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Analysis of mangrove forest ecosystem sustainable management by coastal communities in Sampang District, Madura Island, Indonesia

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Abstract. *Koesdaryanto NSR, Wijayanti M, Simanjuntak MPD, Fathoni MFM, Sulton MN, Lillo EP, Kusumaningrum L, Indrawan M, Setyawan AD. 2024. Analysis of mangrove forest ecosystem sustainable management by coastal communities in Sampang District, Madura Island, Indonesia. Indo Pac J Ocean Life 8: 33-42.* The mangrove forest ecosystem is important in a coastal area to improve the welfare of coastal villages and increase the productivity of coastal ecosystems. This ecosystem has indicators of sustainability efforts, including ecological, economic, and social dimensions. This study aims to determine the sustainability status of mangrove forest ecosystems and compile recommendations in Taddan Village, Camplong Sub-district and Aeng Sareh Village, Sampang Sub-district, Sampang District, East Java, Indonesia. This research and data collection was carried out in December 2023. The methods used in data collection are interview techniques and questionnaire distribution. The primary data is processed with the Multidimensional Scaling (MDS) method through Rapid Appraisal for Fisheries (Rapfish), which displays Monte Carlo analysis, and the data results are aligned with previous literature studies. The results of the Rapfish analysis showed that the sustainability index of mangrove ecosystem management in the two villages included ecological dimensions (sustainability index of Taddan and Aeng Sareh Villages, respectively 62.88 and 21.05), economic dimensions (sustainability index of Taddan and Aeng Sareh Villages, respectively 35.78 and 40.14), and social dimensions (sustainability index of Taddan and Aeng Sareh Villages, respectively 42.94 and 39.51). Alternative strategy recommendations that can be applied for sustainable mangrove ecosystem management in Taddan and Aeng Sareh Villages, Sampang, are improving coordination between stakeholders, making patented regulations, training on creativity and productivity of village communities, formulating mangrove ecosystem management programs, routinely carrying out rehabilitation efforts, and increasing awareness from researchers.

Keywords: Coastal, mangrove ecosystems, Rapfish, strategy, sustainability

INTRODUCTION

Mangrove ecosystems in coastal areas are important for supporting the region's human life and living things (Sierra-Correa and Kintz 2015). The mutual interaction and interdependence between components in mangrove forests are called mangrove ecosystems (Irsadi et al. 2019). Abundant resources of good quality are important in biological processes and support the life of living things, especially in terms of biodiversity or biodiversity (Arifanti et al. 2022). Mangroves are one of the coastal ecosystems that require integrated handling. According to Carter et al. (2015), the priority of the approach is to meet basic human needs, provide sources of income, and develop a healthy living environment. Mangroves will not grow optimally in coastal areas without estuaries, while mangrove growth will be more optimal if they have large river estuaries and mud substrates (Kusmana 2014). This is evident from the distribution of mangroves in Indonesia, which are generally found on the East Coast of Sumatra, Kalimantan, the North Coast of Java, and Irian Jaya (Fikri et al. 2022).

Mangrove ecosystems provide various local and global benefits (Dabalà et al. 2023). These ecosystems are able to store carbon, support biodiversity, and support fisheries (Carrasquilla-Henao and Juannes 2017). Mangroves are an important habitat for marine animals because they are a place to find food (Carrasquilla-Henao et al. 2019). The main contribution of ecosystems to fisheries production tends to come from the primary productivity of phytoplankton, which generally lives in water and is associated with mangroves (Ickowitz et al. 2023). As a nature-based resource, Mangroves effectively reduce coastal flood risk (Menéndez et al. 2020), protect coastal areas during storms, stabilize coastal areas, and prevent erosion (Das 2020). Mangroves also have the potential to improve water quality before it reaches the ocean by absorbing nutrients and pollutants from stormwater runoff (MacDonnell et al. 2017).

Sampang District is located on the coast of Madura Island, Indonesia and has a fairly extensive mangrove ecosystem. Based on mangrove data in Madura by Muhsoni and Pi (2014), in a book entitled 'Persembahan

Prodi Ilmu Kelautan Universitas Trunojoyo Madura untuk Maritim Madura,' the land area of mangrove ecosystems in Sampang District is 915.3 hectares (6.1%) of the 15,118.2 hectares of total mangrove ecosystems area on Madura Island. However, based on these data, mangrove areas have also damaged land area of around 6,324.1 hectares (41.8%) due to mangrove ecosystem management problems. Effective mangrove management can be seen from the nature of open access, the absence of transfer of ownership and use rights to local communities, and the difficulty recognizing and comparing the values of long-term non-consumptive services (Suman 2019). Knowledge of the condition of distribution and density of mangrove forests is needed to plan mangrove forest management in the future, especially on Madura Island (Muhsoni and Pi 2014). Mangrove ecosystems in Madura face two major threats: land conversion into ponds (salt and fish) and the issuance of individual property rights that make it easier for individuals to change land functions and transfer property rights in coastal and mangrove areas (Mahmud 2023).

