

RESEARCH ARTICLE

Current Potential of Seaweeds Cultivation in South Asian Coastal Regions

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ABSTRACT

Seaweed plays an important role in marine ecosystem as a primary biomass producer and they provide food for marine organism and also they have significant contribution on marine carbon cycle. Other hand, it is an important source of food, colloids or gels and medically important elements. Several species of seaweed are commercially farmed in Asian nations. Coastal regions in South Asian countries have good potential for seaweed cultivation, which also offers as an alternative livelihood activity for poor coastal communities. At present seaweed cultivate about 50 countries for various uses such as food, medicine, fertilizer, industrial, *etc.* which seems that the quantities of seaweed being produced were too small to consider any regional cooperation in marketing and processing in coastal areas in South Asian countries. The main problems highlights in South Asian countries is knowledge gaps in coastal region peoples about potentials of seaweeds that need to be filled in order to form a clearer vision of seaweed farming development in the future and facilitate evidence based policy decision making and sector management. Within South Asian communities, seaweed wants to promote as edible source and have to be popularized as food and attempts must be made to develop culture technologies. The extraction of bioactive agents from seaweeds is a new line of work which has opened up further possibilities of utilizing this resource. Connected with this would be the better utilization of seaweeds for production of many important pharmacological products and by using as biological tool, the shrimp farm wastes can he transformed into wealth by bringing the twin benefits of both waste treatment and additional food production. Unlike other forms of aquaculture, seaweed farming wants minimum technological and capital requirements. In addition, grow out cycles are short, normally lasting less than two months. Given these unique characteristics, seaweed farming has generated substantial socio-economic benefits to marginalized coastal communities in developing countries, most of which have reduced access to alternative economic activities. In some communities, seaweed farming has emerged as the most relevant livelihood strategy. However, further development researches and incentive schemes for seaweed farming needs to overcome various barriers and constraints such as inclement weather conditions, disease outbreaks, uncertain and fluctuating market conditions, lack of value-added products, lack of value-adding activities, low incomes of seaweed farmers in some countries and occupational health hazards.

Keywords: coastal, edible, livelihood, seaweed, value-added products

INTRODUCTION

Seaweeds are multicellular, photosynthetic, marine organisms (Macroalgae) they grow cold to tropical coastlines in both hemispheres and where intertidal and sub-tidal area up to 0.1% photosynthetic light is available (Rebours *et al.*, 2014; Wiencke and Amsler, 2012; Dhargalkar and Pereira, 2005). Macro algae show close

relationship to the higher plant but they are completely different from higher plant because of seaweed have primitive plant body (Thallus) it do not contain vascular tissues (xylem and phloem), root, shoot, leaves and flowers. They are attached to the substrate by holdfast and reproduce sexually by spores. Nutrient absorb from surrounding sea water. Thallus show extreme diversity by size,

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shape colour *etc.* According to the thallus color seaweed can be categorized into three distinct groups, green algae (Chlorophyta), brown algae (Phaeophyceae) and red algae (Rhodophyta) (Coppejans *et al.*, 2009). Chlorophyll a is the primary photosynthetic pigment of above 3 group of algae in addition brown algae contain xanthophyll and also red algae contain phycoerythrin and phycocyanin pigments. According to the balance of pigments color of the brown algae vary from yellowish orange to blackish brown and color of red algae vary from pink to purplish red. Approximately it can be found in nature, 900 species of green algae, 1500 brown algae species and 4000 red algae species around the world (Mohamed, 2015).



