Egyptian Journal of Aquatic Biology & Fisheries
Zoology Department, Faculty of Science,
Ain Shams University, Cairo, Egypt.
ISSN 1110 – 6131
Vol. 29(5): 2921 – 2941 (2025)
www.ejabf.journals.ekb.eg

The Role of Community Perception and Participation in Reducing Land-Based Sources of Aquatic Pollution: A Waste Management Model from Badung, Bali

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ARTICLE INFO

Article History:
Received: July 20, 2025
Accepted: Oct. 2, 2025
Online: Oct. 25, 2025

Keywords:
Participatory waste management,
Community perception,
Public participation,
Institutional support,
SEM AMOS,
Sustainable governance,
Bali,
Indonesia,
Coastal waste management

ABSTRACT

The degradation of marine and coastal ecosystems due to land-based pollution is a critical global challenge. In tourism-dependent coastal regions like Badung Regency, Bali, rapidly increasing household and tourism waste threatens aquatic environments, fisheries, and coral reefs. This study addressed this issue by developing a participatory waste management model aimed at mitigating a primary source of aquatic pollution. A mixed-method approach was employed in 2024, combining a quantitative household survey of 400 respondents analyzed using Structural Equation Modeling (SEM-AMOS) with qualitative data from 20 key informant interviews and focus group discussions. The findings reveal that community perception is a significant driver of both public participation in waste management activities (β= 0.41, *P*< 0.001) and the demand for institutional support (β= 0.36, *P*= 0.002). Furthermore, active participation was identified as the most critical predictor of the model's effectiveness (β= 0.48, *P*< 0.001). Institutional support also plays a vital role by directly enhancing effectiveness (β= 0.27, *P*= 0.009) and moderating the relationship between perception and participation. Qualitative data underscored the importance of leveraging local cultural traditions to foster community engagement. This research demonstrates that managing terrestrial waste through a community-centered, participatory framework is an effective upstream strategy for protecting aquatic resources. The validated model provides an evidence-based approach for coastal governance, offering valuable insights for policymakers and practitioners in the fields of aquatic management and conservation. By strengthening community involvement in waste management on land, significant reductions can be achieved in the flow of pollutants into marine and freshwater systems.

INTRODUCTION

The exponential growth of the global population is critically linked to the increasing production of municipal solid waste (MSW), which poses significant

challenges to waste management systems worldwide. With projections indicating that global MSW generation could rise by almost 70% by 2050, reaching approximately 3.4 billion metric tons annually, a multifaceted approach is needed to tackle the underlying drivers of this trend, such as urbanization, economic development, and changing consumption patterns **(Ferronato & Torretta, 2019; Lebreton & Andrady, 2019)**. Nonetheless, it is reported that a staggering 91% of waste worldwide is mismanaged, with only about 13.5% being recycled, indicating a significant failure of existing waste management frameworks to adapt to these rapid changes **(Ferronato & Torretta, 2019)**. The implications of such mismanagement extend beyond environmental degradation; they encompass severe public health risks, economic losses estimated to be up to USD 400 billion annually, and long-term ecological threats, including contamination of soil and waterways **(Ferronato & Torretta, 2019)**. Importantly, the call for integrated and sustainable waste management strategies is amplified by the increasing pressures that urbanization and population growth exert on both developed and developing nations **(Mukama *et al.*, 2016; Ferronato & Torretta, 2019)**.

In the Indonesian context, particularly in regions such as Bali, the waste management issues mirror those of other developing countries but are exacerbated by unique socio-cultural factors. Rapid urbanization alongside population growth has outpaced infrastructure development, significantly contributing to the inadequate management of waste **(Mukama *et al.*, 2016; Ferronato & Torretta, 2019)**. Local studies have highlighted that the low levels of public awareness regarding waste handling, coupled with ingrained behaviors such as improper disposal and inadequate separation of waste, hinder effective waste management **(Okot-Okumu & Nyenje, 2011; Debrah *et al.*, 2021)**. Moreover, the surge in infrastructural projects has led to an increase in construction and demolition waste, further complicating the waste management landscape **(Ferronato & Torretta, 2019)**. As traditional technological or regulatory solutions fall short, the integration of behavioral change, community participation, and culturally relevant practices becomes paramount in developing sustainable governance models **(Yu *et al.*, 2017; Szpilko *et al.*, 2023)**.

