



A study on the socio-economic characteristics of seaweed farmers on Kemojan Island to support the conservation in Karimunjawa Marine Protected Area

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Abstract. Kemojan Island is a part of Karimunjawa Marine Protected Area that is the center of *Eucheuma cottonii* seaweed production. It is necessary to understand the socio-economic characteristics of local communities in Kemojan Island to take the community welfare and the achievement of conservation goals into consideration. This study was conducted from August to September 2022 to describe the socio-economic characteristics of seaweed farmers on Kemojan Island in relation to marine conservation. Data were obtained from interviews done with 185 respondents which reached 60% of the population of seaweed farmers in the area. Data were analyzed using quantitative descriptive approach in the form of path analysis. The results showed that seaweed farmers' education background and age positively affected the success of the conservation. Farmers' knowledge of this matter needed to be improved, particularly regarding the importance of seagrass beds for the human and aquatic ecology.

Key Words: Kemojan Island, path analysis, socio-economic, seaweed farmer.

Introduction. Kemojan Island is part of the Karimunjawa Islands which has been designated as a Marine Protected Area since 1986 based on the Decree of the Minister of Forestry Number 123/Kpts II/1986. Biota diversity in tropical rain forests, mangrove forests, seagrass beds, and coral reefs is the main concern for designating Karimunjawa Islands as a conservation area. Karimunjawa waters have 42 species of flora in mangrove forests, 9 species of seagrass flora, 31 species of macroalgae, 430 species of fish, 178 species of hard coral, and 23 species of soft coral. Some of them are biota with protected status, including bottlenose dolphin (*Tursiops aduncus*), green turtle (*Chelonia mydas*), hawksbill turtle (*Eretmochelys imbricata*), tortoiseshell (*Lepidochelys olivacea*), black coral (*Antipathes* sp.), *Cassia cornuta* and *Hippopus hippopus* (BTNKJ 2019). UNESCO has also set Karimunjawa as a biosphere reserve (Purwanto & Nugroho 2021). Several researchers have investigated the biodiversity in the Karimunjawa Islands, including Hartati et al (2017), Hapsari et al (2020), and Sibero et al (2021).

Kemojan Island is the second largest island connected by a 10 m bridge with Karimunjawa Island (the largest island in the Karimunjawa Islands). Stakeholders in this area should consider the socio-economic characteristics of local communities on Kemojan Island to keep the environment sustainable. Insufficient community welfare and weak pro-conservation attitudes will make it difficult to achieve the conservation goals. Conservation and economic interests are often conflicting. However, the implementation of proper strategy will make the conservation goals and the improvement of local community welfare synergized (Johannesen 2007; Rakotonarivo et al 2017; Wijayanto et al 2022a). Seaweed (*Eucheuma cottonii*) cultivation has been a source of livelihood for Kemojan Island people (Wijayanto et al 2020). Seaweed cultivation does not harm the sustainability of aquaculture in several developing countries (Chowdhury et al 2022). Although there is a potential for conflict of interest with conservation, seaweed cultivation can be managed in such way to prevent it from interfering the conservation objectives (Krishnan et al 2021). This study provides an overview of the socio-economic

characteristics of seaweed farmers on Kemojan Island to support the socio-economic development of the local community on the island.

Material and Method

Research location and time setting. This research was conducted on Kemojan Island (see Figure 1) from August to September 2022. Karimunjawa Islands are administratively located in Jepara Regency (Central Java Province).

