ORIGINAL ARTICLE

Bali Tourism Journal (BTJ) 2023, Volume 7, Number 3, September-December: 47-50
P-ISSN. 2580-913X, E-ISSN. 2580-9148

Challenges of Seaweed Cultivation in Nusa Penida for Economic, Tourism, and Environmental Sustainability

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ABSTRACT

Seaweed production in Indonesia is distributed across 23 provinces. The top five provinces in seaweed production, according to rankings, are South Sulawesi, East Nusa Tenggara, North Kalimantan, Central Sulawesi, and West Nusa Tenggara. Among the dozens of seaweed-producing provinces, Bali has the potential for seaweed cultivation, supported by a vast marine area of 95,000 km2. The Nusa Penida sub-district of Klungkung Regency, the community shows interest in becoming seaweed farmers. The accessibility for seaweed farming in Nusa Penida is due to its location approximately ten nautical miles southeast of Bali, and its coastal area is recognized as a "museum" of rare seaweed globally. Farming activities and the seaweed production process have become a mainstay for export activities, contributing significantly to Indonesia's export value. The ease of cultivation and low capital requirements are factors that determine coastal residents' choice to become seaweed farmers. However, seaweed often faces obstacles in meeting domestic and export demands. While seaweed cultivation in Nusa Penida faces challenges, the community's resilience, coupled with innovative solutions and sustainable practices, positions seaweed as a valuable and versatile marine resource with the potential to contribute to both economic development and environmental conservation in the region.

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Received: 2023-05-06
Accepted: 2023-08-03
Published: 2023-09-22

Keywords: Seaweed, Nusa Penida, Economic, Tourism.
Cite This Article: Putra, I.B.G.K. 2023. Challenges of Seaweed Cultivation in Nusa Penida for Economic, Tourism, and Environmental Sustainability. *Bali Tourism Journal* 7(3): 47-50. DOI: 10.36675/btj.v7i3.96

BACKGROUND

Seaweed cultivation in Indonesia

Indonesia, as an archipelagic country, possesses a diverse range of ecosystems and genetic resources, ranging from lowlands, highlands to aquatic ecosystems. With 70% of its land area consisting of water, Indonesia has the potential for seaweed cultivation. The extent of seaweed habitat in Indonesia reaches 1.2 million hectares, making it the largest in the world.[1] Seaweed, also known as seaweed in the international trade, refers to various types of macroalgae, including green algae (Chlorophyta), brown algae (Phaeophyta), and red algae (Rhodophyta). Seaweed falls under the category of macroalgae and serves as a biological resource that has been utilized by the Indonesian community as one of their livelihoods, with some regions even making it their primary source of income.[2]

According to the Central Statistics Agency (BPS), seaweed production in Indonesia is distributed across 23 provinces. The top five provinces in seaweed production, according to rankings, are South Sulawesi, East Nusa Tenggara, North Kalimantan, Central Sulawesi, and West Nusa Tenggara. Seaweed production in Indonesia has shown positive results from 2021 to 2022. The Ministry of Marine Affairs and Fisheries (KKP) data outlines seaweed production at 9.12 million tons in 2021. Seaweed production increased by 93% until September 2022, with Indonesia exporting 180.6 thousand tons of seaweed valued at USD 455.7 million. The primary destination for Indonesia's seaweed exports is China. Among the dozens of seaweed-producing provinces, Bali has the potential for seaweed cultivation, supported by a vast marine area of 95,000 km2. This area is calculated based on the coastline length and the 200 nautical miles limit from the coastline. The potential land area for marine cultivation is 1,551.75 hectares, with only 418.5 hectares or 26.96% currently utilized for seaweed cultivation.[3]

Districts such as Buleleng, Jembrana, Badung, Karangasem, and Klungkung have also taken similar steps to enhance the potential for seaweed cultivation. For example, in the Nusa Penida sub-district of Klungkung Regency, the community shows interest in becoming seaweed farmers. The accessibility for seaweed farming in Nusa Penida is due to its location approximately ten nautical miles southeast of Bali, and its coastal area is recognized as a "museum" of rare seaweed globally. The coastal ecosystem around this area strongly supports the growth of marine biota such as seaweed.

65% of seaweed is distributed in villages that are central to seaweed production, such as Suana Village, Batununggul Village, Kutampi Kaler Village, Ped Village, and Toyapakeh Village in Nusa Penida. Meanwhile, on Nusa Lembongan Island, seaweed is distributed in Jungut Batu Village and Lembongan Village. The development of seaweed commodities in Bali includes the types Eucheuma spinosum and Eucheuma cotonii (Bali Provincial Marine and Fisheries Service, 2008). Seaweed plays a crucial role as a local resource, generating economic benefits for a significant portion of the coastal population in Nusa Penida.

With its location facing the open sea, Nusa Penida contributes seaweed

Figure 1.[15] Farming activities and the seaweed production process have become a mainstay for export activities, contributing significantly to Indonesia's export value.

