frontiers | Frontiers in Environmental Science

TYPE Original Research
PUBLISHED 06 November 2023
DOI 10.3389/fenvs.2023.1268036

OPEN ACCESS

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RECEIVED 31 July 2023
ACCEPTED 24 October 2023
PUBLISHED 06 November 2023

CITATION
Marzo RR, Chen HWJ, Anuar H, Abdul Wahab MK, Ibrahim MH, Ariffin IA, Ahmad AI, Kawuki J and Aljuaid M (2023), Effect of community participation on sustainable development: an assessment of sustainability domains in Malaysia. *Front. Environ. Sci.* 11:1268036. doi: 10.3389/fenvs.2023.1268036

Effect of community participation on sustainable development: an assessment of sustainability domains in Malaysia

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Introduction: Community participation is also one of the critical factors, in the success of coral reef conservation efforts in Malaysia. The key determinants of community participation in coral reef conservation in the country include awareness, understanding, benefits, and incentives.

Objectives: The study aimed to investigate the impact of community participation on sustainable development in Malaysia, specifically in coral reef conservation. The study assessed the relationships between sociodemographic variables and various sustainability domains, including community participation, ecotourism development, and economic, environmental, and social sustainability.

Methods: This was a cross-sectional study conducted from July to October 2022 in Setiu, Terengganu and recruited 338 adult local villagers. Bivariable and multivariable logistic regression analysis for factors such as employment status, knowledge of coral reefs, practice of coral reef conservation and willingness to volunteer for conservation were analysed using SPSS version 26.

Results: An increase in community participation was associated with an increase in all four sustainability domains of ecotourism development, economic, environmental and social sustainability (Unadjusted B range = 0.46–0.77, all p-value <0.001). Participants with acceptable knowledge of coral reefs (AOR = 7.11, 95% CI: 3.84–13.15), good practice of coral reef conservation (AOR = 5.26, 95% CI: 2.54–10.91), and willing to volunteer for coral reef conservation (AOR = 1.98, 95% CI: 1.02–3.83) had higher odds of positive social sustainability, compared to those with low knowledge, poor practice and not willing to volunteer, respectively. However, those employed in marine-related jobs (AOR = 0.27, 95% CI: 0.10–0.72) had less odds of positive social sustainability, compared to those who are not employed.

Conclusion: The study highlighted the importance of community participation in promoting sustainable development and the influence of socioeconomic factors and education on community participation. The importance of educational initiatives and engagement and the factors associated with positive economic, environmental and social sustainability have been highlighted. These findings can

be used by policymakers and stakeholders to design and implement effective interventions for coral reef conservation, aimed at promoting sustainable development in Malaysia.

KEYWORDS

community participation, sustainability, ecotourism, economic, environmental sustainability, social, resources

1 Introduction

Terengganu, a region situated on the east coast of Peninsular Malaysia, is famous for its varied marine life and coral reefs. Pulau Geluk, a small island in the South China Sea and a part of Terengganu Marine Park, is surrounded by a diverse and thriving coral reef ecosystem (Md Amin et al., 2020). Beyond their ecological importance, these coral reefs substantially underpin the region's economy. Terengganu, with its pristine marine attractions, significantly benefits from tourism revenues. Furthermore, local fisheries, which many residents depend upon for their livelihood, are intrinsically linked to the health and vibrancy of these coral habitats. The intrinsic relationship between these reefs and Terengganu's economic vitality cannot be overstated (Safuan et al., 2022). The coral reefs are home to a wide range of marine species and are essential to supporting the local fishing industry.

Coral reefs play an important role in the marine ecosystem, providing habitat for a diverse range of marine species, and contributing to the local fishing and tourism industries. However, the decline of coral reefs globally has been rapid in recent decades. As per the World Wildlife Fund, an estimated half of the world's coral reefs have already been lost, with another one-fifth at risk of being lost in the next few decades (Coral Reef Rescue, 2023). In Malaysia, the situation is similar. A study by the Marine Parks Department of Malaysia found that about two-fifths of the country's coral reefs have been damaged or destroyed, with the most severe impacts on the east coast (Marine Park, 2023). This pattern mirrors a worrying trend seen nationally. Detailed investigations, such as those conducted by the Marine Parks Department of Malaysia, report an unsettling degradation of these marine ecosystems. Specifically, approximately 40% of Malaysia's coral reefs are in states of decline, with particularly pronounced damage observed along the east coast (Asian Development Bank, 2014). The anthropogenic stressors due to human activities, such as overfishing, coastal development, and pollution, have been the main reasons for this decline. Rising sea temperatures and ocean acidification due to climate change pose a significant threat to Malaysia's coral reefs (Maina et al., 2011). The loss of biodiversity, reduced fish populations, and decreased coastal protection caused by coral reef decline have far-reaching impacts, including significant economic and social consequences, as many coastal communities rely on coral reefs for tourism and fishing. These alarming statistics emphasize the pressing need for conservation efforts to protect and restore coral reefs, both in Malaysia and worldwide.

These efforts include gazetting marine protected areas, habitat restoration, and management of human activities that can harm reefs. Additionally, efforts are being made to reduce the impacts of climate change on coral reefs through research, monitoring, and management (Heron et al., 2016). In some areas, coral reefs are being restored through techniques such as transplantation and accelerated coral growth (Hughes et al., 2017). However, these efforts are often resource-intensive and face challenges, such as limited funding, lack of political will, and limited public awareness. Hence, to effectively conserve coral reefs, a comprehensive, multi-stakeholder approach is necessary, including the involvement of local communities, government agencies, and the private sector.

To protect coral reefs from the impacts of climate change, it is essential to identify those that are less exposed and vulnerable. According to a recent global analysis, only seven countries have more than seven-tenths of the world's coral reefs that are climate-resilient, including Indonesia, the Philippines, Cuba, Fiji, Tanzania, the Solomon Islands, and Madagascar (Coral Reef Rescue, 2023). These resilient reefs can serve as a source of regeneration for the planet's corals, as they are connected by ocean currents that transport coral larvae and fish. The Coral Reef Rescue Initiative is implementing a cooperative strategy to enhance the management and protection of specific seascapes while promoting community resilience through various skill-building and livelihood opportunities that improve their economic capacity in the face of a rapidly changing climate (Coral Reef Rescue, 2023). In conclusion, community participation tends to be an important factor in promoting sustainability across multiple domains. It can lead to a more resilient and sustainable future by promoting environmental protection, social wellbeing, and economic growth.