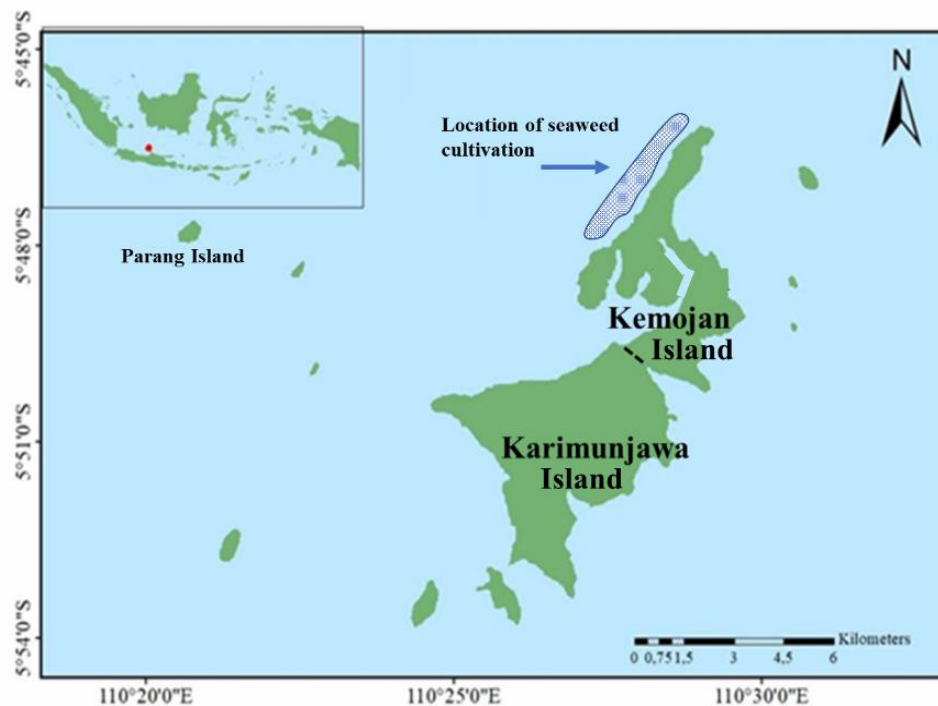


Figure 1. Kemojan Island (research location).

Data collection. Primary data were obtained from questionnaires and interviews to 185 farmers (60% of the population) who consented to the interviews.

Data analysis. The data were analyzed using descriptive-quantitative approach. The socio-economic conditions of the respondents consisted of farmers' living, sources of livelihood, income level, and their opinions on health and marine conservation. Some data were tested in a regression test in the form of path analysis to examine the relationship between those factors (Figure 2).

The education level variable (X_1) is described in 5 scales: 1 (did not graduate from elementary school), 2 (elementary school), 3 (junior high school), 4 (senior high school) and 5 (college). The age variable (Y) uses the unit of age. Opinions on the importance of coral reefs (X_2), mangroves (X_3), seagrass beds (X_4) are dummy variables (it scored 1 if regarded important and 0 if it is regarded unimportant). While farmers' income (X_5) is expressed in IDR per month. We used dummy variable for the support for conservation (Z). Perception modelling using quantitative analysis has been carried out by several researchers, including Liu & Luo (2018), Valizadeh et al (2018), Sapoetra et al (2019) and Zhong et al (2019).

