, 77°18'13.81"E	30

Name of the location	GPS coordinates (D.M.S)	Total available area (ha) (approx.)
Muttom	8° 7'15.59"N, 77°19'11.22"E	70
Pillaithoppu	8°07'29.08"N, 77°20'01.97"E	20
Periyakaadu	8°06'31.93"N, 77°23'38.74"E	30
Kovalam	8°04'50.20"N, 77°31'37.60"E	20
Kanyakumari	8°05'07.69"N, 77°33'11.41"E	40
Chinnamuttom	8°06'05.23"N, 77°33'29.80"E	30
Arokiapuram	8°06'20.15"N, 77°33'31.28"E	50
Total available area for Kanyakumari District		350
Cuddalore District		
Sonankuppam	11° 43' 25" N, 79° 46' 59" E	20
Singarathope	11° 43' 11" N, 79° 46' 56" E	35
Rajapettai	11° 40' 57" N, 79° 46' 24" E	50
Chithirai Pettai	11° 38' 15" N, 79° 45' 49" E	25
Thamanam pettai	11° 37' 10" N, 79° 45' 38" E	50
Annappan pettai	11° 35' 11" N, 79° 45' 31" E	35
Kumarapettai	11° 34' 20" N, 79° 45' 30" E	25
Samiyarpettai	11° 32' 59" N, 79° 45' 38" E	50
Total available area for Cuddalore District		290
Villupuram District		
Bommaya palayam	11° 59' 24" N, 79° 51' 05" E	25
Koonimedu	12° 04' 44" N, 79° 53' 43" E	50
Anumandai	12° 07' 29" N, 79° 55' 25" E	45
Ekkiyarkuppam	12° 10' 55" N, 79° 57' 44" E	20
Total available area for Villupuram District		140
Chengalpattu District		
Edaikazhinadu	12° 17' 37" N, 80° 01' 43" E	25
Paramankeni	12° 20' 45" N, 80° 04' 01" E	25
Kadalur Chinna kuppam	12° 26' 54" N, 80° 08' 43" E	25
Kadalur Periya kuppam	12° 26' 31" N, 80° 08' 18" E	33
Devaneri	12° 39' 00" N, 80° 12' 31" E	35
Nemmeli	12° 42' 49" N, 80° 13' 55" E	30
Semencheri	12° 44' 25" N, 80° 14' 27" E	20
Kovalam	12° 47' 26" N, 80° 15' 10" E	50
Kanathur	12° 51' 58" N, 80° 15' 02" E	30
Total available area for Chengalpattu District		273
Thiruvallur District		
Kalanji	13° 19' 53" N, 80° 20' 36" E	20
Pulicut	13° 25' 14" N, 80° 19' 46" E	25
Total available area for Thiruvallur District		45
Total Area available in Tamil Nadu		5048

Table 9. Potential Areas for Seaweed Farming in Andhra Pradesh

Name of the location	GPS Co-ordinates (D.D)	Total available area (in ha) (approx.)
Visakhapatnam District		
RK Beach	17.715 N, 83.325 E	40
VUDA Park	17.722 N, 83.340 E	10
Tenneti Park	17.747 N, 83.350 E	50
Thotlakonda	17.772 N, 83.378 E	25
Bhimli	17.892 N, 83.455 E	25
Thimmapuram	17.813 N, 83.411 E	50
Mangamaripeta	17.838 N, 83.411 E	50
Yendada	17.769 N, 83.372 E	25
Muthyalampalem	17.535 N, 83.090 E	25
Pudimadaka	17.491 N, 83.004 E	50
Bangarampalem	17.413 N, 82.859 E	25
Rambilli	17.447 N, 82.933 E	25
Total available area for Visakhapatnam District		400
Vijayanagaram District		
Mukkam	17.989 N, 83.560 E	35
Kancheru	17.964 N, 83.544 E	30
Bhogapuram	17.978 N, 83.554 E	40
Musalayya palem	17.764 N, 83.364 E	35
Neelagaddapeta	18.087 N, 83.688 E	25
Total available area for Vijayanagaram District		165
Srikakulam District		
Baruva-Kothuru	18.878 N, 84.593 E	50
Sompeta	18.918 N, 84.630 E	25
Total available area for Srikakulam District		75
East Godavari District		
Uppada	17.078 N, 82.338 E	25
Konapapapeta	17.132 N, 82.395 E	35
Pampodipeta	17.243 N, 82.533 E	30
Cholangi	16.898 N, 82.244 E	25
Mulapeta	17.104 N, 82.365 E	35
Danaiahpeta	17.215 N, 82.493 E	50
Narsipeta	17.212 N, 82.489 E	25
Neelarevu and Pandi	16.539 N, 82.223 E	25
Total available area for East Godavari District		250
West Godavari District		
Vemuladeevi	16.195 N, 81.355 E	50
Perupalem	16.202 N, 81.355 E	50
Total available area for West Godavari District		100
Krishna District		
Urlagondadibba	16.205 N, 81.255 E	50
Chinnagollapalem	16.213 N, 81.405 E	25

