



## Economic Feasibility And Government Intervention On Seaweed Farming In Tamil Nadu

R. Sathish kumar<sup>1\*</sup>, K. Ramesh Kumar<sup>2</sup>

<sup>1</sup>Ph.D. Research Scholar, Department of Economics and Rural Development, Alagappa University, Karaikudi, Tamil Nadu, India

<sup>2</sup>Assistant Professor, Department of Economics and Rural Development, Alagappa University, Karaikudi, Tamil Nadu, India,

**\*Corresponding Author:** R. Sathish kumar

\*Ph.D. Research Scholar, Department of Economics and Rural Development, Alagappa University, Karaikudi, Tamil Nadu, India

### Abstract

This research aims to examine the role of government for promoting seaweed farming in India and with special focus on Tamil Nadu. The primary data covers 357 sample households and data were collected from the selected district of Tamil Nadu. The findings discourses the majority of the seaweed cultivators were well-informed about the welfare initiatives introduced by the Central and state Governments. Moreover, most of the respondents were availed the loan subsidies. The study suggested that policy supports, financial incentives, infrastructure development, changes in environment regulations, market development, capacity building and training for seaweed cultivators have been highly needed for promoting seaweed cultivation in India and specific in Tamil Nadu because of her rich potential in seaweed recourses.

**Keywords:** Seaweed, Aquaculture, Government intervention, Coastal areas, Market development

### Introduction

The fishery sector plays a significant role in the Indian economy; it contributes nearly one percent of gross value added and 5.37 per cent of gross value added from the farming sector. This sector is also a principal source of exports, food, and nutritional security and it makes in employment generation and livelihood for a large sector of the economically underprivileged population of the country, especially in the coastal areas, as per the 2011 census more than one crore family members engaged in fisheries activities (Handbook on Fisheries Statistics, 2018). The country is well on its way to reach the potential of fisheries can be seen from the fact that fish production increased from the level of 0.75 million metric tonnes (MMT) in 1950-51 to 12.59 MMT in 2017-18 from a long coastline of about 8,118 km and 2.02 million sq. km of EEZ (Exclusive Economic Zone), both marine and inland indicative of the immersive growth and potential of the sector.

Sustainable development provides a coherent approach to address pressing global challenges such as climate change, environmental degradation, and resource depletion. However, when shifting from a fossil-based economy to a bio-based economy, it is important to adhere to the fundamentals of recycling in order for it to be a viable solution. When considering the possibilities of new feedstocks, the bio-based economy's acceptable capacity should be kept open because the downward strategy would increase value creation. Seaweed, a bio-product, can replace fossil products because of its distinct chemical features, quick germination rate, and other advantages outside food.

Handling naturally exposed bunches of seaweed is the most basic way to cultivate seaweed. Additionally, in the most innovative method, the ranchers take complete control of the algae's life cycle. There are three methods for growing seaweed. First is the Central Salt and Marine Chemical Research Institute's (CSMCRI) single rope floating raft (SRFR) approach. It is appropriate for growing seaweeds at greater depths and across a larger region. The second is the synthetic seaweed manufactured using the fixed bottom long thread technique. The third method is Integrated Multi-Trophic Aquaculture (IMTA), which is similar to *polyculture* in that it involves the *synchronised* growth of two or more species. To increase production, decrease waste, and support ecosystem services like bioremediation, IMTA produces a variety of marine organisms from various trophic levels.

India has a lot of potential for growing seaweed. India has an exclusive economic zone (EEZ) that spans 2.15 million square kilometres and is one of the world's 12 mega biodiversity countries. The nation's coastline and its numerous water surrounding ecosystems support the prolific growth of several seaweed cultures, each of which has a considerable economic worth. The country, which has a 7500 km coastline, is home to about 844 different types of seaweed. There are plenty of resources in the intertidal and sub tidal zone on the West Coast, especially in Gujarat. The development of industries based on seaweed has tremendous potential thanks to these resources. Seaweed is widely available in Tamil

Nadu, Gujrat coasts, Lakshadweep, Andaman, and the Nicobar Islands. Mumbai, Ratnagiri, Goa, Karwar, Varkala, Vizhinjam, and Pulicat in Tamil Nadu, as well as Chilka in Orissa, are other locations with rich seaweed beds.