In Malaysia, community participation is also one of the critical factors, in the success of coral reef conservation efforts (Masud et al., 2017). The key determinants of community participation in coral reef conservation in the country include awareness, understanding, benefits, and incentives. Local institutions and governance play a significant role in promoting community participation, such as well-functioning community organizations and the implementation of effective management and monitoring systems. It is also important that local communities have access to and control over the coral reef ecosystems. This can be achieved through the establishment of community-based marine protected areas and community-based management programs. Positive community participation also relies on building trust and fostering relationships between different stakeholders, such as government agencies, non-governmental organizations, and local communities. This requires efforts to establish trust and develop partnerships among key stakeholders (The South China Sea, 2023).

FIGURE 1
Map showing the islands of Terengganu. The red star and bold red texts indicate the location of the study area—Pulau Geluk.

The loss of biodiversity and reduced fish populations impact the environmental sustainability of Malaysia, while the loss of coastal protection impacts the social and economic sustainability of many coastal communities that rely on coral reefs for tourism and fishing (Maina et al., 2011). Efforts to engage local communities in coral reef conservation and management, such as the establishment of community-based marine protected areas and the development of community-based management programs, are critical for improving the sustainability of coral reef ecosystems and the communities that depend on them. By addressing these determinants and promoting community participation, we can improve the chances of success in conserving coral reefs in Malaysia.

Hence, the proposed study aimed to investigate the impact of community participation on sustainable development in Malaysia, specifically in coral reef conservation. The study assessed the relationships between sociodemographic variables and various sustainability domains, including community participation, ecotourism development, and economic, environmental, and social sustainability. A conceptual model was developed to determine the cause-and-effect relationships and guidelines for promoting sustainability practices in the community. The findings of the study would be valuable to policymakers, who would better understand the connection between community participation and sustainable development in coral reef conservation. This could potentially result in a competitive edge in Malaysia's marine protected areas.

2 Methods

2.1 Study design and setting

This quantitative-based cross-sectional study was conducted from July to October 2022 in Setiu, Terengganu. Geluk Island is a little island, located in the South China Sea and is a part of Terengganu Marine Park. As Geluk Island is situated approximately 30 km away from Penarik Beach, two local villages—Kampung Rhu 10 and Kampung Mangkuk, which are located across the Penarik Beach of Setiu were chosen to be the study area (Figure 1). This study was approved by the Ethics Committee of Management and Science University.

2.2 Participants and sample size planning

This study recruited a convenience sample of 338 adult local villagers residing in Kampung Rhu 10 and Kampung Mangkuk. The sample size was calculated using the Raosoft online calculator (Raosoft and Inc, 2023). And an additional 20% of the non-response rate was included, giving rise to a final sample size of 452. A total of 371/452 (82.1%) participants took part in the survey. After excluding participants with incomplete data, 338 participants were included in the study analysis. Individuals aged 18 years and above, residing in Kampung Rhu 10 and Kampung Mangkuk, and mentally fit were included in the study.

2.3 Data collection and management

Survey data were collected via paper-based validated interviewer-rated questionnaires. Training was given to all the interviewers by the investigators of the study and informed consent was obtained before data collection. The paper survey allowed only one response per person. Double data entry, comparison of entries and reconciliation of discrepancies were performed using Microsoft Excel before data cleaning. Data encryption was done to protect data confidentiality.

2.4 Measures

2.4.1 Questionnaire

The questionnaire was validated by a panel of five public health researchers and an environmental conservationist. Bilingual researchers translated the English version of the questionnaire into Bahasa Melayu local language. The agreed version was back-translated into English by independent bilingual researchers to ensure linguistic equivalence. The questionnaire was then pilot-tested among 30 individuals from adult local villagers residing in Kampung Rhu 10 and Kampung Mangkuk to assess its clarity and appropriateness. From the pilot study, participants believed that the length was acceptable and the contents were easy to comprehend. These 30 participants did not participate in the actual survey. The panel finalized the questionnaire.

2.4.2 Background characteristics

Participants reported their sociodemographic characteristics including age, gender, education level, monthly income, marital status, employment status, and quality of life.

2.4.3 Domains of sustainability development

Five domains of sustainable development were assessed, which included community participation, ecotourism development, economic, environmental and social sustainability. Community participation was assessed by three questions (e.g., Community participation is needed for sustainable management of marine protected areas), similar to ecotourism development, also assessed by three questions (e.g., Ecotourism development will protect natural resources within marine protected areas). Economic sustainability (e.g., Ecotourism development will improve economic wellbeing), environmental sustainability (e.g., Natural habitats like coral reefs and biodiversity are safe from human interference) and social sustainability (e.g., More socialization programs will be introduced) were assessed by two questions each. All five sustainability domains initially had a seven Likert scale response, ranging from strongly disagree (Md Amin et al., 2020) to strongly agree (Heron et al., 2016), which was recoded into a three response scale; disagree, neutral and agree.

2.5 Statistical analysis

We presented the frequency distribution of all studied variables. We then executed bivariable linear regression models to assess the effect of community participation on the other sustainability domains. Additionally, bivariable and multivariable logistic regression models were conducted to explore the association of background characteristics with each of the five domains of sustainable development. Before logistic regression, the five sustainability domains were initially scored and re-coded as positive/yes if all items were agreed upon and as negative/no for disagree/neutral responses. Only variables significant at 0.25 in univariable analysis were included in the multivariable regression model, considering $p < 0.05$ for statistical significance. We presented the respective odds ratios (crude and adjusted), including their 95% confidence intervals and p-values. All the analysis was done using SPSS version 26.

TABLE 1 Socio-demographic profile of the respondents.