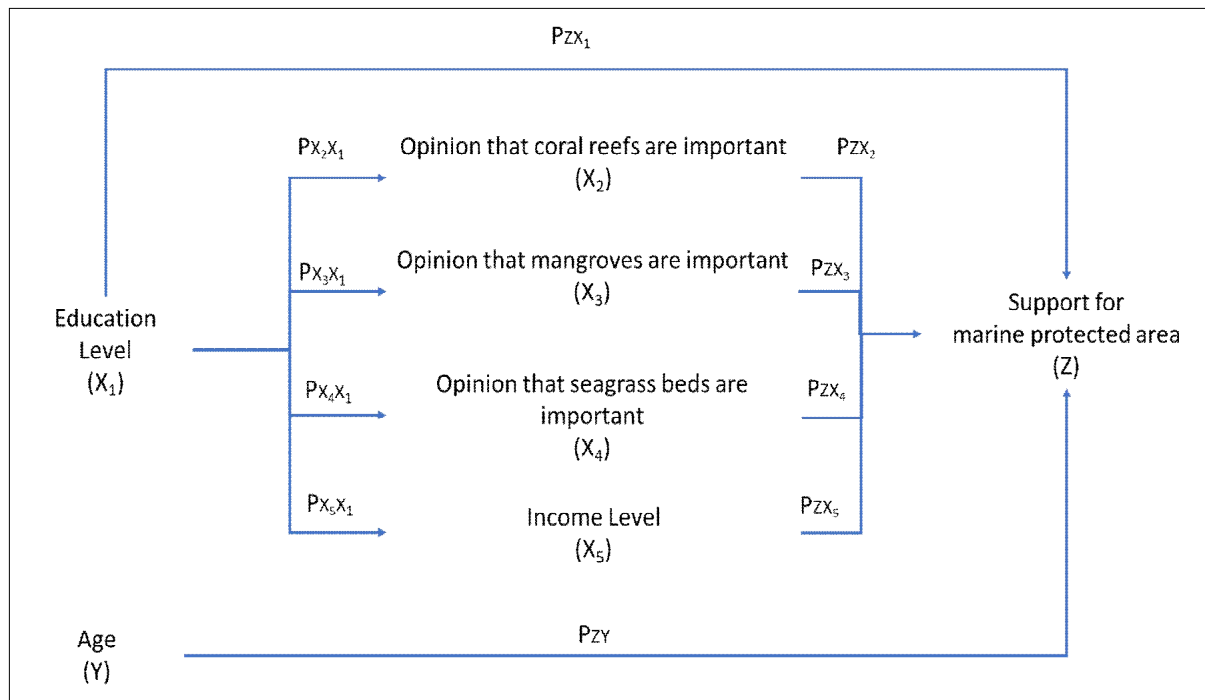


Figure 2. Path analysis model design.

Results and Discussion

Age, education and ethnicity. Seaweed farmers in Karimunjawa are diverse in terms of ethnicity. Many ethnic groups lived in the Karimunjawa Islands including Javanese, Bugis, Banjarese, Madurese, Bajo, Betawi, Buton and Sumbawa (Wibowo et al 2022). Some of these tribes are well-known as excellent wanderers and marine-related professionals, including fishermen. Even though they are not native to Karimunjawa Islands, most of respondents were born and raised in the Karimunjawa Islands. Their ancestors lived in the Karimunjawa Islands for generations.

Table 1
Respondents' gender, age, education and ethnicity

<i>Gender, age, education and ethnicity of respondents</i>	<i>Values</i>
<i>Gender</i>	
Male	98.4%
Female	1.6%
<i>Age</i>	
Under 20 years old	0.6%
21 to 30 years old	7.5%
31 to 40 years old	23.1%
41 to 51 years old	23.1%
51 to 60 years old	31.2%
Over 60 years old	14.5%
Min	19 years old
Average	48 years old
Max	79 years old
<i>Education</i>	
Did not graduate from elementary school	17.7%
Elementary school	63.4%
Junior high school	11.3%
Senior high school	3.8%
College	3.8%

<i>Long lived in Kemojan</i>	
Under 5 years	2.7%
5 to 10 years	3.2%
11 to 20 years	6.0%
21 to 30 years	10.8%
31 to 40 years	24.3%
41 to 50 years	24.9%
51 to 60 years	22.2%
Over 60 years	5.9%
<i>Ethnicity</i>	
Javanese	68.8%
Bugis	25.3%
Madurese	5.9%

Most of the respondents have low education background which affects their way of thinking. Low level of education and limited skills make it not easy to switch to other professions (Wijayanto et al 2019, 2022b). The average age of the respondents is 48 years, indicating problems in the regeneration of fishermen and seaweed farmers. The coastal professions are not favored jobs among the community (Kurohman et al 2020). Young and highly educated generations prefer working in formal sector for better prestige than working as fishermen and seaweed farmers with risky jobs.

The welfare of seaweed farmer. In terms of their residences, farmers lived in relatively adequate areas of 7.2 m² per capita or more. Only 6.5% of respondents live in a building area of smaller than 7.2 m² per capita (Table 2). Permenpera RI Number 22/Permen/M/2008 stipulates that livable houses have a minimum area of 7.2 m² per capita (KPUPR 2016).

Table 2

Respondents' residential characteristics

<i>Residential characteristics of respondents</i>	<i>Values</i>
<i>Residential building area</i>	
Under 7.2 m ² per capita	6.5%
7.2 to 14.3 m ² per capita	39.8%
14.4-21.5 m ² per capita	29.0%
More than 21.5 m ² per capita	24.7%
<i>Types of house wall materials</i>	
Wall	75.3%
Wood	20.4%
Half wall	1.1%
Bamboo	1.1%
Galvalume	2.1%
<i>Types of roofs</i>	
Rooftile	75.3%
Zintile	7.0%
Asbestos	17.2%
'Welit' (woven leaves)	0.5%
<i>Types of house floor</i>	
Ceramics	52.7%
Wood	10.2%
Cement plaster	31.7%
Tile	3.2%
Soil	2.2%
<i>Electricity as a home energy source</i>	100%

Most respondents' houses are made of concrete walls with roof tile, ceramic floors, cement plaster and tiles. Some houses are made of wood on stilts which are the traditional house of Bugis ethnicity. There is only a small number of respondents whose houses are made of cheap materials, such as using roofs of asbestos and 'welit' (from dry leaves), and soil floor. Uninhabitable houses are still found in various areas. Several studies explain that poor management of fishermen's housing in some countries causes overcrowded fishing villages, bad drainage, dirty and slums residential area (Ballesteros 2010; Marx et al 2013; Darmiwati 2016; Michiani & Asano 2019; Wijayanto et al 2022b).