Figure 2.[16] The rise and fall of seaweed conditions are addressed by the community by adapting to the potential or opportunities that can be utilized.

commodities to Bali. This commodity serves as a raw material for various essential products such as food and cosmetics. From this island separated from the mainland of Bali, seaweed is exported via Surabaya to countries such as Japan, China, Taiwan, and Korea.[4]

The Potential of Biodiversity in Nusa Penida

On June 9, 2014, the Minister of Marine Affairs and Fisheries, Sharif Cicip Sutardjo, officially designated the Nusa Penida area as a marine conservation area (KKP). The KKP encompasses the main island of Nusa Penida and two smaller islands, Nusa Ceningan and Nusa Lembongan. The waters of Nusa Penida boast high biodiversity, serving as a habitat for 300 coral species and over 500 species of reef fish, some of which are newly discovered according to the latest scientific knowledge. Another unique aspect is that Nusa Penida is part of the global triangle center with 576 fish species, and this area is a cleaning station for sunfish or mola-mola. Recently, the Nusa Penida Marine Conservation Area was recognized as a Hope Spot by Mission Blue, a global campaign supporting ocean conservation.

According to the Fisheries Law No. 31/2004, later revised by Law No. 45/2009, the KKP has 9 programs, including its establishment, infrastructure provision, guidelines, development of qualified and competent human resources, provision of ecosystem and fisheries data, surveillance, ecosystem threat mitigation, community involvement, and sustainable financial mechanisms. The KKP for fisheries has 4 roles, including fish egg production, increasing fish size, and biodiversity of marine species. These facts make seaweed a commodity widely used for research and innovation, primarily conducted by the Maritime and Fisheries Research and Human Resources Agency (BRSDM KP). In addition to research aimed at improving the quality and quantity of seaweed production for export, studies are also conducted for the utilization of seaweed in other forms. The second option is to use seaweed as plant fertilizer.[5]

Issues with Seaweed in Nusa Penida

Seaweed has provided a source of livelihood for coastal communities across the islands of Indonesia. Farming activities and the seaweed production process have become a mainstay for export activities, contributing significantly to Indonesia's export value. The ease of cultivation and low capital requirements are factors that determine coastal residents' choice to become seaweed farmers. However, seaweed often faces obstacles in meeting domestic and export demands.[6]

According to the Annual Performance Report for the third quarter of 2021 from the Directorate General of Fisheries Cultivation of the Ministry of Maritime Affairs and Fisheries, seaweed production decreased from 7.78 million tons in the third quarter of 2020 to 7.14 million tons in the same period of 2021. The figures for 2021 also indicate a failure to meet the target set by the Ministry in the third quarter, which was 8.45 million tons. This situation has led to a decline in the supply of raw materials for the industry.

The proposed solution is to follow a cultivation calendar based on weather and

seasonal calculations. This method has been used by aquaculture practitioners to develop seaweed commodities. However, due to climate change, this approach is deemed less effective. Specifically, in the waters of Nusa Penida, seaweed cultivation faces various challenges. In 2021, seaweed along the coast of Ped Village, Nusa Penida District, Klungkung, was affected by a disease with symptoms of white spots on the stems, leading to wilting. Coastal farmers attribute this to the unpredictable sea surface temperature. Due to water temperature fluctuations being too warm or too cold, seaweed becomes fragile or rots. Coastal residents of Nusa Penida refer to this condition as *ice-ice*.[7] forcing farmers to harvest seaweed prematurely. Household waste and tourism industry waste further exacerbate the condition of seawater.

Additionally, the traditional sun-drying method of seaweed on plastic tarps poses technical problems. This drying method is considered to cause contamination of seaweed with other materials. The traditional drying process is often mixed with garbage and pebbles. Another classic issue complicating seaweed cultivation is price fluctuations and the lack of integration in processing seaweed into high-value products. Market uncertainties force seaweed farmers to heavily rely on middlemen for the sale of dried seaweed. Farmers are unable to sell directly to exporters or seaweed processors due to limited individual production capacities, while exporters require large quantities. Farmers also cannot sell through collective marketing because they are not part of a group.[8]

Solution purposed

The rise and fall of seaweed conditions are addressed by the community by adapting to the potential or opportunities that can be utilized. In 2017, seaweed cultivation in Nusa Penida decreased primarily because there were fewer buyers for the harvest, and there was a fish pest issue since 2016. Additionally, the ease of obtaining income in the tourism sector led many seaweed farmers in Nusa Lembongan to switch to renting vehicles to tourists. One of the seaweed farmers stated that renting out motorcycles to tourists is easier, more enjoyable, and provides a more certain daily income. The influx of thousands of tourists makes it less challenging for them to earn a living.