Fig. 1: Main algae; A, Green algae (*Ulva lactuca*) L.; B, Brown algae (*Canistrocarpus magneanus*) and C, Red algae (*Gracilaria canaliculata*)

Seaweed plays an important role in marine ecosystem as a primary biomass producer they provide food for marine organism and also they have significant contribution on marine carbon cycle. Seaweed are providing habitat for vast range of invertebrates, fish, mammals, and birds (Rebours *et al.*, 2014; EHS, 2007). They protect coastlines from shore erosion. Furthermore, seaweed has highly economic importance (Domettilla *et al.*, 2013). Therefore it has been traditionally cultivated in some Asian countries like China, Japan and Korea from 100 years ago (Rao and Mantri, 2006; Crawford, 2002). At present seaweed cultivate about 50 countries (FAO, 2016) for various uses such as food, medicine, fertilizer, industrial, *etc.*

Use of Seaweed as food,

Japanese people use it's about 50 species of seaweed for their diet (Abowei and Ezekiel, 2013) among these seaweed red and brown algae are most commonly used for human consumption. Seaweed can be eat form of raw seaweed as salads and also as a processed foods. Globally it's about 145 species of seaweed used for foods. Following seaweed species are used as vegetable salads, *Acanthophora spicifera*, *Caulerpa lentillifera*, *C. racemose*, *Eucheuma denticulatum*, *Gracilaria* spp., *Enteromorpha* spp. (Trono, 1999). *Nori*, *Wakame* and *Kombu* are most commonly consume processed seaweed foods in Japan, Korea, and China. But during past few decades some of these

seaweed products are popularize in western countries like United States (Flynn, 2014; Radmer, 1996). *Nori* produce by species of red algae, *Porphyra* spp. or *Pyropia* spp. Different form of *nori* can be found in the market. *Wakame* produce by *Undaria pinnatifida*, brown algae species *Wakame* major producer is Japan there can be found different type of *Wakame* products in Japan. *Kombu* produce by brown algae species of *Laminaria japonica*, *Kombu* also can be found in different form and different products in the market of those countries. Not only these algae species other algae species also use for seaweed food production as example, green algae species of *Enteromorpha*, *Ulva*, *Caulerpa* and *Codium* are utilized as food sources. (Mohamed, 2015)

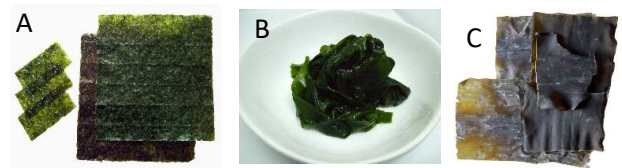


Fig. 2: A – Nori sheet B – Boiled wakame C - Kombu

Industrial uses of sea weed

At least 101 species of seaweeds are globally used for phyco-colloid such as Agar, Alginates & Carrageenan. Agar use for food preparation and in the pharmaceutical industry as a laxative and production of outer cover of capsules. In modern molecular biology and genetic engineering, agarose produce from agar gums extensively use for electrophoresis. Alginates are used for dressing wound and production of dental moulds. And they can absorb many times their own weight of water, have a wide range of viscosity, can readily form gels and are non-toxic, therefore they are used for vast range of industries such as pharmaceuticals, cosmetic creams, paper and cardboard, and processed foods. Carrageenans are generally use as source of gelation therefore they used in food industry like ice cream (Khan and Satam, 2003). Alginic acid, mannitol, laminarin, fucoidin and iodine are other industrial chemicals extract from brown sea weeds. Furthermore seaweeds extract are rich in natural plant growth hormone and beneficial trace element therefore seaweeds may be used as fertilizer, compost for landscaping *etc.*

Medicinal uses

Seaweeds are called medical food of the 21st century because of they are rich in minerals, vitamins, trace elements and bioactive substances.

These substances have Antiviral activity, Antibiotic activity, anti-fungal properties and other wide range of medicinal properties. (Smit, 2004). Some sulphated polysaccharides extract from red algae have antiviral activities, they use for treat Herpes simplex virus (HSV) and research is now being carried out use potential of seaweed extract treat respiratory syncytial virus (RSV) and human immunodeficiency virus (HIV) (Smit, 2004). Halogenated compounds derived from seaweed such as haloforms, halogenated alkanes and alkenes, alcohols, aldehydes, hydroquinones and ketones have antibiotic properties. As an example; halogenated furanone or fimbrolide extract from *Delisea pulchra* are used for treatment for chronic *Pseudomonas aeruginosa* infection (Pal *et al.*, 2014; Smit, 2004). Furthermore seaweed compound have Anti-Inflammatory Activity, Anti-Thrombotic and Anti-Coagulant Activity, and also seaweed compound use for treat cancer as example regular use of *Laminaria japonica* inhibit the risk of the breast cancer considerably (Pal *et al.*, 2014; Smit, 2004)