Only about 15.6% of respondents do seaweed cultivation as their main profession. A total of 55.9% have main job as a fisherman. Hence, seaweed farming is their side job. Wijayanto et al (2020) mentioned that seaweed cultivation can be a good main job if its cultivation scales up to the business level using 19 rope units with an average rope length of 129 m. If the scale is smaller, seaweed farmers need to make living from other occupation. The survey results show that the respondents also own livestock (chickens, goats and cows), and grow vegetables and fruits (Table 3). Several types of fruit such as mango (*Mangifera* sp.), guava (*Psidium* sp.), water apple (*Syzygium* sp.), papaya (*Carica papaya*), banana (*Musa* sp.), orange (*Citrus* sp.), coconut (*Cocos* sp.), jackfruit (*Artocarpus* sp.), pineapple (*Ananas* sp.), breadfruit (*Artocarpus* sp.), rambutan (*Nephelium* sp.), watermelon (*Citrullus* sp.), kedondong (*Spondias* sp.), melon (*Cucumis* sp.), apple (*Malus* sp.), srikaya (*Annona* sp.), and sapodilla (*Manilkara* sp.) are grown by respondents. Some vegetables such as eggplant (*Solanum* sp.), spinach (*Spinacia* sp.), kangkong (*Ipomoea* sp.), asparagus bean (*Vigna* sp.), cabbage (*Brassica oleracea*), mustard greens (*Brassica juncea*) and chinese okra (*Luffa* sp.) were also cultivated. There are no rice fields on the island, while rainfed rice fields are found on Karimunjawa Island.

Table 3

Respondents' livelihoods, budgets and income

<i>Respondents' livelihoods, budgets and income</i>	<i>Values</i>
<i>Breeder</i>	
Chicken (<i>Gallus gallus domesticus</i>)	82%
Goat (<i>Capra aegagrus hircus</i>)	9%
Cow (<i>Bos</i> sp.)	7%
Not breeder	2%
<i>Farmer</i>	
Vegetable	6%
Fruit	94%
<i>Family budget (IDR per month)</i>	
Min	935,000
Average	3,640,450
Max	8,240,000
<i>Family budget for food (%)</i>	
Min	20.0%
Average	87.2%
Max	56.5%
<i>Family income</i>	
Min	1,000,000
Average	4,196,289
Max	12,000,000
<i>Tourism development support</i>	
Support	98.9%
Not support	1.1%

The survey results show that seaweed farmers on Kemojan Island work multiple jobs. Their average income is IDR. 3,640,450 (Table 3). This income is greater than the minimum wage of Jepara Regency of IDR 2,108,403 (Central Java Governor Decree No.

561/39 of 2021). However, there are still around 12% of respondents whose income is below the minimum wage of Jepara Regency. Income that is higher than the minimum wage indicates that the community can fulfil the minimum living needs. Respondents' income positively correlates with the purchasing power and family budget. On average, respondents allocated 87.2% of the household budget for food consumption. According to Halim et al (2015), poor community prioritizes their budget allocation for basic needs (clothing, food and shelter). For those who earn higher allocate their budget for non-essential needs. Regarding the type of staple food, 100% of respondents consume rice. Respondents have positive attitude towards the tourism development for it provides economic advantage through employment opportunity. However, there are a small number of respondents who do not support tourism development as they believe tourism brings tourists who often dress inappropriately against the local cultural values.

The access to public health facilities in Kemojan Island is described in Table 4. 72% of respondents prefer visiting public health center because there is no hospital in the area. If they need to go to the hospital, they have to travel to Jepara Regency (Java Island) via sea trip of about 2 hours by fast boat or 5 hours by ferry. As many as 99.5% of respondents boil well water for drinking. All of the respondents already have bathroom and toilet in their homes. Waste management in the Karimunjawa Islands (including Kemojan Island) still needs to be improved. All respondents still burn their household garbage which can cause air pollution which can lead to respiratory problems. Approximately 11.3% of respondents suffer from respiratory problems and 10.2% of respondents experienced hearing loss and 29.6% have visual impairment because of old age (Table 4).