This situation is highly advantageous for the community compared to the conditions during the 2020 pandemic. Many people who rely on tourism sporadically switch to professions such as seaweed farming. The community is aware of the economic impact if there are no tourists. When there were no international flights to Bali, seaweed was able to support the local economy.[9]

This does not mean they abandoned seaweed farming when Covid-19 cases declined in 2022. Tourists slowly returned to Bali, specifically to Nusa Penida. Most seaweed farmers continued their activities, feeling they learned from the pandemic situation. Dewa Ketut Sueta Negara, the Head of the Food Security and Fisheries Agency in Klungkung, stated that in addition to these factors, seaweed farmers in Nusa Penida are still persisting because the current price of seaweed has improved. This is why many seaweed farmers are not in a hurry to switch back to the tourism sector. "The price of dried seaweed is Rp 38,000/kg," said Dewa Sueta.

Previously, the price of seaweed was around Rp 15,000 - Rp 16,000/kg. The current good condition of seaweed prices is due to high demand from foreign countries such as China, Korea, Japan, and others. In some areas of Nusa Penida, seaweed harvesting is in full swing, especially in Lembongan Village. Conversely, in Suana Village, the current climate cycle is not conducive to seaweed cultivation, but they still persevere and use their time to make stakes and nets.

Nusa Penida's seaweed is known for its derivatives. The story of young entrepreneurs who started a seaweed processing business into various skincare products began with youths from Nusa Lembongan, one of the Nusa Penida archipelago. The couple Ni Luh Putu Wira Astuti and her husband Nyoman Sudiatmika built the Sandu Care group.[10] The processing of seaweed is intertwined with their struggle during the Covid-19 pandemic. From the internet, they learned how to process seaweed into non-food products, and their idea was supported by a team from Udayana University. Furthermore, there was support from the Coral Reef Rehabilitation and Management Program – Coral Triangle Initiative (COREMAP – CTI) supported by the Asian Development Bank (ADB). Currently, in their home, there is a range of products with attractive packaging, such as liquid body and hand soaps with various scents. Their products are already sold in organic retail stores in Bali, and they are currently collaborating with companies outside Bali to develop skincare products like day cream, night care, body lotion, and more.

In terms of food products, seaweed can also be utilized to create derivative products such as dry noodles, crackers, candies, and various sweets[11]. Seaweed bakpia is one of the processed products from seaweed that has high nutritional value. Seaweed has diverse characteristics and shapes, one of which is flat, round, and branching. Seaweed itself contains natural nutrients such as vitamins A, B1, B2, B3, B12, C, D, E, F, K, minerals, and beneficial fatty acids. With such a comprehensive content in seaweed, it's not surprising that seaweed has many health and beauty benefits.[12]

Training activities for making seaweed-based food derivative products remain a mainstay to sharpen the community's skills in utilizing the marine resources of Nusa Penida. Seaweed is not only used for new derivative products; the continuous exploitation of biological natural resources without considering the surrounding environment can threaten the sustainability of biodiversity in this country.[13] Therefore, sustainable regeneration is needed to improve the quantity and quality. According to Bakti Berlyanto Sedayu, a researcher at the Research Center for Fishery Product Processing Mechanization (LRMPHP), who conducted research on seaweed, found that seaweed can not only be used to create new derivative products but can also be used to make seaweed fertilizer beneficial for nourishing plants.

Not only used as food, pharmaceuticals, or cosmetics products, making seaweed fertilizer is a process considered easy and can be done by households in general. To produce organic fertilizer for plants,

seaweed is processed together with fishery waste. These two raw materials have advantages as growth stimulants that can increase crop production and prevent pest attacks. The use of organic fertilizer in plants can reduce the use of chemical fertilizers, improve plant quality, and increase community income. This is because organic fertilizer contains beneficial nutrients such as nitrogen, phosphorus, and potassium (NPK). When seaweed is used as a plant fertilizer, it becomes an important part of utilizing this commodity limitlessly. This activity can create jobs and simultaneously reduce poverty levels in coastal areas.[14]

CONCLUSION

Seaweed cultivation in Indonesia, particularly in the Nusa Penida region, presents a dynamic landscape with both challenges and opportunities. Indonesia's vast aquatic ecosystems and favorable conditions have positioned it as a global leader in seaweed production, with the potential for further growth. The significant increase in seaweed production from 2021 to 2022, as reported by the Ministry of Marine Affairs and Fisheries, highlights the economic importance of this marine resource. Climate change impacts, including unpredictable sea surface temperatures leading to seaweed diseases like *ice-ice*, pose threats to cultivation. Additionally, traditional drying methods and issues related to price fluctuations and market integration contribute to the complexity of seaweed farming in Nusa Penida.

Nevertheless, the community has shown resilience and adaptability in response to these challenges. The shift in focus from seaweed farming to tourism-related activities during the pandemic, followed by a return to seaweed cultivation with improved prices, illustrates the community's ability to leverage opportunities. Furthermore, the utilization of seaweed for organic fertilizer production aligns with environmental conservation goals and offers a pathway to poverty reduction in coastal areas. While seaweed cultivation in Nusa Penida faces challenges, the community's resilience, coupled with innovative solutions and sustainable practices, positions seaweed as a valuable and versatile marine resource with the potential to contribute to both economic development and environmental conservation in the region.

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