Characteristic	Frequency, n (%), N = 338
Gender	
Male	186 (55.0)
Female	152 (45.0)
Age (years)[a]	
18–30	128 (37.9)
31–45	106 (31.4)
46–60	79 (23.4)
Above 60	24 (7.1)
Monthly income (RM)	
0–500	97 (28.7)
501–1000	71 (21.0)
1001–1500	75 (22.2)
1501–2000	38 (11.2)
Above 2000	57 (16.9)
Education level	
No formal education	20 (5.9)
Primary	46 (13.6)
Secondary	184 (54.4)
Tertiary	88 (26.0)
Residence status	
Resident	276 (81.7)
Non-resident	62 (18.3)
Employment status	
Employed, marine-related	44 (13.0)
Employed, non-marine-related	203 (60.1)
Not employed	91 (26.9)
Quality of life	
Poor	20 (5.9)
Neutral	118 (34.9)
Good	200 (59.2)

[a]1 missing values.

3 Results

3.1 Socio-demographic profile of the respondents

The study consisted of 338 participants, of which the majority were male (55.0%), aged 18–45 years (69.3%), had secondary education (54.4%), and with a monthly income of not more than 1500 RM (71.9%). In addition, 81.7% were residents, 60.1% were employed in non-marine-related jobs, and 59.2% reported a good quality of life (Table 1).

3.2 Domains of sustainable development

The majority of the participants had higher agreement scores for the various domains of sustainable development (Table 2). Community participation received agreement score range of

TABLE 2 Domains of sustainable development (*N* = 338).

Domain	Agree, n (%)	Neutral, n (%)	Disagree, n (%)
Community participation			
Community participation is needed for sustainable management of marine protected areas	218 (64.5)	45 (13.3)	75 (22.2)
Community participation will develop cooperation, collaboration, and social interaction among community members	219 (64.8)	50 (14.8)	69 (20.4)
Community participation will improve two-way communication between residents and local government	231 (68.3)	36 (10.7)	71 (21.0)
Ecotourism Development			
Community participation will ensure ecotourism development	225 (66.6)	46 (13.6)	67 (19.8)
Ecotourism development will create multiple livelihood opportunities for marine protected areas	233 (68.9)	42 (12.4)	63 (18.6)
Ecotourism development will protect natural resources within marine protected areas	213 (63.0)	57 (16.9)	68 (20.1)
Economic Sustainability			
Ecotourism development will improve economic wellbeing	232 (68.6)	51 (15.1)	55 (16.3)
Business opportunities for residents will be available	227 (67.2)	52 (15.4)	59 (17.5)
Environmental Sustainability			
Community participation will support environmental conservation and development projects within marine protected areas	236 (69.8)	47 (13.9)	55 (16.3)
Natural habitats like coral reefs and biodiversity are safe from human interference	218 (64.5)	48 (14.2)	72 (21.3)
Social Sustainability			
The community will be involved with various associations/ organizations	200 (59.2)	67 (19.8)	71 (21.0)
More socialization programs will be introduced	221 (65.4)	60 (17.8)	57 (16.9)

TABLE 3 Linear regression on community participation and sustainability domains.

Sustainability domain	Unadjusted B (95%CI)	*p*-value
Ecotourism development	0.77 (0.72–0.83)	**<0.001**
Economic sustainability	0.46 (0.41–0.51)	**<0.001**
Environmental sustainability	0.47 (0.42–0.51)	**<0.001**
Social sustainability	0.47 (0.42–0.52)	**<0.001**

Bold *p*-value = significant at 0.05.

(64.5%–68.3%), Ecotourism development (63.0%–68.9%), Economic sustainability (67.2%–68.6%), Environmental sustainability (64.5%–69.8%) and Social sustainability (59.2%–65.4%).

3.3 Effect of community participation on sustainability domains

The effect of community participation on the different sustainability domains was independently assessed and presented in Table 3. An increase in community participation was associated with an increase in all four sustainability domains. A unit increase in community participation increased ecotourism development by 77%, economic sustainability by 46%, environmental sustainability by 47% and social sustainability also by 47% (Table 3).

3.4 Factors associated with positive community participation

Among the 338 participants, the prevalence of positive community participation was 57.1% (95%CI: 51.8–62.3). Results of bivariable analysis with factors independently associated with community participation highlighted are detailed in Table 4. On adjusting for the included variables in the multivariable logistic regression model, the factors found with significant association included monthly income, knowledge of coral reefs, and practice of coral reef conservation (Table 4).

Participants with monthly income above 2000 RM (AOR = 3.44, 95% CI: 1.03–11.50) had higher odds of positive community participation compared to those of income 0–500 RM. Compared to those with low knowledge, participants with acceptable knowledge of coral reefs (AOR = 14.50, 95% CI: 7.80–26.95) also had higher odds of positive community participation. Similarly, those with good practice of coral reef conservation (AOR = 3.38, 95% CI: 1.66–6.87) had higher odds of positive community participation compared to their counterparts with poor practice.

3.5 Factors associated with positive ecotourism development

Among the study sample, the prevalence of positive ecotourism development was 53.3% (95%CI: 47.9–58.5). On adjusting for the

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TABLE 4 Factors associated with positive community participation.

Characteristic	Crude odds ratio, (95%CI)	*p*-value*	Adjusted odds ratio, (95%CI)	*p*-value**
Gender		0.861		N/A
Male	1		1	
Female	0.96 (0.62–1.48)		N/A	
Age (years)		0.989		N/A
18–30	1		1	
31–45	0.95 (0.57–1.60)		N/A	
46–60	0.97 (0.55–1.70)			
Above 60	0.86 (0.36–2.07)			
Monthly income (RM)		**0.002**		**0.045**
0–500	1		1	
501–1000	0.90 (0.49–1.67)		2.08 (0.70–6.16)	
1001–1500	0.73 (0.40–1.33)		0.93 (0.31–2.74)	
1501–2000	1.03 (0.48–2.18)		1.65 (0.46–5.93)	
Above 2000	3.90 (1.77–8.61)		**3.44 (1.03–11.50)**	
Education level		**<0.001**		0.521
No formal education	1		1	
Primary	1.43 (0.48–4.24)		1.60 (0.37–6.84)	
Secondary	1.94 (0.74–5.08)		1.28 (0.35–4.75)	
Tertiary	8.36 (2.88–24.28)		2.21 (0.53–9.27)	
Residence status		0.650		N/A
Non-resident	1		1	
Resident	0.89 (0.50–1.54)		N/A	
Employment status		**0.233**		0.060
Not employed	1		1	
Employed, non-marine-related	0.63 (0.30–1.29)		0.30 (0.09–1.05)	
Employed, marine-related	1.11 (0.67–1.83)		0.75 (0.28–2.02)	
Quality of life		**<0.001**		0.931
Poor	1		1	
Neutral	2.11 (0.76–5.86)		1.17 (0.25–5.45)	
Good	4.43 (1.63–12.04)		1.27 (0.28–5.88)	
Knowledge of Coral Reefs		**<0.001**		**<0.001**
Low	1		1	
Acceptable	16.72 (9.73–28.72)		**14.50 (7.80–26.95)**	
Practice of Coral Reef Conservation		**<0.001**		**0.001**
Bad practice	1		1	
Good practice	5.45 (3.05–9.74)		**3.38 (1.66–6.87)**	
Knowledge of MyCoral project		0.291		N/A
Poor	1		1	