The coastal area in Madura consists of the north and south regions, both of which have considerable tourism potential; besides that, some beaches have become domestic mangrove tourist destinations (Ikhwan et al. 2021). Like other ecosystems in other areas, the mangrove ecosystem in Sampang District has faced ecosystem problems from various aspects such as ecology, socio-culture, and economy. Mangrove ecosystems are important because they can store large amounts of organic carbon; some mangrove ecosystems also have sediments rich in minerals that are good for the soil (Perera et al. 2018). The problems of mangrove ecosystems are closely related to changes in land used to make other land (Dwijaya et al. 2021). Land change in Sampang District for the creation of salt ponds impacts three important aspects of the mangrove ecosystem. In the ecological aspect, land clearing to create salt ponds can cause the loss of natural habitats and mangrove ecosystems (Cahyaningsih et al. 2022). In the socio-cultural aspect, land clearing impacts the lack of knowledge about local wisdom related to mangroves in the area (Reyes-Arroyo et al. 2021). In the economic aspect, this land clearing can reduce the loss of resources obtained from mangrove ecosystems (Fistiningrum and Harini 2021). This also impacts local communities' decreasing knowledge of managing crops from mangroves to be used as economic resources. Hence, this study aims to determine the sustainability status of mangrove forest ecosystems and compile recommendations in Taddan and Aeng Sareh Villages, Sampang, Madura, East Java, Indonesia.

MATERIALS AND METHODS

Study area

This study is located in residential areas adjacent to mangrove forests on the coast of Madura in December 2023 by conducting interviews with residents around the mangrove forests of Taddan Village, Camplong Sub-district and Song-Osong Beach in Aeng Sareh Village, Sampang Sub-district, District, Madura, East Java, Indonesia (Figures 1 and 2).

Data collection

The data types collected in this study are primary and secondary; primary data are obtained through respondent survey techniques by conducting semi-structured interviews with the public and key informants, while secondary data are obtained through literature studies. The community sample was determined based on the purposive sampling method of 32 respondents in Aeng Sareh Village and 32 in Taddan Village. Respondents were selected purposively with the criteria of respondents interacting more or less with mangroves because they know local environmental conditions and interactions with mangrove forests (Nyangoko et al. 2020). This study's total number of respondents amounted to 64 people (Table 1). In the Rapfish method, sustainability is shown qualitatively with established criteria, then represented in numerical analysis by a group of scored attributes grouped into several areas: ecological, economic, ethical, institutional, technological, and social (Jimenez et al. 2021). This study uses three dimensions of mangrove ecosystem sustainability: ecology with 8 attributes, economy with 7 attributes, and social with 8 attributes (Table 2).

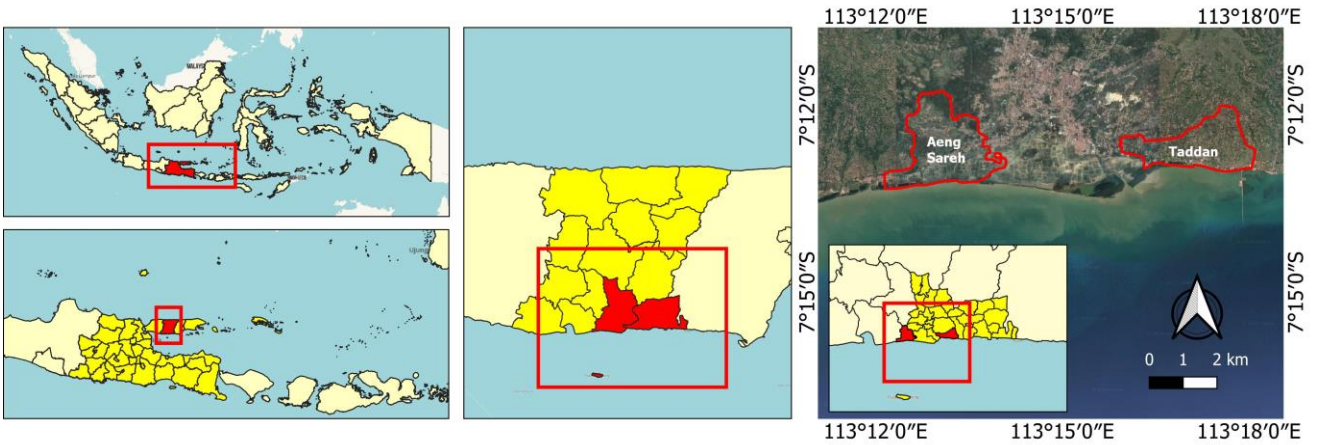

Figure 1. Map of the study area in Taddan Village, Camplong Sub-district and Aeng Sareh Village, Sampang Sub-district, Sampang District, East Java, Indonesia