There are 14,500 miles of open rivers in India. India can benefit much from seaweed cultivation if these natural resources are used. First, freshwater, arable land or dietary inputs are not required for the cultivation of seaweed. This is critical since the nation is facing a serious water scarcity. Second, it is possible to gather seaweed and utilize it to make biofuels, the usage of which is being advocated in India. The potential for carbon sequestration might be greatly enhanced and the reliance on fossil fuels could be decreased by switching to seaweed-based electricity. Preliminary research results from a University of California study indicate that adding a modest amount of seaweed to cattle feed can lower methane emissions from the cattle industry. India has a significant population of cattle, thus since these conditions are present there as well, they would be felt there. Fourth, fish population cultivation and ocean acidification reversal can be supported by seaweed farming. This would support the livelihood and revenue production of the numerous riverside inhabitants who also work in traditional agriculture.

With the help of the Council of Scientific and Industrial Research (CSIR) and CSMRI and their connections to the industry, India is moving towards knowledge-intensive seaweed production rather of relying solely on collecting seaweed from untouched regions of the ocean. By 2025, India hopes to increase seaweed output to at least 1 million tonnes annually with an investment of roughly \$86.8 million. The investment is a component of the Blue Revolution programme under India's Pradhan Mantri Matsya Sampada Yojana (PMMSY). The programme, which was approved by the government in May 2020, aims to "bring about a Blue Revolution through sustainable and responsible development of the fisheries sector in India." Seaweed seed banks, nurseries, tissue culture units, processing and marketing facilities, as well as skill training and business development, will all be funded by the funding. Additionally, the number of jobs and wages available to individuals will increase because to these investments. The government is also luring big investors to this industry by approving 100% FDI through automatic methods in the fisheries and aquaculture industries.

An emerging and promising area of a global circular economy is led by startups. For employing seaweed to help rescue the planet, the Indian startup Sea6 Energy has won praise from all over the world. The goal of this business is to assess the size and level of automation of tropical seaweed farming. It produces sustainable raw materials for enterprises involved in the production of agri-foods, health supplements, cosmetics, bioplastics, and polymers, as well as biomass for use as fuel. For the whole value chain, patents have been obtained. It has created the "Sea Combine," a tractor-like vehicle that is currently being used in India and Indonesia to distribute seeds and collect tropical sea plants offshore.

### **Seaweed demand globally**

- ❖ Demand for red seaweeds is estimated to grow at the highest rate due to its functional qualities.
- ❖ More than 80 per cent of the demand for commercial seaweed in 2015 was from Asia.

### **Seaweeds Resource in India**

Pacific and the region is forecasted to witness the highest growth of more than 9 percent during 2015-24. Seaweeds Resource in India In India seaweed production potential is estimated 1,000,000 tonnes distributed in six states-Gujarat, Tamil Nadu, Kerala, Andhra Pradesh, Maharashtra and Andaman & Nicobar Islands. In 2016 the Tamil Nadu governments introduced a scheme for seaweed cultivation to fishermen community for livelihood support and ensure means of income generation of coastal area community. The coastal area of Tamil Nadu and Gujarat makes the significant contributing to the production of seaweed of the country. These resources have great potential for the development of seaweed-based industries in India. As many as 1000 varieties of seaweed are in existence in India out of which, 300 varieties are in the Gulf of Mannar (south Tamil Nadu) with rich in algal flora. The latest projection shows that in 2020 the production capacity of seaweed reached to 26,000 tonnes. At the same time the ministry was target that the incremental production from 0.56 Lt. in 2020-21 to 11.2Lt, in 2024-25. In the year 2016 the government of Tamil Nadu has introduced a scheme for seaweed cultivation to the fishermen community for livelihood support and ensures the means of income generation of the coastal community.

The study of Food and Agricultural Organization has (Table 2) pointed that, as of 2019 that the aggregate potential of seaweed resources of the Indian coast are 22,044 tonnes in Tamil Nadu, 20,000 and 8000 tonnes in Gujarat and Maharashtra respectively, 2,000 tonnes in Lakshadweep, and 1,000 tonnes in the Andaman and Nicobar Islands.

### **Why seaweed farming in India**

- ❖ Remedy for non-availability of required quantity of seaweeds for various uses.
- ❖ Provide occupation for the coastal people.
- ❖ Provide continuous supply of raw material for seaweed-based industry and reduce CO<sub>2</sub> in global warming.