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TABLE 4 (*Continued*) **Factors associated with positive community participation.**

Characteristic	Crude odds ratio, (95%CI)	*p*-value*	Adjusted odds ratio, (95%CI)	*p*-value**
Good	1.26 (0.82–1.95)		N/A	
Perceived benefit of MyCoral project		**<0.001**		0.110
No	1		1	
Yes	3.77 (1.85–7.69)		2.32 (0.83–6.52)	
Willingness to volunteer for conservation		**<0.001**		0.150
No	1		1	
Yes	3.96 (2.43–6.45)		1.63 (0.84–3.19)	

* = significant at 0.25, ** = significant at 0.05, N/A = not applicable for multiple logistic regression, **bold** = significant *p*-value and odds ratio.

included variables in the multivariable logistic regression model, the factors found with significant association included monthly income, knowledge of coral reefs, and practice of coral reef conservation (Table 5).

Respondents with acceptable knowledge of coral reefs (AOR = 6.29, 95%CI: 3.53–11.20) had higher odds of positive ecotourism development, compared to those with low knowledge. Similarly, those with good practice of coral reef conservation (AOR = 4.19, 95%CI: 2.17–8.11) had higher odds of positive ecotourism development compared to their counterparts with poor practice.

However, compared to those with a monthly income of 0–500 RM, participants with 500–1000 RM (AOR = 0.37, 95%CI: 0.14–0.98) and 1001–1500 RM (AOR = 0.36, 95%CI: 0.13–0.96) had less odds of positive ecotourism development.

3.6 Factors associated with positive economic sustainability

The prevalence of positive economic sustainability was 61.8% (95%CI: 56.6–66.9). On multivariable logistic regression analysis, the factors found with significant association were knowledge of coral reefs and practice of coral reef conservation (Table 6).

Participants with acceptable knowledge of coral reefs (AOR = 5.98, 95%CI: 3.38–10.60) had higher odds of positive economic sustainability, compared to those with low knowledge. Moreover, those with good practice of coral reef conservation (AOR = 3.95, 95%CI: 1.97–7.92) also had higher odds of positive economic sustainability, compared to those with poor practice.

3.7 Factors associated with positive environmental sustainability

The prevalence of positive environmental sustainability was 58.9% (95%CI: 53.6–64.0) among the study participants. On multivariable logistic regression analysis, the factors found with significant association included residence, employment status, knowledge of coral reefs, practice of coral reef conservation and willingness to volunteer for conservation (Table 7).

Compared to non-residents, residents (AOR = 2.46 1.21–4.99) had higher odds of positive environmental sustainability. Similarly, those with acceptable knowledge of coral reefs (AOR = 9.08, 95%CI: 4.83–17.07) and good practice of coral reef conservation (AOR = 3.51, 95%CI: 1.74–7.07) had higher odds of positive environmental sustainability, compared to those with low knowledge and poor practice respectively. Moreover, those willing to volunteer for coral reef conservation (AOR = 1.99, 95%CI: 1.03–3.84) also had higher odds of positive environmental sustainability, compared to those not willing to volunteer. However, compared to the unemployed, participants employed in non-marine-related (AOR = 0.27, 95% CI: 0.08–0.95) and marine-related (AOR = 0.27, 95%CI: 0.10–0.75) jobs had less odds of positive environmental sustainability.

3.8 Factors associated with positive social sustainability

The prevalence of positive social sustainability was 55.6% (95% CI: 50.3–60.9). Results of multivariable logistic regression analysis show that employment status, knowledge of coral reefs, practice of coral reef conservation and willingness to volunteer for conservation were significantly associated with positive social sustainability (Table 8).

Participants with acceptable knowledge of coral reefs (AOR = 7.11, 95%CI: 3.84–13.15), good practice of coral reef conservation (AOR = 5.26, 95%CI: 2.54–10.91), and willing to volunteer for coral reef conservation (AOR = 1.98, 95%CI: 1.02–3.83) had higher odds of positive social sustainability, compared to those with low knowledge, poor practice and not willing to volunteer, respectively. However, those employed in marine-related jobs (AOR = 0.27, 95%CI: 0.10–0.72) had less odds of positive social sustainability, compared to those who are not employed.

4 Discussion

4.1 Primary findings

The study aimed to investigate the impact of community participation on various aspects of sustainability in Malaysia, with a specific focus on coral reef conservation. The study determined the prevalence of positive sustainability domains in Malaysia. Ultimately, it also explored the interplay between sociodemographic variables and these domains and identified plausible factors associated with positive community

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TABLE 5 Factors associated with positive Ecotourism development.