Figure 2. Mangrove ecosystem in Sampang District, East Java, Indonesia. A. Taddan Village, Camplong Sub-district and B. Song-Osong Beach (Aeng Sareh Village, Sampang Sub-district)

Data analysis

The sustainability of mangrove ecosystem management was analyzed using Rapid Appraisal for Fisheries (Rapfish) software. This method is carried out by determining the attributes of each dimension (Adiga et al. 2016) that can represent the sustainability of mangrove ecosystem management. Multidimensional Scaling (MDS) methods is an exploratory and multivariate data analysis technique becoming increasingly popular. MDS is one of the multivariate data analysis techniques that tries to represent the higher dimensional data in lower space (Saeed et al. 2018). The dimensions and attributes that affect the sustainability of mangrove ecosystem management are determined based on regulatory reviews, assessments of experts such as practitioners and academics, and literature studies (Melo et al. 2020). Using the reference Yuliasamaya et al. (2021), this research uses three dimensions of sustainability: ecological, economic, and socio-cultural. Each dimension contains attributes that will be assigned values according to predefined criteria. We then categorize sustainability results into sustainability status (Table 3). An index value <25 indicates not sustainable, an index value between 25-50 indicates less sustainable, an index between 50-75 indicates quite sustainable, and an index between 75-100 indicates sustainable (Table 3). The next stage is a sensitivity analysis (attribute leverage) to see which attributes are the most sensitive in contributing to the sustainability index at the research site. Each dimension requires anomaly analysis that shows the sensitivity of each attribute on each dimension. This study examined the leverage factor from the Rapfish analysis, specifically from the highest Root Mean Square (RMS) value for each sustainability dimension (Chaliluddin et al. 2023). According to Kavanagh and Pitcher (2004), the leverage factor value for each attribute with an RMS of 2-6% has identical importance level. Consequently, we argue that an attribute in each dimension is sensitive if the RMS value exceeds than 6%. Then, the confidence level of sustainability index values of each multidimensional dimension was analyzed using Monte Carlo analysis. This analysis aims to see the effect of assessment errors on each attribute of each dimension, the influence of assessment variations, the stability of the MDS analysis process, data entry errors or missing data, and too high emphasizing values (Muksin et al. 2021). R square (RSQ) is the square of the correlation coefficient, which shows the proportion of variance from the optimization of data scaling contributed by the multidimensional scaling procedure that measures fit/accuracy (goodness of fit measure). The Stress value is the degree of ability to explain the results of the Multidimensional Scaling analysis. The difference between Monte Carlo and MDS reflects the status of sustainability. The difference value < 1 indicates that the value of the status of the sustainability index in the confidence interval according to the RSQ value shows that there is not much difference or means good value (Fadilah et al. 2021).

Table 1. Respondents profile table of Taddan Village, Camplong Sub-district and Aeng Sareh Village, Sampang Sub-district, Sampang District, East Java, Indonesia

Characteristic respondents	Taddan Village	Aeng Sareh Village
Gender		
Male	15	17
Female	17	15
Age		
15-30	5	3
31-45	17	15
46-60	7	8
>60	3	6
Level of education		
No formal education-Primary school	8	12
Junior high school	17	13
Senior high school-college	7	7
Occupation		
Farmer	4	11
Freelancer	5	5
Entrepreneur	6	4
Housewife	11	7
Truck driver	-	2
Laborer	2	3
Breeder	1	-
Unemployed	3	-