**Table-1:** Seaweed Production target

<b>(Lakh ton) in wet Weight</b>							
State/UTs	2020-21 (5%)	2021-22 (10%)	2022-23 (25%)	2023-24 (30%)	2024-25 (30%)	Total (100%)	Rank
Gujarat	0.1	0.2	0.5	0.6	0.6	2	2
Maharashtra	0.05	0.1	0.25	0.3	0.3	1	4
Goa	0.01	0.02	0.05	0.06	0.06	0.2	6
Kerala	0.025	0.05	0.0125	0.15	0.15	0.5	5
<b>Tamil Nadu</b>	<b>0.15</b>	<b>0.3</b>	<b>0.75</b>	<b>0.9</b>	<b>0.9</b>	<b>3</b>	<b>1</b>
Andhra Pradesh	0.075	0.15	0.375	0.45	0.45	1.5	3
Odisha	0.05	0.1	0.25	0.3	0.3	1	4
West Bengal	0.05	0.1	0.25	0.3	0.3	1	4
Karnataka	0.025	0.05	0.125	0.15	0.15	0.5	5
Pondicherry	0.01	0.02	0.05	0.06	0.06	0.2	6
Lakshadweep	0.005	0.01	0.025	0.03	0.03	0.1	7
Andaman & Nicobar Islands	0.005	0.01	0.025	0.03	0.03	0.1	7
Daman & Diu	0.005	0.01	0.025	0.03	0.03	0.1	7
<b>Total</b>	<b>0.56</b>	<b>1.12</b>	<b>2.8</b>	<b>3.36</b>	<b>3.36</b>	<b>11.2</b>	

**Source:** Pradhan Mantri Matsya Sampada Yojana, Ministry of Fisheries, GoI. 2021.

**Note:** UTs: Union Territories’ of India

**Table-2** Seaweed resources in Indian coasts

State/UTs	Annual Yield in tonnes (fresh wt.)
Tamil Nadu	22,044
Gujarat	20,000
Maharashtra	20,000
Lakshadweep islands	8,000
Goa	2,000
Kerala	1,000
Andaman and Nicobar Islands	120

**Source:** FAO, Status of seaweed culture in India (2019).

**Note:** UTs: Union Territories’ of India

**Recent Literatures on Seaweed**

Nupur Bapuly and Nikhil Sharma (2023) have mentioned that seaweed has huge positional in promoting socio and economic conditions of the coastal farmers.

Maiken Bjørkan and Suzannah-Lynn Billing (2022) discourse in their study on commercial of seaweed cultivation in Scotland and social pillar of sustainability, they motioned that the government of Scottish has establish the seaweed cultivation for industrial promotion and to the blue economy for the potential for rural, island and coastal communities.

According to Diego Valderrama (2013), seaweed farming has generated substantial socio-economic benefits to marginalized coastal communities in developing countries. La Ode Muhammad Aslan (2018) analyzes the income of seaweed farming households and seaweed farming has the highest contribution to a household income of all activities. Seaweed is one of the world's main aquaculture products as 70 percent of the seaweed production is exported as a raw material (dried seaweed), while the remaining (30 percent) is processed into *carrageenan* (Ferdouse *et al.* 2018). Seaweed culture provides financial benefits and creates employment opportunity for coastal inhabitants. This study was conducted to assess profitability and to determine the socioeconomic factors that affect the profitability of seaweed culture in the coastal region (TK Ghose & MI Hossain 2020)

Songwe, B. A. *et al.*, (2016) clearly said the study assessed business management capacity; economic return; business model, and level of value addition initiatives on seaweed farming. The study found that farmers were significantly not realizing economic returns due to most of the production being below breakeven point (1,439 kgs of dry seaweed per cycle). Alam *et al.*, (2003) has reviewed the study to adopt commercially viable large-scale culture technologies, and provide them with good marketing facilities. Buschmann H. Alejandro (2017): Ginigaddara, GAS and Lankapura, AIY (2018) seaweed farming is perceived as an important livelihood option for the coastal communities, and developing strategies to mitigate the impact of adverse environmental changes would promote seaweed cultivation.

Kwabena Appiah Agyarko (2017) The study has analyzed women are more patient to complete the cycle of planting, weeding, harvesting, and selling involved in the cultivation of seaweed. D. Valderrama *et al.*, (2015) and Zamroni. An *et al.*, (2011) study assessed the opportunities and constraints of seaweed farming projects with regard to sustainable coastal management in Indonesia.

Ganesan, M.; Trivedi, N.; Gupta, V. (2019); Johnson, B. and Gopakumar, G (2011) pointed out that the regions of Tamil Nadu and Gujarat have rich seaweed diversity in India.