Characteristic	Crude odds ratio, (95%CI)	*p*-value	Adjusted odds ratio, (95%CI)	*p*-value
Gender		0.504		N/A
Male	1		1	
Female	1.16 (0.75–1.78)		N/A	
Age (years)		0.574		N/A
18–30	1		1	
31–45	0.79 (0.47–1.32)		N/A	
46–60	0.68 (0.39–1.19)			
Above 60	0.86 (0.36–2.07)			
Monthly income (RM)		**<0.001**		**0.040**
0–500	1		1	
501–1000	0.35 (0.18–0.65)		**0.37 (0.14–0.98)**	
1001–1500	0.40 (0.21–0.74)		**0.36 (0.13–0.96)**	
1501–2000	0.57 (0.26–1.21)		0.55 (0.17–1.72)	
Above 2000	1.45 (0.71–2.95)		0.85 (0.30–2.42)	
Education level		**0.005**		0.758
No formal education	1		1	
Primary	1.15 (0.40–3.36)		1.23 (0.33–4.69)	
Secondary	1.47 (0.57–3.76)		1.17 (0.35–3.87)	
Tertiary	3.39 (1.24–9.24)		1.13 (0.31–4.10)	
Residence status		0.996		N/A
Non-resident	1		1	
Resident	1.00 (0.58–1.74)		N/A	
Employment status		**0.034**		0.490
Not employed	1		1	
Employed, non-marine-related	0.45 (0.22–0.94)		0.55 (0.19–1.63)	
Employed, marine-related	0.63 (0.38–1.04)		0.85 (0.36–2.04)	
Quality of life		**0.002**		0.788
Poor	1		1	
Neutral	1.84 (0.66–5.11)		1.60 (0.41–6.14)	
Good	3.65 (1.35–9.90)		1.58 (0.41–6.08)	
Knowledge of Coral Reefs		**<0.001**		**<0.001**
Low	1		1	
Acceptable	7.77 (4.78–12.63)		**6.29 (3.53–11.20)**	
Practice of Coral Reef Conservation		**<0.001**		**<0.001**
Bad practice	1		1	
Good practice	5.72 (3.26–10.04)		**4.19 (2.17–8.12)**	
Knowledge of MyCoral project		**0.221**		0.592
Poor	1		1	

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TABLE 5 (*Continued*) Factors associated with positive Ecotourism development.

Characteristic	Crude odds ratio, (95%CI)	*p*-value	Adjusted odds ratio, (95%CI)	*p*-value
Good	1.31 (0.85–2.02)		0.85 (0.48–1.53)	
Perceived benefit of MyCoral project		**0.004**		0.444
No	1		1	
Yes	2.77 (1.38–5.55)		1.45 (0.56–3.78)	
Willingness to volunteer for conservation		**<0.001**		0.399
No	1		1	
Yes	3.10 (1.92–5.02)		1.31 (0.70–2.47)	

* = significant at 0.25, ** = significant at 0.05, N/A, not applicable for multiple logistic regression, **bold** = significant *p*-value and odds ratio.

participation, ecotourism development, economic sustainability, and social sustainability. According to the general sociodemographic profile of 338 participants included in the study, the majority agreed with the various domains of sustainable development. The agreement scores ranged from 64.5% to 68.3% for community participation, 63.0%–68.9% for ecotourism development, 67.2%–68.6% for economic sustainability, 64.5%–69.8% for environmental sustainability, and 59.2%–65.4% for social sustainability. The findings of this research, while initially focused on a Malaysian context, have broader implications for global conservation efforts. Sustainable practices, anchored by the engagement of local communities, extend beyond national boundaries, and our study offers insights that can be adopted by international policymakers. From reef restoration to the establishment of Marine Protected Areas (MPAs), the strategies illuminated in this study can serve as benchmarks for sustainable efforts worldwide. The interconnectedness of our ecosystems underscores the need for a unified global approach, and our research contributes to this collective knowledge, urging international communities to adopt and adapt these practices.

Specifically, the effect of community participation on the different sustainability domains was independently assessed and it was found that a unit increase in community participation was associated with an increase in all four sustainability domains, namely, ecotourism development, economic sustainability, environmental sustainability, and social sustainability. The study's outcome affirms the belief of Osman et al., that engaging local communities in coral reef conservation is crucial for sustainable development (Osman et al., 2018). Despite the challenges, community involvement in managing ecotourism projects and programs in coral reef conservation can offer social and economic advantages and enhance acceptance of conservation strategies (Bittar Rodrigues and Prideaux, 2017). This suggests that involving local communities is essential for promoting and managing economic resources, which can lead to increased sustainability of coral reefs. This aligns with the notion that community participation is an essential aspect of sustainable development, particularly in the context of natural resource management.

The study investigated the interplay between sociodemographic variables and various sustainability domains. On analysis, it found that the prevalence of positive sustainability domains was high and the majority of participants showed agreement towards each domain. The highest prevalence of positive sustainability domains was in community development, and economic sustainability, followed by environmental sustainability and ecotourism development (Table 4). This finding is supported by the research conducted by Muniandy et al. (2020) which also revealed a high prevalence of positive attitudes towards sustainable development in Malaysia.

The findings emphasize the pivotal role of sustainable practices and the active engagement of local communities in advancing conservation initiatives. Such endeavors encompass reef restoration, the establishment of Marine Protected Areas (MPAs), and the promotion of sustainable fishing. These collective efforts, deeply rooted in community involvement, have the potential to amplify sustainability across various sectors. This can have important implications for the management and conservation of marine protected areas, as well as for the wellbeing of the communities that depend on these resources.

It found that monthly income, knowledge of coral reefs, and practice of coral reef conservation were significant factors associated with positive community participation in sustainable development efforts, specifically in the context of coral reef conservation in Malaysia. Such practices of coral reef conservation typically encompass a spectrum of activities. These range from direct actions like reef clean-up drives, coral planting, and rehabilitation efforts to more indirect efforts such as awareness campaigns, eco-friendly fishing practices, and adherence to sustainable tourism guidelines. Furthermore, the active involvement of local communities in monitoring and reporting illegal activities detrimental to the reef ecosystem, such as coral mining or use of destructive fishing methods, is a significant component of conservation practice. In other words, pparticipants with higher monthly incomes, acceptable knowledge of coral reefs, and good practices of coral reef conservation were more likely to demonstrate positive community participation. This finding is supported by Khan et al. (2016) research, which also found that community participation in conservation efforts was significantly influenced by socioeconomic factors. Similarly, Adekola et al. (2020) study, also revealed that education and awareness played a significant role in promoting sustainable practices in waste management. This highlights the importance of education and engagement in promoting sustainable practices and suggests that economic status may play a role in community involvement in conservation efforts.

TABLE 6 Factors associated with positive Economic sustainability.