Table 2. Attributes of every sustainability dimension

Dimension	Attribute	Indicator	Sources
Ecology	Mangrove density	(0) sparse (< 1,000 trees /ha), (1) moderate (≥ 1,000 – 1,500 trees /ha), (2) very dense (≥ 1,500 trees /ha)	Pratiwi and Muhsoni 2021; Ainindya et al. 2024; *Field survey*
	Mangrove cover	(0) sparse (coverage <50%), (1) moderate (coverage ≥50 – 75%), (2) very dense (coverage ≥75%)	Aftsari et al. 2024; *Field survey*
	Mangrove pressure	(0) there is a change in the function of mangrove land without considering environmental functions, (1) there is a natural change in the area of mangrove land, (2) there is no decrease in the area of mangrove land	Aftsari et al. 2024; *Field survey*
	Mangrove diversity	(0) low (H' ≤ 1), (1) medium (1<H'<3), (3) high (H'>3)	Pratiwi and Muhsoni 2021; Tsani and Muhsoni 2022; *Field survey*
	Mangrove rehabilitation	(0) does not exist, (1) exists but is not managed well, (2) exists and is managed well	Aftsari et al. 2024; *Field survey*
	Fauna diversity of mangrove	(0) low (<2 types of fauna), (1) medium (2-10 types of fauna), (2) high (>10 types of fauna)	*Field survey*
	Salinity level	(0) low (EC 2-4 dS/m), (1) medium (EC 4-8 dS/m), (2) high (EC >8 dS/m)	Muhsoni 2020; *Field survey*
	Coastline changes	(0) decreases (abrasion), (1) remains constant, (2) increases (accretion)	Muhsoni 2020
Economic	Community income	(0) < average minimum wage, (1) = average minimum wage, (2) > average minimum wage	*Field survey*
	Mangrove zone	(0), not available, (1) available, but not yet complied with, (2) available and complied with	*Field survey*
	Mangrove utilization	(0) never, (1) sometimes, (2) always	*Field survey*
	Economic value	(0) low (<25% of total daily income), (1) medium (≥25 – 50% of total daily income), (2) high (>50% of total daily income)	*Field survey*
	Other income	(0) part time, (1) seasonal, (2) full time	*Field survey*
	Stakeholder involvement	(0) does not involve stakeholders, (1) involves several stakeholders, (2) involves various stakeholders	*Field survey*
	Utilization inventory	(0) not available, (1) available	*Field survey*
Social	Managing role	(0) low, (1) medium, (2) high	*Field survey*
	Citizen's awareness	(0) low (<50% of activities carried out), (1) medium (50-75% of activities carried out), (2) high (75-100% of activities carried out)	*Field survey*
	Local wisdom	(0) does not exist, (1) exists but is not efficient, (2) exists and is efficient	*Field survey*
	Citizen's knowledge	(0) low, (1) medium, (2) high	*Field survey*
	Level of education	(0) no school and elementary school, (1) middle school, (2) high school and university	*Field survey*
	Access to mangrove ecosystem	(0) have no access at all, (1) have poor access, (2) have good access	*Field survey*
	Destruction of mangrove	(0) low (cover reduced <25%), (1) medium (cover reduced 25-50%), (2) high (cover reduced >50%)	*Field survey*
	Utilization conflict	(0) a lot (>5 times/year), (1) some (2-5 times/year), (2) a little (<2 times/year)	*Field survey*

Table 3. Mangrove ecosystem sustainable category (Bakri et al. 2023)

Index value	Sustainability status
<25	Not sustainable
25-50	Less sustainable
50-75	Quite sustainable
75-100	Sustainable

RESULTS AND DISCUSSION

Sustainability status

Sustainability status is carried out by combining all dimensions, including ecological, economic, and social. Thus, 23 attributes were used to determine the sustainability status of mangrove ecosystem management in this study. The sustainability index values in these three dimensions can be visualized in triangular diagrams (Figures 3 and 4).

The triangle radar diagram depicts the sustainability status in an integrated manner between dimensions. In research conducted in Taddan Village, the value of the sustainability index on the economic dimension is 35.78; in the ecological dimension, it is 62.88; and in the social dimension 42.94 (Figure 3). This shows that the ecological dimension has a fairly sustainable status, and the social and economic dimensions in Taddan Village are less sustainable. In research conducted in Aeng Sareh Village, the value of the sustainability index in the economic dimension was 40.14, the ecological dimension was 21.05, and the social dimension was 39.51 (Figure 4). The results showed that the ecological dimension in Aeng Sareh Village is not sustainable, and the social and economic dimensions are less sustainable.

Moreover, the Monte Carlo value on all three dimensions in both villages is a good model because it has a value of <5 (Table 4). In research conducted in Taddan Village and Aeng Sareh Village, each dimension has a stress value of less than 0.25, meaning that the stress value analyzed using the MDS method is sufficient. This shows the accuracy of point configurations or goodness of fit models built for sustainability can represent good models. The smaller the stress value obtained, the better the quality of the analysis results (Dahliani and Maharani 2018). The Squared Correlation (RSQ) value of each dimension in this study is close to 1. Generally, if the Squared Correlation (RSQ) value is getting closer to 1, it shows the quality of the analysis results is improving. The difference value < 1 indicates that the value of the status of the sustainability index in the confidence interval according to the RSQ value shows that there is not much difference or means good value (Fadilah et al. 2021). Furthermore, an ordinal score to each attribute of 0 (lowest) and 3 (highest) for each attribute, and by Rapfish support, there are similarities or differences between each of the grouped attributes. Therefore, each attribute's sustainability level can be determined using the sustainability index. The attribute level that needs attention is also known based on the root mean square ordination percentage order (RMS). And evaluate the influence of errors using the Monte Carlo method.

