Assessing The Impact of Marine Protected Areas on Food Security of The Bajau Community In Wakatobi National Park, Indonesia

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Abstract
Global conservation efforts, such as Marine Protected Areas (MPAs), have garnered attention, yet their impact on food security within indigenous sea-nomadic communities remains underexplored. This study examines how MPAs affect the Bajau community in Wakatobi National Park (WNP), Indonesia, focusing on dietary diversity and household food security. The research surveyed 93 households in Mola villages between December 2023 and January 2024. Food security was measured using indicators like the Household Dietary Diversity Score (HDDS) and the Household Food Insecurity Access Scale (HFIAS). Spearman's correlation and multiple linear regression analyzed relationships between socio-economic variables and food security. Results showed that the Bajau's diet was moderately diverse, with a mean HDDS of 8.04, and food insecurity was relatively low (mean HFIAS = 1.0968). Significant correlations were found between dietary diversity, food insecurity, and dependency ratios. Households with higher education had more diverse diets, while those with higher dependency ratios faced greater food insecurity. Non-fishing households exhibited higher HDDS, likely due to alternative income sources. These findings suggest that while the Bajau community generally experiences moderate food security, vulnerabilities persist, especially in households with higher dependency ratios. Enhancing livelihood diversification and access to education may improve food security and resilience in this sea-nomadic community.

Keywords: Marine Protected Areas (MPAs), Bajau community, food security, Household Dietary Diversity Score (HDDS), Household Food Insecurity Access Scale (HFIAS)

Abstrak
Upaya konservasi global, seperti Kawasan Konservasi Laut (KKP), telah menarik perhatian, namun dampaknya terhadap ketahanan pangan dalam komunitas nomaden laut asli masih kurang dieksplorasi. Studi ini mengkaji bagaimana KKL memengaruhi masyarakat Bajau di Taman Nasional Wakatobi (WNP), Indonesia, dengan fokus pada keanekaragaman makanan dan ketahanan pangan rumah tangga. Penelitian ini mensurvei 93 rumah tangga di desa Mola antara Desember 2023 dan Januari 2024. Ketahanan pangan diukur menggunakan indikator seperti Skor Keanekaragaman Diet Rumah Tangga (HDDS) dan Skala Akses Kerawanan Pangan Rumah Tangga (HFIAS). Korelasi Spearman dan regresi linier berganda menganalisis hubungan antara variabel sosial-ekonomi dan ketahanan pangan. Hasil penelitian menunjukkan bahwa pola makan orang Bajau cukup beragam, dengan rata-rata HDDS 8,04, dan kerawanan pangan relatif rendah (rata-rata HFIAS = 1,0968). Korelasi yang signifikan ditemukan antara keragaman makanan, kerawanan pangan, dan rasio ketergantungan. Rumah tangga dengan pendidikan tinggi memiliki pola makan yang lebih beragam, sementara mereka yang memiliki rasio ketergantungan yang lebih tinggi menghadapi kerawanan pangan yang lebih besar. Rumah tangga non-nelayan menunjukkan HDDS yang lebih tinggi, kemungkinan karena sumber pendapatan alternatif. Temuan ini menunjukkan bahwa meskipun masyarakat Bajau umumnya mengalami ketahanan pangan sedang, kerentanan tetap ada, terutama pada rumah tangga dengan rasio ketergantungan yang lebih tinggi. Meningkatkan diversifikasi mata pencaharian dan akses ke pendidikan dapat meningkatkan ketahanan dan ketahanan pangan di komunitas nomaden laut ini.

Kata Kunci: Kawasan Lindung Laut (KKP), masyarakat Bajau, ketahanan pangan, Skor Keanekaragaman Makanan Rumah Tangga (HDDS), Skala Akses Kerawanan Pangan Rumah Tangga (HFIAS)

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INTRODUCTION

Marine ecosystems, which provide critical resources and services to millions of people worldwide, are under increasing threat from overfishing, habitat destruction, and climate change. According to the Food and Agriculture Organization (FAO, 2022), over 35% of the world's fish stocks are being harvested at unsustainable levels, posing a serious risk to global food security. As a response, Marine Protected Areas (MPAs) have been widely implemented to preserve marine biodiversity and ensure the sustainable use of ocean resources (Edgar et al., 2014). Globally, MPAs cover approximately 8% of the ocean, with ambitious international targets like the 30x30 initiative aiming to protect 30% of marine areas by 2030 (UNEP-WCMC, 2022).