Characteristic	Crude odds ratio, (95%CI)	*p*-value*	Adjusted odds ratio, (95%CI)	*p*-value**
Gender		0.651		N/A
Male	1		1	
Female	1.11 (0.71–1.72)		N/A	
Age (years)		0.469		N/A
18–30	1		1	
31–45	1.19 (0.70–2.02)		N/A	
46–60	0.92 (0.52–1.63)			
Above 60	1.99 (0.74–5.34)			
Monthly income (RM)		0.174		N/A
0–500	1		1	
501–1000	0.76 (0.41–1.42)		N/A	
1001–1500	0.75 (0.41–1.39)			
1501–2000	0.91 (0.42–1.95)			
Above 2000	1.81 (0.87–3.76)			
Education level		**0.016**		0.755
No formal education	1		1	
Primary	1.30 (0.45–3.73)		1.14 (0.32–4.16)	
Secondary	1.36 (0.54–3.42)		0.74 (0.24–2.28)	
Tertiary	3.19 (1.17–8.71)		0.77 (0.22–2.66)	
Residence status		0.922		N/A
Non-resident	1		1	
Resident	1.03 (0.58–1.81)		N/A	
Employment status		0.765		N/A
Not employed	1		1	
Employed, non-marine-related	0.78 (0.37–1.64)		N/A	
Employed, marine-related	0.85 (0.51–1.42)			
Quality of life		**0.003**		0.082
Poor	1		1	
Neutral	4.38 (1.49–12.84)		4.66 (1.18–18.40)	
Good	6.09 (2.12–17.48)		3.55 (0.91–13.91)	
Knowledge of Coral Reefs		**<0.001**		**<0.001**
Low	1		1	
Acceptable	7.63 (4.64–12.55)		**5.98 (3.38–10.60)**	
Practice of Coral Reef Conservation		**<0.001**		**<0.001**
Bad practice	1		1	
Good practice	6.12 (3.24–11.56)		**3.95 (1.97–7.92)**	
Knowledge of MyCoral project		0.714		N/A
Poor	1		1	

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TABLE 6 (*Continued*) Factors associated with positive Economic sustainability.

Characteristic	Crude odds ratio, (95%CI)	*p*-value*	Adjusted odds ratio, (95%CI)	*p*-value**
Good	1.09 (0.70–1.69)		N/A	
Perceived benefit of MyCoral project		**<0.001**		0.069
No	1		1	
Yes	4.18 (2.08–8.42)		2.31 (0.94–5.67)	
Willingness to volunteer for conservation		**<0.001**		0.069
No	1		1	
Yes	3.57 (2.21–5.78)		1.73 (0.96–3.14)	

* = significant at 0.25, ** = significant at 0.05, N/A, not applicable for multiple logistic regression, **bold** = significant *p*-value and odds ratio.

The study findings show that respondents who had acceptable knowledge of coral reefs and good practices of coral reef conservation were more likely to have positive ecotourism development. However, the study also found that monthly income had a negative association with positive ecotourism development, with participants earning 500–1000 RM and 1001–1500 RM having lower odds of positive ecotourism development compared to those with a monthly income of 0–500 RM. These findings are supported by previous research on the role of education and engagement in promoting sustainable practices, as well as the impact of socioeconomic factors on conservation efforts (Kaplan-Hallam et al., 2013; Zahari et al., 2021; Rahman et al., 2022). These findings suggest that efforts to promote ecotourism development should prioritize education and engagement to improve knowledge and practice, and should also consider the impact of socioeconomic factors on participation and engagement.

Moreover, study results show that participants with acceptable knowledge and good practice had higher odds of positive economic sustainability compared to those with low knowledge and poor practice, respectively. The findings are in line with the results of previous research. For example, Gopalakrishnan et al. (2014) found that sustainable fishing practices, including coral reef conservation, were positively associated with the economic sustainability of fishing communities in India. Similarly, a study by Mambrasar et al. (2018) found that the sustainable use of coral reef resources was positively associated with economic sustainability in fishing communities in Indonesia. The findings of the study emphasize the importance of knowledge and good practices of coral reef conservation in achieving positive economic sustainability. This further highlights the need for education and training programs that can improve the knowledge and skills of local communities and stakeholders involved in coral reef conservation. Such programs can help promote the sustainable use of coral reef resources, leading to improved economic sustainability.

The study found that participants who were residents had higher odds of positive environmental sustainability compared to non-residents, similar to those with acceptable knowledge and good practice of coral reef conservation, as well as those willing to volunteer for conservation. However, participants employed in non-marine-related and marine-related jobs had lower odds of positive environmental sustainability compared to the unemployed. One relevant reference supporting these findings is a study by Cinner et al. (2014) which also found that community engagement and participation in conservation efforts are important factors for achieving positive environmental outcomes. Another study by Weeks et al. (2014) also found that knowledge and awareness of coral reef conservation are crucial for achieving sustainable reef management. Our findings bring forth pivotal implications for the larger realm of sustainable development. They underscore the immense transformative power that community engagement, when amalgamated with knowledge and proactive coral reef conservation practices, can wield. The insights acquired can guide tailored strategies, ensuring they resonate with regional socio-demographic characteristics, fostering a deeper and more impactful engagement in conservation. The findings of the study suggest that improving knowledge and promoting good practices of coral reef conservation can have positive impacts on economic sustainability. Unpacking the mechanisms behind the evident influence of community participation, it becomes evident that informed community engagement acts as a catalyst. When the community is not just aware but also understands the intricacies of coral reef conservation, it manifests in ground-level proactive actions, creating a ripple effect. This seamless translation from awareness to actionable steps is the bedrock of sustainable positive outcomes, building a resilient and thriving ecosystem. This highlights the importance of education and outreach efforts to increase awareness and understanding of the value of coral reefs and the benefits of conservation practices. These efforts can lead to more sustainable use of coral reef resources and ultimately contribute to the long-term economic viability of communities dependent on these resources.