Ecological dimension

Attributes that can determine the sustainability of mangrove ecosystems when viewed from the ecological dimension are based on eight attributes, namely (i) mangrove density, (ii) mangrove cover, (iii) mangrove pressure, (iv) mangrove diversity, (v) mangrove rehabilitation, (vi) fauna diversity of mangrove, (vii) salinity level, and (viii) coastal changes. The results of the leverage analysis show 2 attributes are most sensitive to ecological dimensions in both locations (Figure 5), namely mangrove diversity (RMS = 8.45) and mangrove rehabilitation (RMS = 6.36) in Taddan Village and mangrove fauna diversity (RMS = 11.53) and salinity levels (RMS = 7.73) in Aeng Sareh Village.

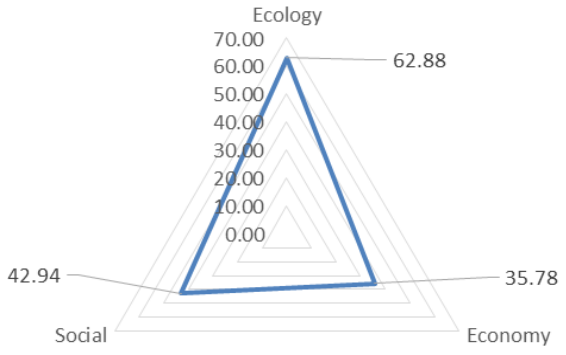

Figure 3. Sustainability index dimension in Taddan Village, Camplong Sub-district, Sampang District, East Java, Indonesia

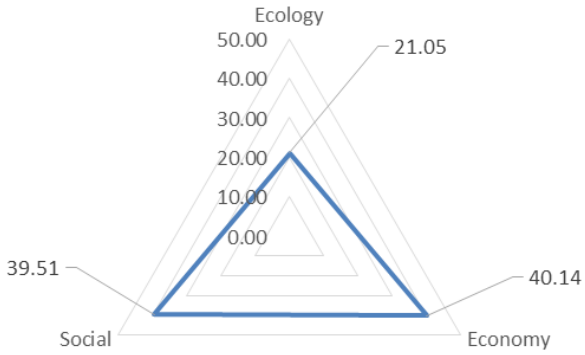

Figure 4. Sustainability index dimension in Aeng Sareh Village, Sampang Sub-district, Sampang District, East Java, Indonesia

Table 4. Sustainability index, Monte Carlo value, RSQ, and Stress value in Taddan Village, Camplong Sub-district and Aeng Sareh Village, Sampang Sub-district, Sampang District, East Java, Indonesia

Dimension	Sustainability Index	Monte Carlo Value	Difference	RSQ	Stress Value
Taddan Village					
Ecology	62.88	62.08	0.8	0.949571	0.13213
Economic	35.78	36.14	0.36	0.907535	0.195373
Social	42.94	43.66	0.72	0.884645	0.17625
Aeng Sareh Village					
Ecology	21.05	23.79	2.74	0.943764	0.133656
Economic	40.14	41.03	0.89	0.911163	0.188734
Social	39.51	40.3	0.79	0.901803	0.183514

Economic dimension

The determination of the sustainability status of mangrove ecosystem management on the economic dimension is based on seven attributes, namely (i) community income; (ii) mangrove zone; (iii) mangrove utilization; (iv) economic value; (v) other income; (vi) stakeholder involvement; and (vii) utilization inventory. Based on the results of the leverage of attributes chart (Figure 6) in Taddan Village, two attributes are most sensitive to the economic dimension: stakeholder involvement (RMS = 8.07) and economic value (RMS = 7.68). In comparison, the leverage of attributes chart results in Aeng Sareh Village display the two most sensitive attributes: community income (RMS = 7.82) and economic value (RMS = 6.62).

Social dimension

The attributes assessed on the socio-cultural dimension are eight attributes, namely (i) managing role, (ii) public awareness of the importance of mangroves, (iii) local wisdom, (iv) community knowledge about mangroves (v) community education level, (vi) community access to mangrove ecosystems, (vii) mangrove damage by the community, and (viii) utilization conflicts. Based on the results of leverage analysis shown in Figure 7, one attribute is sensitive to the value of the socio-cultural dimension in Taddan Village: mangrove use conflicts (RMS = 7.00). In comparison, two attributes are sensitive to the value of the socio-cultural dimension in Aeng Sareh Village: Access to mangrove ecosystem (RMS = 8.02) and level of education (RMS = 6.01).