Indonesia, as the world's largest archipelagic country, relies heavily on its marine and coastal ecosystems for economic and social development. These ecosystems contribute approximately 22% to Indonesia's Gross National Product (GNP) and support nearly 39 million jobs, particularly in fisheries and tourism (Badan Pusat Statistik, 2023). However, despite the ecological benefits of MPAs, their establishment often creates socio-economic challenges for local communities. For instance, indigenous groups like the Bajau, a sea-nomadic population residing in areas such as Wakatobi National Park, face significant disruptions to their traditional fishing practices and food security due to MPA-related restrictions (Clifton, 2013).

Wakatobi National Park, a UNESCO World Heritage site, is a hotspot for marine biodiversity, home to over 750 coral species and 942 fish species (Dahuri et al., 2003). While the park contributes significantly to global conservation efforts, it imposes limitations on fishing activities, particularly for indigenous communities like the Bajau who rely on subsistence fishing for their livelihoods. Studies suggest that restrictive conservation measures can lead to conflicts between ecological goals and socio-economic needs (Cinner et al., 2012). This conflict is evident in the Bajau community, where reduced access to fishing grounds threatens not only their traditional way of life but also their dietary diversity and food security (Arias et al., 2015).

The urgency of this issue lies in the need to balance marine conservation with the socio-economic well-being of indigenous populations. Globally, indigenous communities play a critical role in biodiversity conservation, as their traditional ecological knowledge often complements modern conservation science (Berkes et al., 2000). However, their marginalization in decision-making processes and restricted access to resources frequently result in adverse socio-economic outcomes (Chuenpagdee et al., 2013). Addressing these conflicts is essential for achieving the dual goals of sustainable development and biodiversity conservation, as outlined in the United Nations Sustainable Development Goals (SDGs), particularly Goal 14 (Life Below Water) and Goal 2 (Zero Hunger) (UN, 2021).

This study addresses the gap in understanding the socio-economic impacts of MPAs on indigenous sea-nomadic communities, focusing on the Bajau in Wakatobi National Park. Unlike previous research that predominantly highlights the ecological effectiveness of MPAs (Edgar et al., 2014), this research emphasizes the intersection of conservation policies and food security, particularly how MPA restrictions affect the Bajau's dietary diversity, food access, and overall well-being. The novelty of this research lies in its focus on a holistic assessment of food security indicators within an indigenous context, providing insights that are often overlooked in conservation studies (Bennett et al., 2015).

The objectives of this study are threefold: (1) to analyze the impacts of MPA restrictions on the dietary diversity of the Bajau community, (2) to evaluate how conservation measures influence their access to key food resources, and (3) to explore strategies for reconciling conservation goals with the food security needs of indigenous populations. The findings are expected to provide practical recommendations for

policymakers, conservation practitioners, and local stakeholders to design more inclusive and equitable marine management strategies that account for the socio-economic realities of indigenous communities.

In terms of benefits, this research contributes both theoretically and practically. Theoretically, it expands the discourse on MPAs by integrating socio-economic dimensions, particularly the food security of indigenous groups, into conservation policy evaluations (Jupiter et al., 2014). Practically, the study provides actionable insights for local governments and conservation organizations to enhance the inclusivity and effectiveness of MPAs while safeguarding the livelihoods and cultural heritage of indigenous populations like the Bajau (Kittinger et al., 2013). Ultimately, the research underscores the importance of participatory approaches in marine conservation to achieve long-term sustainability and equity.

METHODS

Study Area: The present study was conducted in Wakatobi National Park, located in Southeast Sulawesi, Indonesia. This national park covers an area of approximately 1.39 million hectares, encompassing marine biodiversity hotspots, coral reefs, seagrass meadows, and mangrove forests. The Bajau community, primarily residing in the Mola villages of the Wakatobi Regency, relies heavily on marine resources for their livelihoods. The Wakatobi region is known for its high marine biodiversity, making it a significant area for conservation efforts and a focus for assessing the socio-economic impacts of Marine Protected Areas (MPAs) on indigenous communities.

Sampling and Data Collection: A quantitative approach was adopted for this study, utilizing household surveys conducted with the Bajau community. A total of 93 households were randomly selected from the Mola villages. Data collection took place between December 2023 and January 2024. The survey aimed to gather information on food security indicators, including Household Dietary Diversity Score (HDDS), Household Food Insecurity Access Scale (HFIAS), and dependency ratios. The survey also included demographic questions related to household characteristics, education levels, and occupation.