Table 4

Environmental health characteristics

<i>Environmental health characteristics</i>	<i>Values</i>
<i>A place for treatment if respondents are sick</i>	
Public Health Center	72.0%
Hospital	10.3%
Nurse	11.5%
Doctor	1.7%
Midwife	1.1%
Witch doctor	3.4%
<i>Source of drinking water</i>	
Well	99.5%
Clean water company	0.5%
<i>Garbage handling</i>	
Burned	100%
Family toilet ownership	100%
Family bathroom ownership	100%
<i>Health problem</i>	
Respiration	11.3%
Ear	10.2%
Eye	29.6%

Tradition, potential conflicts and conflict resolution. Respondents mostly speak Indonesian language and local languages. Wibowo et al (2022) mentioned several tribes living in the Karimunjawa Islands: Javanese, Bugis, Banjarese, Madurese, Bajo, Betawi, Buton and Sumbawa. The Javanese are the largest ethnic group inhabiting the Karimunjawa Islands as the location of the islands is adjacent to Java. In terms of ethnic diversity, Karimunjawa Island is more diverse than Kemojan Island. Since Javanese are dominant in population, the Javanese language is also used as a lingua franca between the tribes living in the Karimunjawa Islands. The survey showed that the potential for conflict on Kemojan Island is relatively very low. The community there prefers solving various conflicts deliberately (*musyawarah*). The '*gotong royong*' principle (collaboration)

is also still maintained by the residents of Kemojan Island (Table 5). '*Musyawarah*' and '*gotong royong*' are Indonesian traditions that are still preserved, especially in rural areas, including on Kemojan Island as local wisdom. Herawati et al (2021) explained that '*musyawarah*' is a realization of democracy where people communicate to reach an agreed win-win solution.

Parents and children living on Kemojan Island share close relationship. Many married couple still live with their parents and a house is often occupied by more than 1 family (Table 5). Living with parents after marriage is quite common in Indonesia, especially in rural areas (Pardede & Mulder 2021).

Table 5

Tradition, potential conflict and conflict resolution

<i>Characteristics of respondents</i>	<i>Values</i>
<i>Perception of conflict intensity</i>	
Never	2.7%
Very low	69.2%
Low	10.3%
Moderate	10.8%
High	7.0%
<i>Conflict resolution</i>	
' <i>Musyawarah</i> ' (deliberation)	90.7%
Physical clash	3.8%
Debate	3.3%
Back down	2.2%
<i>Most respected local figure</i>	
Religious leaders	95.9%
Village head	3.6%
Village elder	0.5%
<i>'Gotong royong' tradition</i>	
Incidental	71.3%
Routine	22.2%
Never	6.5%
<i>Number of households (HH) in 1 house</i>	
1 HH	74.6%
2 HH	21.6%
More than 2 HH	3.8%
<i>Number of people living in 1 house</i>	
1 to 2 people	14.0%
3 to 4 people	55.4%
5 to 6 people	27.9%
7 to 8 people	2.7%

Seaweed farmer as a profession. Most of the seaweed farmers on Kemojan Island mainly work as fishermen (55.9%). There are also those whose main professions are teachers, private employees, tour guides, repairmen, carpenters, and traders. Only some respondents work as seaweed farmers as their main job and they can allocate up to 10 hours of work per day (Table 6).

For respondents who make the profession of seaweed farmers as a side job, they perceive that seaweed cultivation cannot meet the economic needs of the family. They are required to scale up the business to meet the needs of family. As explained by Wijayanto et al (2020), seaweed farmers can generate adequate income if the cultivation business is scaled up using 19 rope units with an average rope length of 129 m. Meanwhile, the survey results show an average number of ropes of 13 units with an average length of 111 m ropes.