Narayanakumar, R. and Krishnan, M. (2013); Krishnana, M. and Narayanakumar, R (2010) in their study has examined the structure, conduct, and performance of the value chain in seaweed farming in India inquiring into the production, institutional, marketing, social and community relationships in small-scale seaweed farming. Irmayani et al., (2015), Tandel Kirtankumar V. et al., (2016) have studied seaweed cultivation and its potential to generate new opportunities for revenue generation and the empowerment of fisherwomen, Radhika Rajasree SR and S Gayathri (2014). M. F. A. Pratama et al., (2021) have explored the study based on the SWOT analysis increasing production to meet sponge demand, expanding the area for sponge breeding, empowering local communities.

### Scope of the Study

Farming of seaweeds is widespread, promising economic activity, and an important livelihood option in many tropical coastal households. Compared to other types of aquaculture activities, seaweed farming has little impact on the environment. The significant research works are carried out at the national and international levels. Most of the researchers have focused on the macro aspects of seaweed farming (Vaibhav, 2019; Sajid, I. Khan, and Satam, 2003; Kaplinsky, Raphael, and Morris, Mike, 2001) and some others have covered national aspects (Krishnan, and Narayanakumar, 2010; Ganesan, 2019) the limited studies focused on the micro-level impact on the economic feasibility and government intervention on promoting seaweed farming and create the socio-economic characteristics of the local population and their ability and willingness to work on the farms. These things are essential to consider for the sustainability of livelihood and income generation.

### Objectives of the study

- ❖ To study the economic significance of seaweed cultivation and it's potential to generate new opportunity of revenue generation in India.
- ❖ To analyse the significance of governments schemes and its involvement in promoting seaweed cultivation.
- ❖ To study the awareness among Eco-friendly and hygienic seaweed Methods of collection by the seaweed farmers in the study area, and
- ❖ To suggest the suitable policy implications to promotion of seaweed cultivation in the feasibility districts of India.

### Methodology & Data collection

This study is designed as a descriptive approach based on both primary and secondary data. Primary data were collected through a structured interview schedule. The schedule includes family size, age composition experience in fishing and seaweed farming, asset ownership, income, and employment status, indebtedness, and socio and economic status improvement associated with seaweed farming. The sample was drawn based on purposive sampling proportionate to size. For this purpose one district was identified namely Ramanathapuram district, Eleven villages are selected on the basis of the high-level proportion of seaweed farming, as the study area analyzes the structure, conduct, and performance of seaweed farming, as these districts are the center of seaweed farming in Tamil Nadu. Based on a detailed analysis of the existing literature and the gaps therein, the following hypotheses have been framed and to be tested. After the intervention of seaweed farming, household income was increased and there is a considerable diversification in livelihood and generation employment in general particularly to women in the coastal seaweed farming households.

### Data Analysis

The collected data of 357 were analysed with the help of simple descriptive tables, percentage analyses were employed to assess the economic feasibility and livelihood status of seaweed farming farmers in Tamil Nadu and selected district.

### Results & Discussion

**Table-1** Percentage of Awareness on Welfare Schemes Provided by the Central Government

S. No	Opinion	No. of the Respondents	Percent
1.	Yes	326	91.3
2.	No	31	8.7
<b>Total</b>		<b>357</b>	<b>100.0</b>

**Source:** This source collected from field survey

The above table presents the awareness level of respondents regarding the welfare schemes of the Central Government. Among the total 357 respondents, a significant majority of 326 individuals (91.3% of the sample) were aware of the welfare schemes provided by the Central Government. Conversely, a small proportion of 31 respondents (8.7% of the sample) reported not being aware of these schemes.

The findings reported that the majority of the surveyed population is well-informed about the welfare initiatives introduced by the Central Government. However, it is essential to note that a minority still lacks awareness about these programmes. Addressing this lack of awareness among the smaller group could be an area of improvement for the government, ensuring that more citizens can benefit from the available welfare schemes.

**Table-2** Percentage of Awareness on Welfare Schemes Provided by the State Government

S. No	Opinion	No. of the Respondents	Percent
1.	Yes	332	93.0
2.	No	25	7.0
<b>Total</b>		<b>357</b>	<b>100.0</b>

**Source:** This source collected from field survey

It was observed that a substantial majority of the participants, around 93.0%, were knowledgeable about the welfare schemes provided by the State Government. In contrast, a smaller minority of approximately 7.0% admitted to being unaware of these initiatives. These findings suggest a considerably high level of awareness among the respondents concerning the state government's social welfare programs.