Indicators of Household Food Security: Food security was evaluated using several key indicators: HDDS, HFIAS, and dependency ratio. The HDDS was assessed through a series of yes/no questions regarding the consumption of 12 distinct food groups by all household members within the preceding 24 hours. HFIAS was utilized to measure food insecurity levels by asking questions regarding food access over the past four weeks. The dependency ratio was calculated by dividing the number of non-working individuals by the number of working individuals in each household.

Data Analysis: Statistical analysis was conducted using SPSS software version 28. Spearman's correlation and multiple linear regression analyses were performed to assess the relationships between socio-economic variables (such as education and occupation) and food security outcomes. The analysis aimed to identify any statistically significant correlations between HDDS, HFIAS, and the dependency ratio among the sampled households.

Ethical Considerations: Ethical approval for this study was obtained from the relevant ethical review committee at Khon Kaen University. Informed consent was secured from all participants, ensuring their voluntary participation and understanding of the study's purpose and procedures.

RESULTS AND DISCUSSION

Characteristics of the Bajau Households: Based on **Figure 1,** The Bajau community in Wakatobi National Park demonstrates a strong reliance on marine resources for their livelihood, reflecting their long-standing seafaring traditions. Fishing remains the primary economic activity for most households, with approximately 72% of surveyed families listing it as their main source of income. However, their heavy dependence on fishing makes these households vulnerable to external factors such as environmental changes and marine conservation policies that limit access to certain fishing areas, affecting their economic stability and food security.

In addition to fishing, a small proportion of households (8%) engage in fish trading, while only 4% of families have diversified into other sectors such as tourism-related jobs and salaried employment. These activities provide supplementary income but are not widespread within the community, reflecting limited occupational diversity. A significant barrier to income diversification is the community's traditional reliance on marine-based livelihoods, leaving few households with the resources or opportunities to expand into other economic sectors.
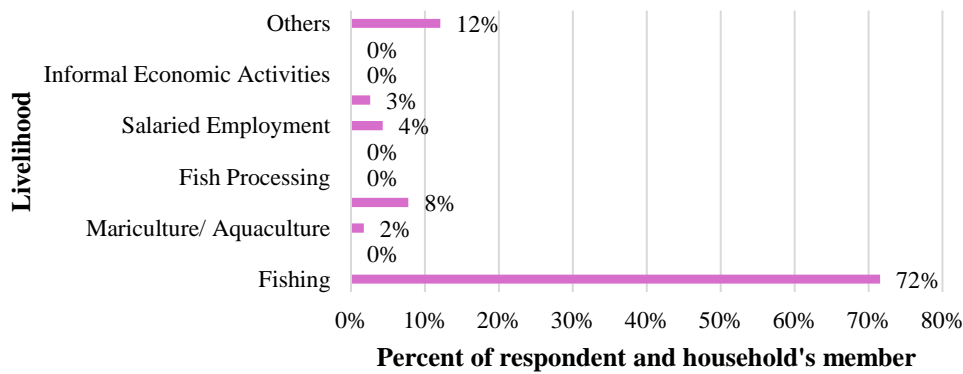
Figure 1. Percentage of all nominated livelihoods diversity by village in WNP.

Household Dietary Diversity Score (HDDS): **Table 1** presents the mean value of HDDS, dependency ratio and HFIAS of the Bajau. HDDS is a critical indicator used to measure dietary diversity within the Bajau community households. It reflects the economic ability of households to access a variety of food groups, serving as a proxy for the nutritional quality of their diet. The study found that the average HDDS for the surveyed households was 8.04, indicating a moderately diverse diet. The HDDS was calculated based on the consumption of 12 different food groups over the previous 24 hours, with each food group representing one point on the HDDS scale. Higher HDDS scores indicate greater access to a wide range of nutrients, which contributes to better food security.

Table 1. Mean value of three groups: HDDS, dependency ratio, and HFIAS

	N	Minimum	Maximum	Mean	Std. Deviation
Household Dietary Diversity Score	93	4	12	8.04	2.058
Dependency ratio	93	0.50	5.00	2.0377	1.16845

	N	Minimum	Maximum	Mean	Std. Deviation
Household Food Insecurity Access Scale	93	0.00	4.00	1.0968	1.39147