Table 6

The characteristics of seaweed farmers

<i>Characteristics of seaweed farmers</i>	<i>Values</i>
<i>Seaweed farmer profession</i>	
Main job	15.6%
Side job	84.4%
Fishermen as main job	55.9%
<i>Can seaweed cultivation be sufficient to meet the needs of life?</i>	
Yes	41.5%
No	59.5%
<i>The number of seaweed cultivation ropes (units)</i>	
Min	1
Average	13
Max	75
<i>Seaweed cultivation rope length (m)</i>	
Min	30
Average	111
Max	400
<i>Long working seaweed per day (hours per day)</i>	
Min	0.5
Average	4.2
Max	10.0

The pricing of seaweed is determined by the buyer (100% respondents) and 92% of the respondents have weak bargaining power. However, most of the respondents (68%) are satisfied with the price of seaweed. The main obstacle in seaweed cultivation is disease (98.9%). Other obstacles are also identified, including epiphytic plant disturbances, turtle and herbivore fish (as predator), weather, and limited capital. Respondents find the peak of the seaweed cultivation business occurred in 2018-2019 where the price was high, well-controlled disease, faster seaweed growth, and good production. At that time, the number of seaweed farmers was still small. As the business is considered profitable, more people are interested in seaweed cultivation, causing the growth of the seaweed disrupted by disease attacks. The worst performance occurred in 2015 due to low prices and environmental pollution problems around the airport location. Wijayanto et al (2022a) warned that massive seaweed cultivation on Kemojan Island could pollute the aquatic environment and trigger more diseases. Moreover, rotten seaweed accumulates at the bottom of the waters. Therefore, the carrying capacity of the waters for seaweed cultivation should be considered in the management of seaweed cultivation. According to Chowdhury et al (2022), the performance of seaweed cultivation is influenced by the accuracy of site selection, productivity, market value and demand. Hasyim et al (2012) reported that the ideal location for seaweed cultivation is clear waters that flow well but are protected from strong waves and predators.

Paradigm regarding conservation. Based on the survey results, most of respondents support conservation (96.2%) (Table 7). They believe that the preservation of natural resources is beneficial for their generations. Meanwhile, those who object to conservation mostly have conflicts with conservation interests. Some of them also do not find the approach taken by conservation officers to local communities less optimal.

The survey showed that respondents were aware of the need for coral reefs and mangroves. Coral reefs are the fish habitat, fishing ground, fish shelter, tourist attraction and barrier to waves. Therefore, they did not take out coral reefs, except for dead corals to be used as ballast of 'bubu' (trap). As stated by Brandl et al (2019), coral reefs are the habitat for various biota with the highest biodiversity that can hold back the wave. Coral reefs are also the raw materials for the drug industry, as well as marine tourism destinations. Respondents are also aware that mangroves protect the land from abrasion. According to Carugati et al (2018), mangroves provide food, spawning grounds, and breeding grounds for several land and marine biota, including commercial fish and reef

fish. Mangroves plants can provide wood, medicinal materials and food for humans. Mangroves also protect the environment from coastal abrasion and wind storm. Meanwhile, Hapsari et al (2020) argued that mangrove deforestation for shrimp ponds on Kemojan Island inhibits the mangrove conservation.

Table 7

Respondents' opinion on conservation

<i>Respondents opinion</i>	<i>Values</i>
<i>Do you need coral reefs?</i>	
No	13.0%
Yes	87.0%
<i>Have you ever picked coral?</i>	
Yes	8.1%
No	91.9%
<i>Do you need mangroves?</i>	
No	9.8%
Yes	90.2%
<i>Have you ever taken mangrove wood?</i>	
Yes	11.4%
No	88.6%
<i>Do you need seagrass?</i>	
No	71.2%
Yes	28.8%
<i>Are you interested in using basket in seaweed cultivation?</i>	
No	82.4%
Yes	17.6%
<i>Do you support conservation?</i>	
No	3.8%
Yes	96.2%

In this study, many respondents are not aware about the importance of seagrass beds. Hartati et al (2017) found six types of seagrass in Karimunjawa Islands. The lack of awareness about the importance of seagrass beds should be improved. Seagrass beds are beneficial for humans and the aquatic ecology. Nordlund et al (2016) highlighted the functions of seagrass beds fertilizer raw materials, habitat for various aquatic biota, food sources for humans, sources of medicinal raw materials, coastal protection, water pollution control and can be used for education, research and tourism destinations.

Respondents are not interested in using basket in seaweed cultivation due to limited capital. In addition, they also see the use of basket would increase the workload and inhibit the water circulation for seaweed which could reduce the growth of seaweed. While some respondents who are interested in using basket expect to get rid of turtles and herbivorous fish. The use of basket is also considered as a solution when strong wave hits to keep them in the basket. Whereas, when using line, seaweeds will be damaged and drift into the water when strong waves hit. Nugroho et al (2021) stated that the longline method offers higher productivity than the basket method, but the basket method has lower risk of getting attacked by predatory animals and wave.