**Table-3** Percentage of subsidies availed from the governments for seaweed cultivation

S. No	Opinion	No. of the Respondents	Percent
1.	Yes	291	81.5
2.	No	66	18.5
<b>Total</b>		<b>357</b>	<b>100.0</b>

**Source:** This source collected from field survey

According to the table above, the respondents' views on government subsidies for seaweed cultivation are as follows: 81.5 percent, or 291 respondents, reported availing the subsidy, while 18.5 percent, or 66 respondents, stated that they did not receive any subsidy from the government.

**Table-4** Percentage of nature of subsidy availed

S. No	Description	No. of the Respondents	Percent
1.	Loan	250	70.0
2.	Raft	57	16.0
3.	Seaweed	50	14.0
<b>Total</b>		<b>357</b>	<b>100.0</b>

**Source:** This source collected from field survey

The data provided in the table above illustrates the types of subsidies utilized by the respondents. According to the study, 70.0% of the participants benefited from a loan subsidy, whereas 16.0% chose a raft assistance subsidy. Furthermore, 14.0% of the respondents took advantage of a seaweed-related subsidy.

**Table-5** Percentage of bank loan available for seaweed cultivation

S. No	Opinion	No. of the Respondents	Percent
1.	Yes	276	77.3
2.	No	81	22.7
<b>Total</b>		<b>357</b>	<b>100.0</b>

**Source:** This source collected from field survey

According to the study findings, the respondents utilized a bank loan to support their seaweed cultivation endeavors. Among the participants, 276 individuals (77.3%) acknowledged having obtained the bank loan, while 81 respondents (22.7%) stated that they did not have access to this financial assistance.

**Policy Implications**

- **Policy Support:** Governments should create favorable policies and regulations that incentivize and support seaweed cultivation. This includes providing permits and licenses for seaweed farming operations, defining property rights and access to coastal areas, and establishing clear guidelines for sustainable practices.
- **Research and Development:** Governments should invest in research and development initiatives to improve seaweed farming techniques, optimize seaweed species for cultivation, and explore new applications for seaweed-based products. This can lead to increased productivity and efficiency in the industry.
- **Financial Incentives:** Governments should offer financial incentives, grants, and subsidies to encourage individuals and businesses to invest in seaweed cultivation. These incentives can help offset initial setup costs and stimulate growth in the industry.
- **Infrastructure Development:** Supporting the development of necessary infrastructure, such as seaweed processing facilities and transportation networks, can facilitate the growth of the seaweed sector and create a conducive environment for businesses to thrive.
- **Environmental Regulation:** Since seaweed cultivation takes place in marine environments, governments must set and enforce environmental regulations to ensure that farming practices do not harm marine ecosystems. Sustainable and

responsible seaweed cultivation practices should be promoted to protect biodiversity and maintain the health of coastal ecosystems.

- **Market Development:** Governments can assist in the creation of markets for seaweed products by promoting awareness of seaweed's potential uses and benefits. Encouraging domestic consumption and facilitating international trade can boost the economic prospects of the seaweed industry.
- **Capacity Building and Training:** Supporting training programs and capacity building for seaweed farmers can help improve their skills and knowledge, leading to more efficient and sustainable cultivation practices.
- **Public-Private Partnerships:** Governments can collaborate with private companies, research institutions, and non-governmental organizations to promote seaweed cultivation. Public-private partnerships can leverage expertise, funding, and resources to accelerate the growth of the industry.
- **International Cooperation:** Seaweed cultivation often transcends national borders. Governments can engage in international collaborations to share knowledge, best practices, and technology related to seaweed farming for mutual benefits.
- **Climate Change Mitigation:** Seaweed has the ability to sequester carbon dioxide from the atmosphere, making it a valuable tool in climate change mitigation. Governments can support research and projects focused on utilizing seaweed to combat climate change.