The analysis of HDDS categories within the Bajau Community in Wakatobi National Park reveals several key trends as shown in **Figure 2**. A significant portion of households achieved relatively high HDDS scores, with 29% of households scoring 9, the most common category, followed by 12% scoring 8. This suggests that a large part of the community enjoys a commendable level of dietary diversity, potentially indicating stable access to a variety of food groups. However, the percentage of households with higher HDDS scores (10 to 12) progressively declines, with only a small proportion reaching the top categories. Notably, no households scored in the lowest HDDS categories (0 to 3), signaling an absence of extreme dietary inadequacy. Despite the generally positive outcomes, 11% and 6% of households had moderate HDDS scores of 5 and 6, respectively, pointing to room for improvement. These results highlight the need to sustain efforts to enhance dietary diversity, particularly for households with lower scores, and to explore factors such as socioeconomic status and resource access to guide interventions that can further improve food security and nutrition in the community.
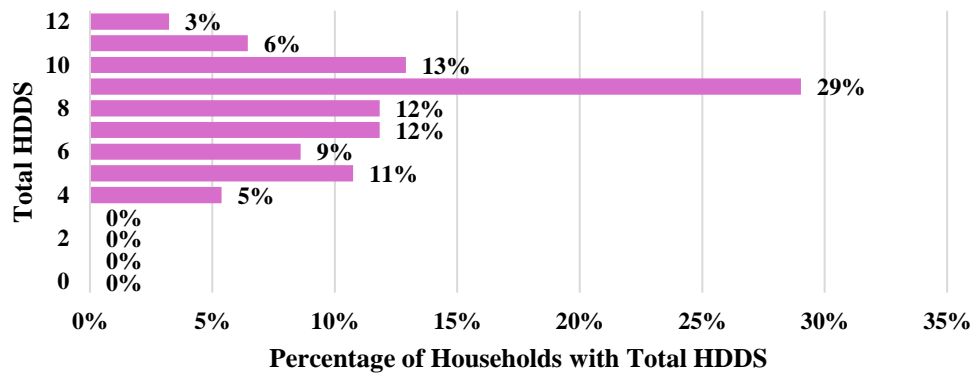

Figure 2. The percentage of HDDS categories as a function of each HDDS

Households with higher HDDS typically had access to more diverse sources of food, such as cereals, vegetables, proteins, and fruits, contributing to greater food security and nutritional outcomes. The correlation between HDDS and income was found to be positive, suggesting that households with higher income levels were able to afford a more varied diet. Additionally, education played a role in influencing dietary diversity: households where the head of the family had higher educational attainment generally reported higher HDDS scores. This indicates that access to education can help households make informed food choices, improving overall dietary quality.

Dependency Ratio: The dependency ratio is a crucial indicator for assessing the economic burden on productive members of the Bajau community. In this study, the mean dependency ratio was 2.0377 referring **Table 1**, which means that, on average, there are about two dependent individuals (children and elderly) for every working-age adult in the sampled households. This ratio ranged from a low of 0.5 to a high of 5.0 across the 93 surveyed households, indicating significant variation in household composition. Households with a lower dependency ratio (closer to 1.0) tend to have fewer dependents per working-age individual, which generally results in a lesser economic burden on the productive members of the household. This can enhance the

household's ability to allocate resources for a more diverse diet, as fewer financial and food resources are required to sustain dependents. In the study, households with lower dependency ratios exhibited higher Household Dietary Diversity Scores (HDDS), reflecting their ability to access and afford a broader variety of food items. Conversely, households with higher dependency ratios, particularly those with a ratio of 3.0 or more, face greater pressure on their working-age members. These households must divide their income and food resources among more non-working dependents, which can reduce the available resources for purchasing diverse and nutritious foods. Consequently, these households tended to have lower HDDS and showed greater vulnerability to food insecurity. The strain on resources in such households can also result in higher levels of Household Food Insecurity Access Scale (HFIAS) scores, indicating that these families are more likely to experience periods of food shortage or rely on cheaper, less nutritious food options.

Household Food Insecurity Access Scale (HFIAS): The Household Food Insecurity Access Scale (HFIAS) is another key metric used in this study to assess the degree of food insecurity experienced by households over a 30-day period. The HFIAS measures the frequency and severity of food insecurity, with households reporting on experiences such as reducing the number of meals, consuming less preferred foods, or skipping meals entirely. The study revealed that the average HFIAS score for the surveyed households was relatively low, at 1.0968, suggesting that most households experienced a mild degree of food insecurity. **Figure 3** presenting the result of surveyed households, most households (55%) reported no food insecurity (HFIAS score of 0), while 17% experienced moderate to severe insecurity. No household fell within the most severe food insecurity categories.
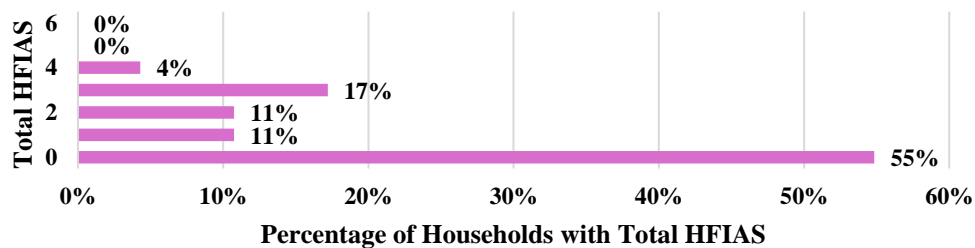
Figure 3. The percentage of total
Household Food Insecurity Access Score (HFIAS) of households in Bajau Mola