The study found that participants with acceptable knowledge, good practice, and willingness to volunteer had higher odds of positive social sustainability, while those employed in marine-related jobs had lower odds. One study that supports the association between knowledge and coral reef conservation is by Sutcliffe et al. (2019) which found that increased knowledge of coral reef conservation can lead to improved attitudes towards conservation and increased pro-environmental behaviour. Another study by Bhatia et al. (2021); Marzo et al. (2023) found that willingness to volunteer for conservation can positively impact environmental sustainability. While the study underscores the value of community engagement, it equally brings to light challenges impeding community participation in coral reef conservation. Economic disparities can overshadow long-term conservation

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TABLE 7 Factors associated with positive environmental sustainability.

Characteristic	Crude odds ratio, (95%CI)	*p*-value	Adjusted odds ratio, (95%CI)	*p*-value
Gender		**0.221**		0.235
Male	1		1	
Female	1.31 (0.85–2.04)		1.45 (0.79–2.66)	
Age (years)		0.984		N/A
18–30	1		1	
31–45	0.96 (0.57–1.63)		N/A	
46–60	0.95 (0.54–1.69)			
Above 60	1.14 (0.46–2.80)			
Monthly income (RM)		**0.011**		0.459
0–500	1		1	
501–1000	0.40 (0.21–0.75)		0.95 (0.34–2.71)	
1001–1500	0.62 (0.34–1.16)		1.52 (0.52–4.46)	
1501–2000	0.71 (0.33–1.53)		1.76 (0.51–6.11)	
Above 2000	1.32 (0.65–2.70)		2.13 (0.68–6.72)	
Education level		**0.055**		0.267
No formal education	1		1	
Primary	0.63 (0.22–1.81)		0.42 (0.11–1.65)	
Secondary	1.16 (0.46–2.94)		0.58 (0.17–1.97)	
Tertiary	1.75 (0.65–4.71)		0.32 (0.08–1.25)	
Residence status		**0.118**		**0.013**
Non-resident	1		1	
Resident	1.56 (0.89–2.71)		**2.46 (1.21–4.99)**	
Employment status		**0.018**		**0.039**
Not employed	1		1	
Employed, non-marine-related	0.44 (0.21–0.92)		**0.27 (0.08–0.95)**	
Employed, marine-related	0.48 (0.28–0.82)		**0.27 (0.10–0.75)**	
Quality of life		**0.002**		0.204
Poor	1		1	
Neutral	2.50 (0.90–6.94)		3.57 (0.88–14.54)	
Good	4.53 (1.67–12.31)		3.26 (0.81–13.15)	
Knowledge of Coral Reefs		**<0.001**		**<0.001**
Low	1		1	
Acceptable	8.44 (5.14–13.85)		**9.08 (4.83–17.07)**	
Practice of Coral Reef Conservation		**<0.001**		**<0.001**
Bad practice	1		1	
Good practice	5.39 (2.98–9.74)		**3.51 (1.74–7.07)**	
Knowledge of MyCoral project		**0.025**		0.644
Poor	1		1	

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TABLE 7 (*Continued*) Factors associated with positive environmental sustainability.

Characteristic	Crude odds ratio, (95%CI)	*p*-value	Adjusted odds ratio, (95%CI)	*p*-value
Good	1.66 (1.07–2.58)		1.16 (0.63–2.13)	
Perceived benefit of MyCoral project		**0.003**		0.608
No	1		1	
Yes	2.82 (1.43–5.56)		1.28 (0.50–3.28)	
Willingness to volunteer for conservation		**<0.001**		**0.041**
No	1		1	
Yes	3.71 (2.29–6.01)		**1.99 (1.03–3.84)**	

* = significant at 0.25, ** = significant at 0.05, N/A, not applicable for multiple logistic regression, **bold** = significant *p*-value and odds ratio.

benefits due to immediate necessities. Despite living near these ecosystems, many community members may not fully grasp the ecological importance of coral reefs. Even with enthusiasm, communities might face resource limitations, both financial and skill-based. Those engaged in marine-centric professions might face conflicting interests, such as prioritizing immediate catches. Some long-standing cultural practices might inadvertently hinder conservation efforts, requiring adaptive approaches that respect these traditions. Moreover, the absence of robust support from governmental bodies or NGOs can deter community conservation initiatives. Addressing these challenges demands a holistic approach, including policy reforms, educational campaigns, and inclusive conservation strategies. The findings suggest that promoting awareness and education on coral reef conservation and encouraging community participation in conservation efforts can have positive impacts on social sustainability. Additionally, supporting and incentivizing volunteering for conservation can further improve social sustainability. It also highlights the importance of considering the employment status of individuals in the design and implementation of conservation initiatives.

4.2 Implication of study findings

The implications of the study findings are wide-ranging and can be applied to various aspects of sustainable development and community participation in Malaysia. First, the findings suggest that promoting community participation can be an effective strategy for achieving sustainable development, particularly in the context of coral reef conservation. After highlighting the potential for our findings to guide policymakers and stakeholders, it's pivotal to suggest concrete steps. Short-term measures could include establishing immediate no-fishing zones in critical reef habitats and deploying rapid response teams for chemical or waste spills. For a medium-term approach, it's beneficial to invest in public education campaigns about reefs, craft eco-tourism standards, and train communities on sustainable fishing. Long-term initiatives might focus on integrating coral reef conservation into the national curriculum, establishing dedicated research institutes, and fostering international collaborations for consistent monitoring. Policymakers and stakeholders can use these findings to prioritize community engagement and involvement in sustainability initiatives, to achieve long-term success and competitiveness in sustainable development.

Second, the study identifies socioeconomic factors and education as important aspects in efforts to promote community participation in sustainable development. It is important to understand the influence of these factors on sustainable development to effectively promote community participation. By addressing socioeconomic factors and promoting education and engagement, it may be possible to improve community participation in sustainable development and support the long-term sustainability of the region.

Third, the study suggests that efforts to promote ecotourism development in the context of coral reef conservation should prioritize educational initiatives and engagement with the community, particularly those with low knowledge and poor practices of conservation. Policymakers and stakeholders should consider these factors when designing and implementing programs aimed at promoting ecotourism development and sustainable practices in Malaysia. It also emphasizes the importance of empowering communities with knowledge and skills to effectively manage and conserve natural resources, which can contribute to sustainable economic growth. Efforts to promote economic sustainability in coral reef conservation should prioritize education and engagement to improve knowledge and practice of conservation, which can lead to positive economic outcomes.