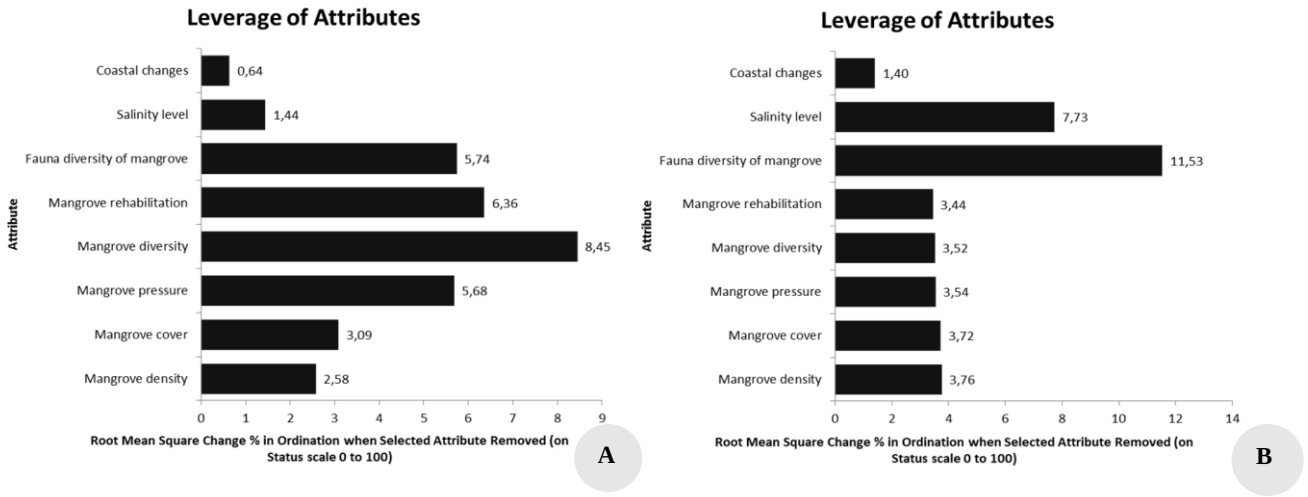

Figure 5. Leverage factor bar chart on ecological dimensions in A. Taddan Village, Camplong Sub-district and B. Aeng Sareh Village, Sampang Sub-district, Sampang District, East Java, Indonesia

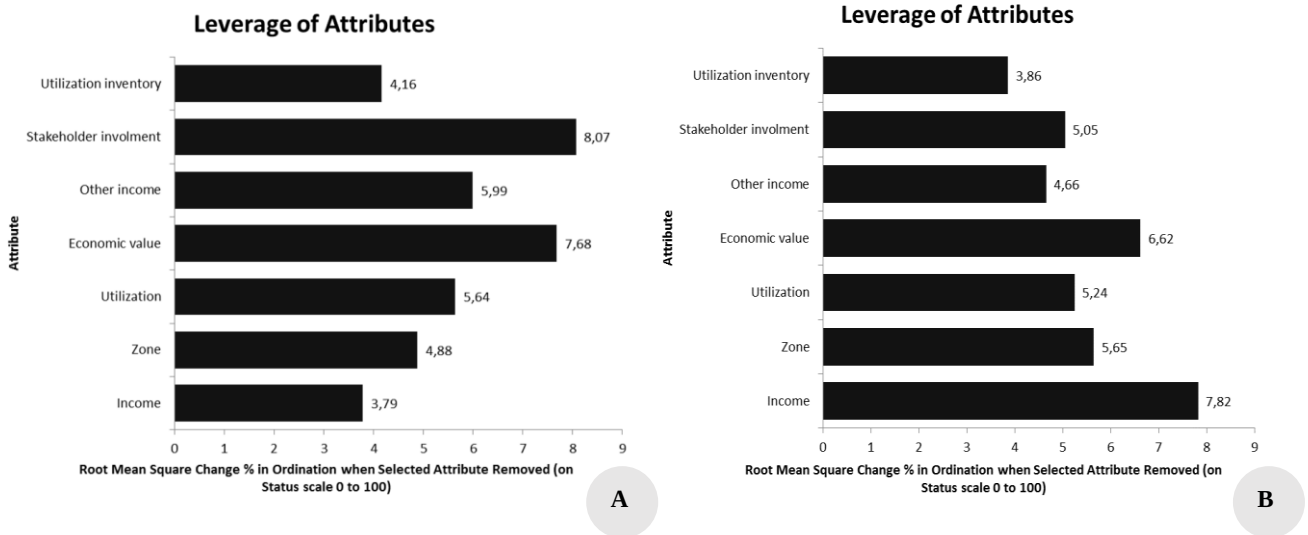

Figure 6. Leverage factor bar chart on economic dimensions in A. Taddan Village, Camplong Sub-district and B. Aeng Sareh Village, Sampang Sub-district, Sampang District, East Java, Indonesia