### Conclusion

Seaweeds are regarded as an essential part of the current global food security due to their extra functions in the mitigation of climate change and the empowerment of women. Due to its straightforward culture method, outstanding nutritional profile, and contribution to global climate change mitigation and adaptation measures, some recent study suggests seaweed farming as an alternative to terrestrial agriculture. The seaweed sector is expected to benefit the majority of farmers, particularly women, by increasing their purchasing power, fostering social empowerment, and aiding in efforts to fight poverty. Although seaweed farming technology has made considerable strides over the past few decades, there are still a number of barriers that need to be overcome before its sustainable production methods, varied uses, and societal acceptance can be fully realized. To achieve sustainable production at a reasonable cost with the greatest possible benefits, the initial phase in cultivation should involve careful selection of the proper species and adequate culture locations in the coastal waters. It's also essential to keep the market price at a level that encourages farmers to engage in the farming system. Establishing necessary rules is crucial to raising the calibre of seaweed species and the products developed from them for human use. Determining the daily intake of seaweed or seaweed products is also essential for a balanced diet. The collaboration and coordination between the nations and countries that produce and consume seaweed must be improved if the seaweed farming sector is to become sustainable. National and international organisations should develop and share best management practices for the seaweed farming technologies that are economically viable, environmentally benign, and socially acceptable among tropical and subtropical nations. To guarantee the contribution of these nourishing aquatic crops for a healthy earth and human populations, this should be done right away.

### Acknowledgements

The present paper has been developed as a part of a major research work funded by the Indian Council of Social Science Research (ICSSR) and the Ministry of Human Resource Development (MHRD). Financial support to the above paper by ICSSR and MHRD is gratefully acknowledged by the author.

### References

1. Alex Brown (2022), "Seaweed Farming has vast Potential- (But good luck getting a permit)," Stateline.
2. Bennett et al., (2020), "The COVID-19 Pandemic, Small- Scale Fisheries and Coastal Fishing Communities," Coastal Management, Vol.48, No.4, pp.336-347.
3. Beltonet al., (2019), "Fisheries development, labour and working conditions on Myanmar's marine resource frontier," Journal of Rural Studies, Vol. 69, pp.204-213
4. Bhaskar, RN, (2018), "Cultivating Seaweed could be a Massive opportunity for India," Money Control.
5. Buschmann H.et al., (2017), "Seaweed production: overview of the global state of exploitation, farming and emerging research activity", European Journal of Psychology, Vol. 52, No. 4, pp. 391-406.
6. Carlos M Duarte et al., (2017), "Can Seaweed Farming Play a role in Climate Change Mitigation and Adaptation?" Frontiers in Marine Science, Vol. 4, pp. 1-8.
7. Caddy, J.F. and Santelices, B. (1988), "Case Studies of Seven Commercial Seaweed Resources," FAO, Fisheries and Aquaculture Technical Paper, pp. 123-161.
8. Department of Fisheries, Government of India, "Seaweed Cultivation"
9. Diane Nelson, (2021), "Feeding Cattle Seaweed Reduces their Greenhouse Gas Emissions 82 Percent," College of Agricultural and Environmental Science, UC Davis.
10. Douglas Broom, (2022), "Only 15% of the World's Coastlines remain in their Natural state," World Economic Forum.
11. DuBois, and Zografos, (2012), "Conflicts at sea between artisanal and industrial fishers: inter- sectoral interactions and dispute resolution in Senegal," Marine Policy, Vol.36, No. 6, pp. 1211-1220.
12. Diego Valderrama (2013), "Social and economic dimensions of carrageenan seaweed farming" FAO, Fisheries and Aquaculture Technical Paper, No. 530, pp. 5-57