4.3 Limitations and future studies

While the study provides valuable insights into the relationship between community participation and sustainable development in Malaysia, there are some limitations to consider. The use of a cross-sectional design only provides a snapshot of the current situation and cannot establish causality. Longitudinal studies or experimental designs would provide more robust evidence of the impact of community participation on sustainable development over time. Moreover, the reliance on self-reported data, may be subject to social desirability bias. Participants may have provided answers they felt were expected or socially acceptable rather than their true beliefs or behaviours. The study was also limited to a specific geographic area in Malaysia and focused specifically on the context of coral reef conservation and ecotourism development, future studies should explore other sustainable development sectors and regions.

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TABLE 8 Factors associated with positive Social sustainability.

Characteristic	Crude odds ratio, (95%CI)	*p*-value	Adjusted odds ratio, (95%CI)	*p*-value
Gender		0.156		N/A
Male	1		1	
Female	1.369 (0.887–2.112)		N/A	
Age (years)		**0.249**		0.505
18–30	1		1	
31–45	0.695 (0.412–1.171)		1.03 (0.51–2.08)	
46–60	0.575 (0.326–1.014)		0.60 (0.28–1.30)	
Above 60	0.868 (0.358–2.107)		0.97 (0.25–3.68)	
Monthly income (RM)		**0.043**		0.733
0–500	1		1	
501–1000	0.559 (0.301–1.039)		1.62 (0.57–4.62)	
1001–1500	0.627 (0.341–1.153)		1.69 (0.58–4.94)	
1501–2000	0.644 (0.303–1.371)		1.22 (0.35–4.24)	
Above 2000	1.515 (0.754–3.048)		2.08 (0.66–6.55)	
Education level		**0.004**		0.664
No formal education	1		1	
Primary	0.964 (0.330–2.819)		0.95 (0.23–3.84)	
Secondary	1.825 (0.713–4.675)		1.39 (0.39–4.99)	
Tertiary	3.389 (1.243–9.238)		0.91 (0.23–3.77)	
Residence status		0.891		N/A
Non-resident	1		1	
Resident	1.040 (0.598–1.809)		N/A	
Employment status		**0.035**		**0.032**
Not employed	1		1	
Employed, non-marine-related	0.59 (0.28–1.23)		0.36 (0.11–1.20)	
Employed, marine-related	0.51 (0.30–0.85)		**0.27 (0.10–0.72)**	
Quality of life		**<0.001**		0.214
Poor	1		1	
Neutral	1.72 (0.62–4.78)		1.76 (0.39–8.07)	
Good	4.53 (1.67–12.31)		2.73 (0.60–12.44)	
Knowledge of Coral Reefs		**<0.001**		**<0.001**
Low	1		1	
Acceptable	8.14 (4.99–13.28)		**7.107 (3.84–13.15)**	
Practice of Coral Reef Conservation		**<0.001**		**<0.001**
Bad practice	1		1	
Good practice	8.70 (4.60–16.45)		**5.26 (2.54–10.91)**	
Knowledge of MyCoral project		**0.001**		0.311
Poor	1		1	

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TABLE 8 (*Continued*) **Factors associated with positive Social sustainability.**

Characteristic	Crude odds ratio, (95%CI)	*p*-value	Adjusted odds ratio, (95%CI)	*p*-value
Good	2.10 (1.35–3.26)		1.38 (0.74–2.57)	
Perceived benefit of MyCoral project		**0.004**		0.885
No	1		1	
Yes	2.73 (1.38–5.42)		1.08 (0.40–2.92)	
Willingness to volunteer for conservation		**<0.001**		**0.044**
No	1		1	
Yes	4.07 (2.49–6.65)		**1.98 (1.02–3.83)**	

* = significant at 0.25, ** = significant at 0.05, N/A, not applicable for multiple logistic regression, **bold** = significant *p*-value and odds ratio.

5 Conclusion

Our research underscores the profound significance of active community participation in the realm of sustainable development. Delving deep into the intricate relationships between various sustainability domains, this study provides insights into how socioeconomic variables and education shape community engagement in conservation efforts. The undeniable correlation between informed communities and favorable environmental and social outcomes became evident, stressing the pivotal role of targeted educational drives and robust community interactions. For policymakers and stakeholders, this research acts as an invaluable guide. The data illuminates the nuances that often determine the success or failure of interventions. By identifying key socioeconomic determinants, intervention strategies can be more tailored, ensuring they resonate with specific community dynamics or address particular challenges. Moreover, discerning the educational gaps can pave the way for more impactful awareness campaigns that foster genuine understanding and tangible action. But beyond these insights, the study solidifies a crucial notion: for sustainable development and coral reef conservation to truly prosper in Malaysia, strategies must be community-centric, harnessing the collective strength and knowledge of local populations. It's this grassroots involvement, informed by the study's findings, that will anchor lasting, positive change in the realms of conservation and sustainable development.

Data availability statement

The original contributions presented in the study are included in the article/Supplementary Material, further inquiries can be directed to the corresponding authors.

Ethics statement

The studies involving humans were approved the by Ethics Committee of Management and Science University. The studies were conducted in accordance with the local legislation and institutional requirements. The participants provided their written informed consent to participate in this study.

Author contributions

RM: Conceptualization, Data curation, Formal Analysis, Investigation, Methodology, Project administration, Resources, Software, Supervision, Validation, Visualization, Writing–original draft, Writing–review and editing. HC: Writing–original draft, Writing–review and editing. HA: Writing–original draft, Writing–review and editing. MAb: Writing–original draft, Writing–review and editing. MI: Writing–original draft, Writing–review and editing. IA: Writing–original draft, Writing–review and editing. AA: Writing–original draft, Writing–review and editing. JK: Data curation, Formal Analysis, Methodology, Software, Writing–original draft, Writing–review and editing. MAl: Writing–original draft, Writing–review and editing.

Funding

The author(s) declare financial support was received for the research, authorship, and/or publication of this article. The authors of this study extend their appreciation to the Research Supporting Project, King Saud University, Saudi Arabia, for supporting this study (RSP-2023R481).

Conflict of interest

The authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

Publisher's note

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