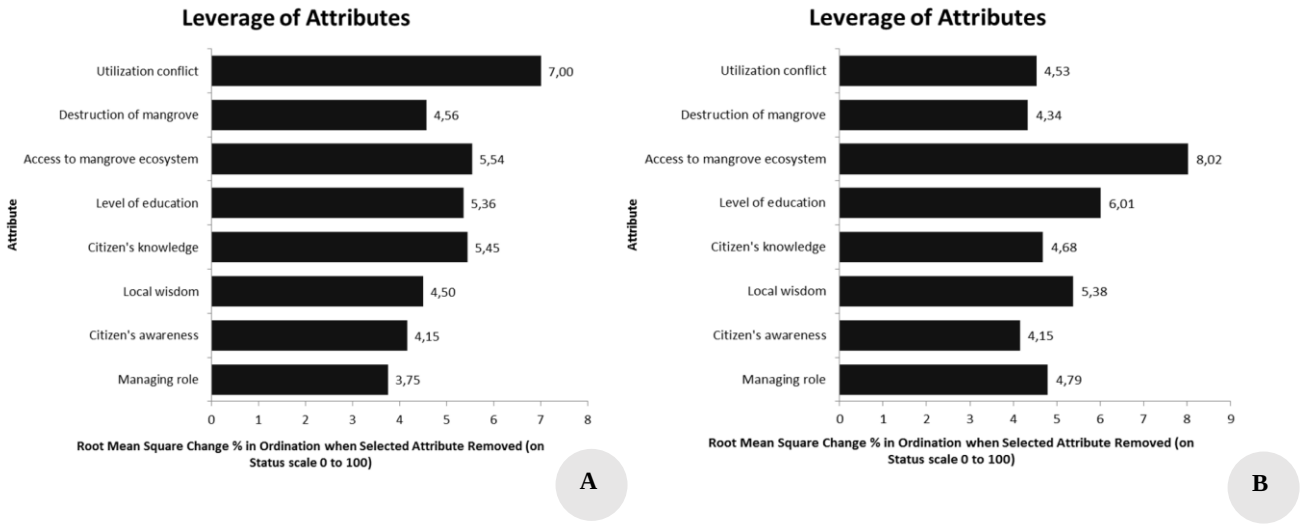

Figure 7. Leverage factor bar chart on social dimensions in A. Taddan Village, Camplong Sub-district and B. Aeng Sareh Village, Sampang Sub-district, Sampang District, East Java, Indonesia

Discussion

The ecological dimension of mangrove ecosystems is influenced by and affects various environmental aspects involved in these ecosystems. Mangrove ecosystems are unique and important coastal ecosystems that grow along tropical and subtropical coastlines. Sustainable management of mangrove ecosystems is necessary because many mangrove forests worldwide have suffered severe damage (Askar et al. 2021). In the ecological dimension, mangrove ecosystems have a role in maintaining biological integrity and marine resources around the ecosystem so that they can contribute significantly to other ecosystems around (Faridah-Hanum et al. 2019). The ecological importance of mangroves has been explained repeatedly, but globally between 2000 and 2016, mangroves were still lost with an annual average rate of 0.13% in several large countries (Su et al. 2021).

Land subsidence due to land clearing for new areas is a globally recognized problem, and land restoration that has been declining to date has become a major international agenda (Romijn et al. 2019). As with land decline, the decline in mangrove diversity and fauna diversity in mangrove ecosystems requires restoration and rehabilitation of the mangrove land itself (Su et al. 2021). In Aeng Sareh Village, many mangrove lands have been converted into salt ponds, which clearly impact various aspects of the mangrove ecological dimension. The role of the government and the community is needed for the rehabilitation of mangroves because mangroves have diverse ecological values, such as being able to produce natural resources that can be used for various needs and place to store carbon and reduce nitrogen levels in seawater (Jennerjahn 2020), and can be a safe reproductive habitat for many species of fauna such as fish, crabs, and mollusks.

The existence of mangrove ecosystems affects the surrounding community's economy through the potential of existing resources such as wood, food sources, cosmetic ingredients, dyes and tanners, and animal and bee feed sources (Andiny 2020). The location of mangrove forests adjacent to residential areas causes people to feel economic benefits directly related to meeting the community's needs for their survival. Economic activities carried out by the community on mangrove ecosystems can be detrimental if they are not regulated harmoniously with the environment (Raihan et al. 2021). Therefore, sustainable use of mangrove ecosystems must harmonize with resource usage management.