Correlations Between Food Security Indicators: According to **Table 2**, a significant negative correlation was found between HDDS and HFIAS (-0.871), meaning households with higher dietary diversity experienced lower food insecurity. This indicates that dietary diversity plays a crucial role in food security. There was also a weak positive correlation between HDDS and the dependency ratio (0.237), suggesting that households with higher dependency ratios may have reduced dietary diversity. Lastly, a weak negative correlation between HFIAS and dependency ratio (-0.234) suggests that as food insecurity decreases, the dependency burden also lessens.

**Table 2. The result of correlations among food security indicators
in Bajau Mola Villages.**

Correlations			Household Dietary Diversity Score	Dependency ratio	Household Food Insecurity Access Scale
Spearman 's rho	**Household Dietary Diversity Score**	Correlation Coefficient	1.000	.237*	-.871**
		Sig. (2-tailed)	.	.022	<.001
		N	93	93	93
	Dependency ratio	Correlation Coefficient	.237*	1.000	-.234*
		Sig. (2-tailed)	.022	.	.024
		N	93	93	93
	Household Food Insecurity Access Scale	Correlation Coefficient	-.871**	-.234*	1.000
		Sig. (2-tailed)	<.001	.024	.
		N	93	93	93
*. Correlation is significant at the 0.05 level (2-tailed).					
**. Correlation is significant at the 0.01 level (2-tailed).					

Correlation between socio-economic characteristic and HDDS: Based on **Table 3**, the multiple regression analysis examines the relationship between socio-economic factors and *Household Dietary Diversity Score (HDDS)* among the Bajau community in Wakatobi National Park, Indonesia. The results indicate that the *dependency ratio* has a coefficient (B = 0.197), suggesting a small predicted increase in HDDS for every one-unit rise in the ratio. However, with a p-value of 0.329, this effect is not statistically significant, implying that the dependency ratio does not have a meaningful influence on dietary diversity in this community. Similarly, fishing practices, whether seasonal (B = -0.509, p = 0.748) or year-round (B = 1.649, p = 0.129), do not significantly affect HDDS when compared to non-fishing households. Additionally, the number of occupations within households does not show a significant relationship with HDDS, as households with two or three occupations show no notable difference in dietary diversity compared to those with only one occupation.

On the other hand, education emerges as a significant factor in influencing HDDS. Households where the head completed *senior high school* show a substantial increase in HDDS (B = 3.313, p < 0.001) compared to those with no formal education, indicating that education plays a crucial role in improving dietary diversity. However, education levels below senior high school, such as primary or junior high school, and even university-level education, do not show significant impacts on HDDS. These findings suggest that while higher education, particularly at the senior high school level, significantly improves dietary diversity, other socio-economic factors such as the

dependency ratio, fishing practices, and occupational diversity do not have a significant influence on the HDDS of the Bajau households.

Table 3. Extract of multiple regression analysis results
for the relationship between socio-economic characteristic and HDDS.

Model	Unstandardized Coefficients		Standardized Coefficients	t-value	Sig. (p-value)
	B	Std. Error	Beta		
Main effects (Constant)	6.180	1.011		6.115	<.001
Dependency ratio	.197	.200	.112	.981	.329
No Education	Reference group				
Primary School	-.164	.537	-.040	-.305	.761
Junior High School	.522	.774	.075	.675	.502
Senior High School	3.313	.812	.579	4.080	<.001
University Level	1.657	1.310	.227	1.265	.209
Non-fishing Households	Reference group				
Seasonal Fishing	-.509	1.580	-.106	-.322	.748
Year-Round Fishing	1.649	1.075	.373	1.534	.129
One Occupation	Reference group				
Two Occupations	-.623	1.916	-.131	-.325	.746
Three Occupations	-.476	2.928	-.034	-.162	.871