Name of the location	GPS Co-ordinates (D.D)	Total available area (in ha) (approx.)
Sorlagondi	15.824 N, 80.988 E	30
Total available area for Krishna District		105
Prakasam District		
Rajupalem	15.137 N, 80.061 E	25
Ethamukkala	15.372 N, 80.125 E	25
Ullapalem	15.242 N, 80.085 E	25
Total available area for Prakasam District		75
SPSR Nellore District		
My padu	14.506 N, 80.179 E	20
Kothapallipalem	14.442 N, 80.175 E	25
Total available area in SPSR Nellore District		45
Total Area Available in Andhra Pradesh		1215

Table 10. Potential Areas for Seaweed Farming in Odisha

Name of the location	GPS Coordinate (D.D)	Total available area (in ha) (approx.)
Puri District		
Chilka lake Arakuda (Near Bar mouth area)	19.7329°N, 85.67939°E	50
Satpada	19.70856°N, 85.62587°E	125
Ramchandi Muhanan near Chandrabhaga	19.854580°N, 86.059211°E	50
Baliharichandi area	19.74802 N, 85.69988 E	50
Total available area for Puri District		275
Ganjam District		
Puruna bandha area	19.2899° N, 84.98094° E	150
Ramayapatnam	19.15088°N, 84.83727° E	150
Kalijai area	19.53661° N, 85.30235° E	200
Gopalpur Open sea	19.22097° N, 84.88213° E	100
Total available area for Ganjam District		600
Baleswar District		
Balaramgadi to Mahi sahi area	21.47339°N, 87.0557°E	100
Balarampur Panchubisha to Januka	21.27523°N, 86.86788°E	150
Kirtania to Talasari	21.56294°N, 87.388°E	100
Total available area for Baleswar District		350
Jagatsingpur District		
Jatadhari Muhana Gadakujanga	20.215°N, 86.61137°E	150
Sea Near Neheru Banglow	20.24755° N, 86.61137° E	50
Gada Harishpur	20.18932°N, 86.52473°E	100
Total available area for Jagatsingpur District		300
Total Area Available in Odisha		1525

Table 11. Potential Areas for Seaweed Farming in West Bengal

Name of the location	GPS Coordinates (D.M.S)	Total available area (in ha) (approx.)
South 24 Praganas District		
Fraserhanj (Bakkhali)	21° 31'41"N, 88° 15'52"E	100
Sagar Island Systems	21° 35'16"N, 88° 04'18"E	125
Sundarban Dhanchi Forest	21° 34'42"N, 88° 25'45"E	95
Total available area for South 24 Parganas District		320
Purba Medinipur District		
Mandarmani	21° 36'14"N, 87° 43'29"E	70
Shankarpur	21° 35'33"N, 87° 37'12"E	60
Total available area for Purba Medinipur District		130
Total Area Available in West Bengal		450