Seaweed cultivation

Global seaweed industry represents by wild harvest seaweed and cultivated in offshore and onshore farms (Nayar and Bott, 2014). In 2013, world seaweed production was 26.89 million tons (FAO, 2015). According to the Food and Agriculture Organization of the United Nations (FAO, 2012) in 2010 majority of seaweed production come from farmed seaweed and wild harvested seaweed represent 4.5% in total seaweed production. In 2010, Japanese kelp (*Saccharina/Laminaria japonica*), *Eucheuma* seaweeds, *Gracilaria* spp., nori/laver (*Porphyra* spp.), wakame (*Undaria pinnatifida*) and unidentified marine macro-algae species represent 98.9 percent of world production as dominant species. China, Indonesia, Philippines, Republic of Korea and Democratic People's Republic of Korea are the top five seaweed producers in the world. East and Southeast Asian countries account 99.6 percent by quantity and value of global seaweed production in 2010.

Potential of seaweeds cultivation in South Asia

South Asia comprises Afghanistan, Bangladesh, Bhutan, India, Maldives, Nepal, Pakistan, and Sri Lanka. The South Asian Seas Region is comprised of the Northern Indian Ocean and incorporates the marine and coastal environments, including the Exclusive Economic Zones of Bangladesh, India, Maldives, Pakistan and Sri Lanka. It accounted

about 12,000 km long coastline and the large marine area. The marine environment is physically divided by the Indian subcontinent into three distinctive areas: two large marine ecosystems - the Arabian Sea in the west and the Bay of Bengal in the east; and a large area of the open Indian Ocean to the south of India and Sri Lanka (SACEP, 2014). These coastal areas of Asian countries are characterized by the most extensive and diverse tropical marine ecosystems such as, mangroves, coastal wetlands, seagrass meadows, coral reefs and sand dunes (SACEP, 2014). Seaweeds occur in three major marine communities: seaweed vegetation, seagrass beds and mangrove forests. These coastal environments of South Asia are more suitable for the growth of seaweeds. In addition, sandy, coralline bottoms with shallow coastal belts are the ideal habitat for many economic types of seaweed. The geographical distribution of seaweeds is very extensive and the main areas are Chile, Japan, India, Sri Lanka, Indonesia, Brazil, Madagascar, Vietnam, Philippines, North Korea, Taiwan and South Africa (Chennubhotla, 1996). A number of studies showed that seaweed diversity in South Asia is comparatively high. In India, a total of nearly 700 species of marine algae have been recorded from different parts of Indian coasts, of these about 60 species are commercially important. From the resource survey conducted along the various maritime states the seaweed resources of India was estimated at 2 lakh tones (Chennubhotla *et al.*, 1992). In Sri Lanka, relatively rich, with about 440 taxa, belonging to 148 genera currently recorded along a coastline of 1585 km (Baldwin *et al.*, 1991; Silva *et al.*, electronic version). Concerning above mentioned facts; the coastal environments and seaweed diversity in South Asia have corroborated that there is a high potential to cultivate seaweeds in South Asia.

Seaweeds are used in a large number of applications throughout the world. Hence, the demand for seaweeds are high and it has favorable prices; it provides a rapid and high return on investment. As a livelihood activity, it could offer relatively high and continuous incomes to coastal families. Seaweed farming is a relatively simple technology and it requires low initial capital investment; materials are usually not a major expense. No fertilizer is needed. In addition, with grow out cycles as short as six weeks. Seed materials are usually self-propagated. Thus, farming techniques are relatively easy to grasp and it can be conducted most of the year with