a. Dependent Variable: Household Dietary Diversity Score

Discussion

Though food security studies have attracted attention in diverse regions, research specific to the Bajau community in Wakatobi National Park remains scarce. Available studies largely overlook the unique socio-ecological dynamics of this seafaring community (Bennett & Dearden, 2014). Similar gaps exist in assessing how marine protection policies impact the food security of such coastal populations. The findings from this study provide important insights into the food security and dietary diversity of the Bajau Mola community in Wakatobi National Park. Despite the challenges posed by their heavy reliance on marine resources, the community has maintained a commendable level of food security, as evidenced by their relatively high HDDS and low HFIAS scores. The average HDDS of 8.04 suggests that most households consume a variety of food groups, contributing to nutritional adequacy within the community. While the majority of households exhibit moderate to high dietary diversity, a notable minority faces challenges related to food access, particularly those with lower scores on the HDDS and higher HFIAS scores. However, the reliance on marine resources like fish and seafood, combined with limited agricultural access due to their water-based homes, constrains dietary diversity. Cereals such as rice, roots/tubers, and vegetables were common, while the intake of protein from poultry and legumes was minimal. This emphasizes the vulnerability of their food security to environmental and economic fluctuations, including climate impacts and regulatory constraints on fishing.

The correlation between HDDS and HFIAS, with a strong negative coefficient of -0.871, highlights the critical role of dietary diversity in mitigating food insecurity.

Households with more diverse diets tend to experience less food insecurity, which underscores the importance of ensuring access to a wide variety of food groups. Interestingly, the analysis also revealed a positive correlation between HDDS and the dependency ratio (0.237), suggesting that households with more dependents may still maintain higher dietary diversity, potentially due to collective household efforts to secure food. However, this does not discount the financial pressures these households face, as they must balance resource allocation across a larger group of dependents.

The study highlights a statistically significant inverse correlation between the dependency ratio and food security, with households experiencing higher dependency ratios being more likely to encounter challenges in meeting their dietary needs. This is consistent with the broader literature, which suggests that households with a higher number of dependents tend to have greater difficulty maintaining food security due to increased economic demands on fewer productive members.

The dependency ratio's impact on food security in the Bajau community is particularly notable given their reliance on fishing and other natural resources, which are subject to seasonal fluctuations and restrictions imposed by Marine Protected Areas (MPAs). Higher dependency ratios exacerbate the challenges faced by these households, as they must balance the needs of their dependents with the limitations placed on their traditional livelihoods by conservation regulations.

Education also plays a significant role in shaping dietary outcomes within the Bajau community. The results show that households where the head has completed senior high school education have a significantly higher HDDS, with a coefficient of 3.313 (p < 0.001). This finding aligns with previous research indicating that higher education levels lead to better awareness of nutrition and increased access to diverse food options (Megbowon & Mushunje, 2018). This suggests that education initiatives could be an effective strategy for improving food security and dietary diversity within this community.

Finally, the study's limitations must be acknowledged. The gendered dimensions of food security were not explored, leaving a gap in understanding how gender roles within Bajau households influence food access and dietary decisions. Future research should explore these dynamics to provide a more comprehensive understanding of food security in the community. Overall, this study offers valuable insights into the socio-economic factors that influence food security in the Bajau Mola community and highlights the need for multifaceted interventions to address the community's vulnerabilities and improve their resilience to food insecurity.

CONCLUSIONS

The Bajau community in Wakatobi National Park relies heavily on marine resources, with 72% of households primarily dependent on fishing for their livelihoods, making them vulnerable to environmental changes and marine conservation policies. While 55% of households reported no food insecurity, 17% experienced moderate to severe food insecurity, reflecting unequal access to nutritious food. About 29% of households achieved a high dietary diversity score (HDDS) of 9, while others had lower scores, indicating the need for targeted interventions. Factors contributing to food insecurity include low income, limited livelihood diversification, and the economic burden of larger households. Education also plays a critical role, with households led by individuals who completed senior high school exhibiting higher dietary diversity. To improve food security, recommendations include diversifying income sources, strengthening education initiatives, and enhancing access to resources. Revitalizing local food systems and promoting sustainable fishing practices could reduce reliance on external factors and improve dietary diversity and food security. The research was supported by the ASEAN-GMS Scholarship

and Khon Kaen University, Thailand, with deep appreciation extended to the Bajau community for their participation and hospitality. The authors declared no conflict of interest.

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