13. Flower e. Msuya (2011), "The impact of seaweed farming on the social and Economic structure of seaweed farming communities in Zanzibar, Tanzania", World Aquaculture, pp.45-60.
14. FAO (2023), "Introduction to Commercial Seaweeds," Food and Agriculture Organization
15. G20 Agenda (2023), We Forum, Accessed 1 April 2023, <https://www.weforum.org/ocean-20/g20-agenda>.
16. "G20 Action Plan on the 2030 Agenda for Sustainable Development," G20 2016 China, Accessed 28 March 2023.
17. Ginigaddara et al., (2018), "Farmer's Perspective on Importance and Constraints of Seaweed Farming in Sri Lanka," Current Investigation in Agriculture and Current Research, Vol. 3, No. 1, pp. 286-290.
18. Haward M and Haas B, "The Need for Social Considerations in SDG 14," Frontiers in Marine Science, October 2021.
19. Ginigaddara, GAS and Lankapura, AIY (2018) "Seaweed farming as a sustainable livelihood option for northern coastal communities in Sri Lanka", Future of Food: Journal on Food, Agriculture and Society, Vol. 6, No.1, pp. 57-70.
20. Ganesan, M.; Trivedi, N.; Gupta, V. (2019), " Seaweed resources in India – current status of diversity and cultivation: prospects and challenges", Botanical Marina, Vol. 62, No.5, pp. 463-482.
21. Ganesan, M., Trivedi, N. Gupta, V. (2019), "Seaweed resources in India – current status of diversity and cultivation: Prospects and challenges". Bot. Mar., Vol.62, pp.463–482.
22. Irmayani et al., (2015)"Increasing Farmer's Income with Production of Seaweed *Euचेuma cottonii* sp.pdf", Advances in Economics and Business, Vol. 3, No. 3, pp. 83-92.
23. Jayasankar, Reeta and Kaliaperumal, N. (1991), "Experimental culture of *Gracilaria edulis* by spore shedding method", Seaweed Research Utilization, Vol.14, No.1, pp.21-23
24. Johnson, B. and Gopakumar, G (2011), "Farming of the seaweed *Kappaphycus alvarezii* in Tamil Nadu coast - status and constraints", Marine Fisheries Information Service T&E Ser, No. 208, pp.1-5
25. Kundu S.K. and H. Santhanam (2021), "All pain and no gain: Factors impacting local and regional sustainability due to COVID-19 pandemic with respect to the Indian marine fisheries," Current Research in Environmental Sustainability, Vol. 3, pp. 1-8.
26. Kaladharan. P (2017), "Large scale Mariculture of Seaweeds- Need of the Hour,"Indian Council of Agricultural Research- Central Institute of Fisheries Technology, pp. 37-40.
27. Kaliaperumal, N. and Kalimuthu, S. (1997), "Seaweed potential and its exploitation in India", Seaweed Research Utilization, Vol. 19, No.1&2, pp 33-40. Kaplinsky et al., (2001), "A
28. Handbook for Value Chain Research", International Development Research Centre, Duke University. Canada. pp.113.
29. Khan, S. I and Satam, S.B, (2003), "Seaweed mariculture: scope and potential in India," Aquaculture Asia, Vol. 8, No.4, pp. 26-29.
30. Krishnan, M. and Narayanakumar, R. (2009), "Socio-economic Dimensions of Seaweed Farming in India", Consultancy Report, Personal Services Agreement, FAO of UN, Rome, pp.103.
31. Krishnan, M and Narayanakumar, R (2010), "Structure, Conduct and Performance of Value Chain in Seaweed Farming in India," Agriculture Economics Research Review. Vol.23, pp. 505-514.
32. Krishnan, M. and Narayanakumar, R. (2010), "Socioeconomics of Seaweed Farming in India," Central Marine Fisheries Research Institute, Kochi, Special Bulletin, No. 104, pp.103
33. Kwabena Appiah Agyarko (2017), "Assessing the Socio-Economic Benefits of Seaweed Production to the Rural Coastal Areas in Ghana", International Journal of Advances in Science, Engineering and Technology (IJASEAT), Vol. 5, No. 3, pp. 32-36.
34. Aslan et al. (2018), " Seaweed Cultivation of Micropropagated Seaweed (*Kappaphycus alvarezii*) in Bungin Permai Coastal Waters, Tinanggea Sub-District, South Konawe Regency, South East Sulawesi", IOP Conf. Series: Earth and Environmental Science No. 175, pp. 1-8.
35. Leonel Pereira, "Seaweeds as Source of Bioactive Substances and Skin Care Therapy—Cosmeceuticals, Algototherapy, and Thalassotherapy," Cosmetics, Vol. 5, No. 4, pp. 1-41.
36. Mantri, Vaibhav A., et al., (2019), "Seaweed Biodiversity of India: Reviewing Current Knowledge to Identify Gaps, Challenges, and Opportunities," Diversity, Vol. 12, No.1, pp. 1-22.
37. Maiken Bjørkan and Suzannah-Lynn Billing (2022) "Commercial Seaweed Cultivation in Scotland and the Social Pillar of Sustainability: A Q-Method Approach to Characterizing Key Stakeholder Perspectives", Frontiers in Sustainable Food Systems. Agroecology and Ecosystem Services, Vol.6.<https://doi.org/10.3389/fsufs.2022.795024>
38. Narayanakumar, R. and Krishnan, M. (2013), "Social and economic dimensions of carrageenan seaweed farming" FAO, Fisheries and Aquaculture Technical Paper, No. 530, pp. 164-183.
39. Narayana kumar, R and Krishnan, M (2013), "Socio – economic of seaweed farmers in Tamil Nadu – A case study in Ramanathapuram District," Indian journal of Fisheries, Vol. 60, No.4, pp. 51-57.
40. National Ocean Services (2023), "What is Seaweed?," National Oceanic and Atmospheric Administration, US Department of Commerce, Government of the United States of America.
41. NOAA Fisheries, (2020), "Seaweed Aquaculture,"National Oceanic and Atmospheric Administration, US Department of Commerce, Government of the United States of America.
42. Nupur Bapuly and Nikhil Sharma (2023) "Seaweed Cultivation as a Means to Realise the G20's Agenda for Sustainability", T20 Policy Brief, May 2023.
43. OECD and UN (2019), "G20 Contribution to the 2030 Agenda,"Organization for Economic Co-operation and Development and United Nations.