The results of the path analysis are shown in Table 8. Education and age are positively correlated to conservation support. Higher education is followed by more advanced perspective. Well-educated seaweed farmers tend to support conservation. Likewise, senior farmers have broader experience and insight that they also support conservation. The results of the path analysis indicate the need to improve farmers' awareness regarding the importance of seagrass beds. Moreover, seaweed cultivation is prone to conflicts of interest with seagrass conservation. According to Hartati et al (2017), *Holothuria atra* is one of the aquatic animals that like seagrass beds. Meanwhile, seaweed cultivation on the surface of the water will reduce the light intensity on seagrass beds at the bottom of the waters. Johannesen (2007) stated that conservation and the

economic development are often conflicting. Unless it is properly managed, the conservation could fail and the economic benefits could not be achieved.

Table 8

Path analysis

<i>Coefficient types</i>	<i>Notation</i>	<i>Coefficient values</i>
The direct effect of education on conservation support	P_{ZX1}	0.013
The direct effect of education on opinion requires coral reefs	P_{X2X1}	0.050
The direct effect of opinion requires coral reefs on conservation support	P_{ZX2}	0.066
Indirect effect of education (through opinion needs coral reefs) on conservation support	$P_{ZX2} \cdot P_{X2X1}$	0.003
The direct effect of education on opinion requires mangroves	P_{X3X1}	0.053
The direct effect of opinion requires mangroves on conservation support	P_{ZX3}	0.148
Indirect effect of education (through opinion on the need for mangroves) on conservation support	$P_{ZX3} \cdot P_{X3X1}$	0.008
The direct effect of education on opinion requires a seagrass	P_{X4X1}	-0.017
The direct effect of opinion requires seagrass on conservation support	P_{ZX4}	-0.009
Indirect effect of education (via opinion needs seagrass) on conservation support	$P_{ZX4} \cdot P_{X4X1}$	-0.001
Direct effect of education on income	P_{X5X1}	123,436
Direct effect of income on conservation support	P_{ZX5}	0.0000000003
Indirect effect of education (through income) on conservation support	$P_{ZX5} \cdot P_{X5X1}$	0.00004
Total indirect effect of education on conservation support	$P_{ZX2} \cdot P_{X2X1} + P_{ZX3} \cdot P_{X3X1} + P_{ZX4} \cdot P_{X4X1} + P_{ZX5} \cdot P_{X5X1}$	0.010
Total direct and indirect effect of education on conservation support	$P_{ZX1} + P_{ZX2} \cdot P_{X2X1} + P_{ZX3} \cdot P_{X3X1} + P_{ZX4} \cdot P_{X4X1} + P_{ZX5} \cdot P_{X5X1}$	0.023
Direct effect of age on conservation support	P_{ZY}	0.00021

Coastal areas (including Kemojan Island) are prone to the impacts of climate change. Many poor communities live in coastal areas with land height of less than 10 meters (Barbier 2015). Therefore, the management of coastal areas becomes very important. Conservation officers in the Karimunjawa Islands have empowered the community to support conservation programs. There are 4 community groups that support conservation in 4 villages: Karimunjawa, Kemojan, Parang, and Nyamuk. Violations of conservation have been done by fishermen from outside the Karimunjawa Islands in which they used purse seine and Danish seine (trawl modification) to catch fish in Karimunjawa Islands. Potassium cyanide was known to be used to catch fish and trade in protected animals (BTNKJ 2019). According to Rakotonarivo et al (2017), local communities should be educated regarding the aims and functions of conservation programs in order to support the success of marine conservation in Karimunjawa Islands, including on Kemojan Island.

Conclusions. The results of this study indicate that education background and age of seaweed farmers have a positive impact on conservation support. Seaweed farmers' knowledge about the importance of seagrass beds for human and aquatic ecology needs to be improved. The survey shows that seaweed farmers on Kemojan Island farm seaweed as their side business. Most of them have low education background and their average age is 48 years. The welfare among the community is relatively good in terms of housing, income, and health aspects. However, the waste management system that they apply needs to be improved. Kemojan Island residents are religious residents who respect religious leaders. They still apply the principles of '*gotong royong*' (collaboration) and '*musyawarah*' (deliberation) on Kemojan Island.

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Conflict of interest. The authors declare that there is no conflict of interest.

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