short production cycles of seaweeds. These characteristics make seaweed farming a favorable source of livelihoods in coastal communities of South Asia and further, seaweed farming has the potential to generate further socio-economic benefits to coastal communities in South Asia. A number of studies have corroborated the positive impact of seaweed farming on the socio-economic conditions of coastal villages in countries as diverse as the Philippines, Indonesia and Solomon Islands. In Indonesia, carrageenan seaweed farming provided a stable annual average income USD5 000 to a typical nuclear family farm; for a leader farm, the annual income could be more than USD15 000. Many surveyed farmers indicated that seaweed farming contributed to most of their incomes but only cost half or even less of their time (Neish, 2013, Zamroni and Yamao, 2011). In the Philippines, seaweed culture could offer higher returns than alternative activities. Surveyed farmers reported that income from seaweed farming had increased their annual income by USD 632–1 895, helping them to meet daily needs, including children's education. Cultivation periods are a maximum of 66 days compared with several months for growing abalone, finfish or lobster, or agriculture crops, such as rice, corn and cassava (Hurtado, 2013). In Solomon Islands, surveyed farmers deemed seaweed farming a diversified livelihood source that improved their incomes and living standards and made them more food secured. Although traditional fisheries could be more lucrative on an hourly basis, seaweed farming tends to be a more stable livelihood source, providing more income to households on an annual basis than fisheries, which relies on depleting natural resources (Valderrama, 2012). Seaweed farming is a labour intensive activity. Though, there are plenty of labour can be found for seaweed farming from coastal communities. Because of a large portion of the Asian population lives along coastal areas and they are intimately associated with the sea and its resources. Most of these coastal populations are mainly depending on fishing and they have minimum access to alternative economic activities; they have less alternative activities like tourism. Thus, there are abundant labours. On the other hand, most of the seaweed farming countries used family labour. In India, women were the first and primary adopters of seaweed farming (Krishnan and Narayanakumar, 2013; Ramachandran, 2012). In United Republic of Tanzania, women are leaders both in seaweed cultivation and in adding value (Msuya, 2013). A women's group in northern

Zanzibar (the United Republic of Tanzania) has started producing seaweed flour, doubling its net profits and adding new products (Msuya, 2011). Further, seaweed farming can have positive effects on the environment because seaweeds could improve the benthic ecosystem, and sequester carbon, thereby offering the potential for carbon credits. Seaweed grown on rafts can also become an attractive haven for fish. On the other hand, seaweed farming helps to reduce the overexploitation of fishing. Through intensive fishing, these coastal areas have been and will continue to be depleted of resources on which the very lives of the coastal population directly or indirectly depend. The grave concern for the consequences of the depletion of the fisheries in shallow coastal areas is best dramatized by the closure of traditional fishing grounds to big fishing operations. The Philippines, Indonesia and Thailand have enacted measures to prevent the overexploitation of the fishery stocks in some fishing grounds (Valderrama *et al.*, 2013; Smith, 1979) recommended alternative income sources such as seaweed farming as one type of incentive to reduce fishing pressure as long as they are attractive enough to reduce full-time fishing (Padilla and Lampe, 1989) reported that seaweed farming in the Philippines was an attractive economic alternative to fishing. However, they also indicated that while profits from seaweed farming are well above the opportunity cost of capital, with a return of 78 percent per annum. The decline in coastal productivity coupled with population increase consequently would lead to the lowering of living standards in the coastal areas. The development of seaweed cultivation in South Asian coastal regions will help to reduce food insecurity and alleviate poverty of coastal communities; by increasing food availability and accessibility, generating employment and income and improving national economies too. In addition, seaweed helps to increase the health of people; seaweeds that are found as suitable for human food are include an unusual range of micro nutrients like all the B vitamins, trace minerals and complex micronutrients as well as all the antioxidants (Ranger and Rose, 2015). Hence, seaweed is typical part of East-Asian diets. But in South Asian countries, seaweed consumption is relatively less. By development of seaweed cultivation in South Asia, it can increase the potential of consumption of seaweed in South Asian regions.

CONCLUSION

Sea weeds can grow as alternative income source for coastal areas in South Asian countries and can use to produce many economically valuable products in South Asia which are in high nourishment and healthy diet.

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