Table 12. Potential area for seaweed farming in Lakshadweep

Name of the location	GPS Coordinates (D.M.S)	Total available area (in ha) (approx.)*
Agatti	10° 51'N, 72° 11'E	17.5
Amini	11° 07'N, 72° 43'E	1.5
Androth	10° 48'N, 73° 40'E	0.5
Bitra	11° 35'N, 72° 11'E	45.6
Bangaram	10° 56'N, 72° 17'E	46.3
Chetlath	11° 41'N, 72° 43'E	1.6
Kiltan	11° 29'N, 72° 59'E	1.8
Kadmath	11° 12'N, 72° 45'E	37.5
Kalpeni	10° 04'N, 73° 37'E	25.6
Kavaratti	10° 33'N, 72° 38'E	5.0
Minicoy	8° 70'N, 73° 03'E	30.6
Total Area Available in Lakshadweep Islands		213.5

* Atoll-wise (all inhabited atolls) area of lagoon and one percentage (area suitable for farming)

Actions to be undertaken before implementing seaweed farming

The identified areas must be precisely modelled using GIS based studies by considering the physico-chemical and biological parameters for the identified locations prior to the mass scale implementation of this farming activity. Necessary permission may be obtained in the Biosphere Reserves/Marine Protected Areas including marine national parks and sanctuaries if any, prior to seaweed farming implementation. Local community consensus through stakeholder consultations has to be obtained prior to implementation of seaweed farming activities. Wherever possible, seaweed farming area needs to be demarcated to avoid sectoral and spatial conflict with other livelihood activities. Pilot scale farming can be undertaken to study the

suitability of seaweed species and farming methods in each of the identified sites before large scale implementation of the programme. Impact assessment studies of seaweed farming (e.g. corals, seagrass, etc.) must be carried out. Infrastructure for drying and storing of seaweeds and marketing channels also need to be created for success of seaweed farming in the country.

Expansion of seaweed farming as an additional livelihood option in the Indian coastal region will pave the way for socioeconomic upliftment of coastal fishers/farmers. Further it will be helpful for mitigating the negative effects of climate change along with many other natural benefits. Owing to the importance of seaweed, the Government of India is promoting seaweed farming and its related activities through the recently launched

flagship programme *Pradhan Mantri Matsya Sampada Yojana* (PMMSY) by providing financial, marketing and logistical support. Thus this is the ideal moment to take seaweed farming forward in the country.

Recommendations and Way forward

The current study is a preliminary assessment only. In order to explore suitable sites for seaweed culture in detail, it is necessary that the available sea space be modelled by using advanced computational tools like GIS. Site suitability indexes need to be developed for seaweed farming systems. Along with this, species-specific analysis must be developed for further sustainable planning for expansion of this activity in a commercial manner.

Comprehensive planning for seaweed farming in the territorial waters needs to be carried out. This must be performed by considering the opinions of wide range of stakeholders along with the existing coastal communities' acceptance of this activity through technology demonstration and validation. Unexplored sheltered Island waters need to be explored for seaweed farming by considering all potential impacts over its specific existing sensitive ecosystems. Lagoons, the shallow and sheltered area in the atoll islands of Lakshadweep is ideal for seaweed farming. An approximate area of 213.4 ha has been preliminarily identified at Lakshadweep waters (in all the 11 inhabited Islands) and studies are progressing at Andaman and Nicobar Islands. Due to geographic and ocean climate advantages it is suggested that 10% of lagoon areas of the islands can be used for seaweed farming. In the island ecosystems, we recommend farming of native seaweed species only.

Development of analytical tools for spatial management is the need of the hour. Therefore, future research can focus on development of spatial management tools which could provide decision makers with a science-based objective tool to harness the ocean sustainably. As the current study is only a preliminary approach for obtaining site suitability for seaweed farming by taking into consideration suitable water quality parameters for culture, there are chances that many sites which may be suitable for culture might not have been included in this assessment. The current study can also be considered as a guide for further studies in these lines. The site suitability studies for seaweed farming needs a detailed and comprehensive analysis including experimental farming, consultation of stakeholders and coastal communities involved in the various seaweed farming activities, considering the constraints such as marine protected areas, marine national parks, impact assessment studies on other fauna and flora, feeding and breeding grounds of some specific region for protected marine species such as Olive Ridley turtles along Odisha coast and also the natural disasters. As the coastal conditions along various maritime states are not uniform, it is very important that the assessment needs to proceed by taking into consideration all region-specific aspects while developing the final model for seaweed farming along the Indian coast.

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