The RMS value obtained determines the magnitude of each attribute's role in maintaining status sensitivity, with higher RMS values showing more impact on sustainability (Hanifah et al. 2023). The lack of stakeholder and government involvement in maintenance activities and increasing the economic value of mangroves in Taddan Village is a factor that needs to be improved to create a sustainable mangrove ecosystem. In particular, village governments have an important role in the community's welfare through ponds on mangrove land (Velde et al. 2019). The use of mangroves for processed products can increase the productivity of local communities, so it has an impact on the economy and sustainability of mangroves. According to Razafindratsima et al. (2021), the diversification of mangrove-based food products reduces the burden of environmental degradation and further sharpens the ecological and economic functions of mangroves. In addition, careful planning related to utilizing mangrove potential into products with high selling value is needed while still paying attention to environmental aspects. Optimal and environmentally friendly resource utilization is an effort to preserve natural resources (Singgalen 2020).

The social dimension shows how the lives of local people which influence mangrove ecosystems, and the social dimension attributes show how the use of aquatic resources, especially mangrove ecosystems, affects the surrounding community or not (Noktasatria and Farid 2021). Therefore, managing mangrove ecosystem areas

requires cooperation between communities and stakeholders to create a balance of ecosystems in mangrove areas (Pradana et al. 2023). In comparison, the cultural dimension emphasizes the importance of considering the benefits of culture for human well-being in making decisions because this dimension has many facets and is complex (Queiroz et al. 2017). The socio-cultural dimension shows the relationship between living things and other living things, and the existence of environmental problems is an amalgamation of human values and their management (Reyes-Arroyo et al. 2021).

The absence of restrictions on these resources shows the high access of local communities to mangrove ecosystems. To improve human welfare, improvements and wise management of mangrove ecosystems are carried out to obtain value benefits from these resources (Widayanti et al. 2023). However, if access to mangrove resources is allowed without clear regulations, it can negatively impact them. Mangrove resources will be damaged due to lack of proper management. The level of education of the people in Aeng Sareh Village is relatively low. If the community knows about mangrove ecosystems, mangrove management can run well. This is following the statement of Damastuti et al. (2023) that community involvement and increasing knowledge are determining factors for the success of mangrove rehabilitation and management. This is also follows research conducted by Yunus et al. (2023) based on the social dimension of the Biringkassi coastal mangrove area, high community access is seen from the many people who utilize mangrove areas by harvesting wood and fishing. However, freedom of access can be detrimental to the community in the mangrove. This is due to the lack of a sense of belonging to the survival of the mangrove ecosystem. Low levels of education lead to a lack of understanding, participation, and community responsibility for mangrove ecosystem management.

The increasing number of communities, followed by higher activity in utilizing mangroves and reduced resources, will trigger social conflicts. According to Wang et al. (2024), social conflicts can occur between communities or communities with governments. This conflict occurs due to limited resources but needs to increase continuously. Therefore, the available resources will continue to decrease if they are not managed properly. The existence of good access will make it easier for the community and other managers to monitor the management and review of mangrove locations easily (Akram et al. 2023). Community access in ecosystem management can affect the sustainability of mangrove ecosystems (Haris et al. 2021). Community access to management will lead to the role of the community in managing the ecosystem, conducting counseling, and mentoring for the community to be involved in protecting and maintaining mangrove ecosystems to create sustainable mangrove ecosystem management (Santoso and Nugraha 2019).

Based on the results obtained from the study, alternative strategy recommendations that can be applied for sustainable mangrove ecosystem management in Taddan and Aeng Sareh Villages, Sampang are improving coordination between stakeholders, making patented regulations, training on creativity and productivity of village communities, formulating mangrove ecosystem management programs, routinely carrying out rehabilitation efforts, and increasing awareness from researchers.

Based on the research, the sustainability management of mangrove ecosystems in Taddan Village and Aeng Sareh Village, Sampang District, it can be concluded: (i) The results of the Rapfish analysis in Taddan Village show the value of the sustainability index in the ecological dimension of 62.88, the value of the sustainability index in the economic dimension of 35.78, and the value of the sustainability index in the socio-cultural dimension of 42.94. (ii) The results of the Rapfish analysis in Aeng Sareh Village show a sustainability index value in the ecological dimension of 21.05, a sustainability index value in the economic dimension of 40.14, and a sustainability index value in the socio-cultural dimension of 39.51. Alternative strategy recommendations that can be applied for sustainable mangrove ecosystem management in Taddan and Aeng Sareh Villages, Sampang District, are improving coordination between stakeholders, making patented regulations, training on creativity and productivity of rural communities, formulating mangrove ecosystem management programs, routinely carrying out rehabilitation efforts, and increasing attention from researchers.

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