44. Recineet al., (2021), "A case for seaweed aquaculture inclusion in U.S. nutrient pollution management," *Science Direct*, Vol. 129, pp. 1-5.
45. Pratama, M. F. A. et al., (2021), "Strategy for the Development of Seaweed Cultivation in Karawang Regency, West Java Province", *Asian Journal of Fisheries and Aquatic Research*, Vol. 11, No. 4, pp. 12-22.
46. Silvia Lomartire et al, (2022), "An Overview of the Alternative Use of Seaweeds to Produce Safe and Sustainable Bio-Packaging," *MDPI- Applied Sciences*, Vol. 12, pp.1-17.
47. Sathishkumar and Ramesh Kumar, (2022), "Impact of Covid-19 on Fisheries Community to Achieve Sustainability," *A Multidisciplinary Approach on Future Prospects of Sustainable Development Publisher: Royal Book Publishing*,
48. Sathishkumar et al., (2020), "MGNREGA's Impact on income and employment in seaweeds cultivating households: Pamban Village of Ramanathapuram District", *Journal of Critical Reviews*, Vol. 7, No. 8, pp. 2149- 2156.
49. Sathishkumar, et al., (2020), "COVID-19: Lives and Livelihoods of Seaweed Farming and its Impacts", *Virtual National Conference on the Changing Economic Models and Trends in the Post Covid-19 World*, pp. 89-97.
50. Subba Rao, and Mantri (2006), "Indian seaweed resources and sustainable utilization: Scenario at the dawn of a new century," *Current Science*, Vol.91, No. 2, pp. 164-174.
51. Ramesh Kumar et al., (2022), "Climate Change and Agricultural Losses in India", *American Journal of Economics and sociology*, Vol. 81, No. 2, pp. 339-358.
52. Radhika Rajasree SR and S Gayathri (2014), "Women Enterprising in Seaweed Farming With Special References Fisherwomen Widows in Kanyakumari District Tamilnadu India", *Journal of Coastal Development*, Vol.17, No.1, pp.1-5.
53. Sajid, I. Khan and Satam, S.B, (2003), "Seaweed Mariculture: Scope and Potential in India", *Aquaculture Asia*, Vol. 8, No.4, pp. 26-29.
54. The University of Maine "Sea Vegetables: The Science of Seaweeds," *Cooperative Extension*, Accessed 22 May 2023.
55. Songwel, B.A, et al., (2016): "Commercial Seaweed Farming in Zanzibar Coastal Villages: Potential for Innovative and Competitive Economic Growth," *Huria: Journal of the Open University of Tanzania*, Vol. 22. No.1.
56. The Intergovernmental Panel on Climate Change, "Synthesis Report of the IPCC Sixth Assessment Report (AR6)," *IPCC*, Accessed 8 May 2023.
57. Tandel Kirtankumar V. et al., (2016)"Seaweed Cultivation in India, A New Opportunity of Revenue Generation", *Advances in Life Sciences*, Vol. 5, No.7, pp. 2487-2491.
58. Vaibhav A. Mantri, et al., (2019), "Seaweed Biodiversity of India: Reviewing Current Knowledge to Identify Gaps, Challenges, and Opportunities", *Diversity*, Vol.12, No.13.
59. Valderrama et al., (2015), "The Economics of Kappaphycus Seaweed Cultivation in Developing Countries: A Comparative Analysis of Farming Systems", *Aquaculture Economics & Management*, Vol. 19, No. 2, pp. 251-277.
60. United Nations (UN), "Global Issues," *UN*, Accessed 25 March 2023.
61. Xi Xiao et al., (2021), "Seaweed farms provide refugia from ocean acidification," *Science Direct*.
62. Zamroni. A et al., (2011), "Coastal Resource Management: Fishermen's Perceptions of Seaweed Farming in Indonesia", *World Academy of Science, Engineering and Technology*, No. 60, pp. 32-38.