Particularly acute in Bali is the issue of household waste management amidst an ever-expanding tourism sector, which significantly inflates waste generation. Current assessments indicate that Bali produces approximately 3,436 tons of waste daily, predominantly from household sources **(D.C. *et al.*, 2020)**. In areas like Badung Regency, the waste management systems remain heavily reliant on collection and disposal practices, which have proven insufficient given the scale and complexity of waste generation **(D.C. *et al.*, 2020)**. Efforts to implement initiatives such as the 3R programs (Reduce, Reuse, Recycle) and community-based waste banks have encountered numerous challenges, including inadequate infrastructure and weak legal enforcement, highlighting the need for stronger community engagement **(Oteng-Ababio, 2011; D.C. *et al.*, 2020)**. Regulatory efforts, such as the Governor of Bali's new orders banning single-use plastics,

demonstrate a shift toward sustainable practices; however, significant barriers in public awareness and enforcement persist **(Mukama *et al.*, 2016)**.

The relationship between community perception and participation in waste management is critical to success. Empirical research demonstrates that the effectiveness of waste management initiatives is strongly influenced by public willingness to engage in waste sorting and responsible disposal practices **(Dias, 2016; Ugoeze *et al.*, 2024)**. However, Indonesia's waste governance largely remains a top-down model, providing minimal opportunities for public input, which may hamper the desired outcomes of waste management programs **(Aryampa *et al.*, 2019)**. In light of this, fostering awareness and participation among local stakeholders will be essential for ensuring the sustainability and efficacy of these management systems, especially in tourism-driven areas like Bali **(Yu *et al.*, 2017; Szpilko *et al.*, 2023)**.

This research endeavors to fill existing gaps in the literature by deeply investigating community perceptions and participation in Badung Regency's waste management initiatives, particularly in relation with enhancing sustainable source-based waste management models. With an eye toward generating actionable insights for local policies while contributing to global discussions on effective waste governance in emerging tourism zones, the study pursued the following objectives: 1) assess community perceptions of waste management policies and practices; 2) evaluate public participation levels in waste management initiatives; and 3) analyze the relationship between perception, participation, and institutional support in enhancing participatory waste management systems. While previous research has explored various facets of waste management, a significant gap remains in understanding the interplay between community perception, participation, and institutional support within a holistic model, especially in the context of a tourism-driven economy like Bali. This study aimed to fill that gap by developing and validating a participatory waste management model using Structural Equation Modeling (SEM).

MATERIALS AND METHODS

Study area and context: A coastal system under pressure

This research was conducted in Badung Regency, Bali, Indonesia, a coastal region characterized by a dense population and a globally significant tourism industry. The regency's extensive coastline and the economic reliance on marine resources (including fisheries, aquaculture, and tourism-related activities) make its aquatic ecosystems particularly vulnerable to land-based sources of pollution. Ineffective management of solid waste generated by both residential and tourism activities is a primary pathway for pollutants, particularly plastics and organic matter, to enter rivers and ultimately the marine environment, posing a direct threat to coral reefs, mangrove forests, and coastal

water quality. This study focuses on understanding and modeling waste management at its source as an upstream intervention to protect these critical aquatic habitats.

Research design

This study employed a cross-sectional survey design to collect data from households in Badung Regency, Indonesia. The sample size was determined to be 400 households using Cochran's formula, ensuring a 95% confidence level and a 5% margin of error. A multi-stage stratified random sampling technique was implemented to ensure a representative sample. The regency was first stratified by its six districts, and households were then randomly selected from within these strata to reflect variations in urbanization and proximity to the coast.

Data collection

Quantitative data: Household survey

A structured questionnaire was administered to a sample of 400 households across Badung Regency in 2024. The sample size was determined using Cochran's formula to ensure a 95% confidence level and a 5% margin of error. A multi-stage stratified random sampling technique was used to ensure representation across different sub-districts, reflecting varying levels of urbanization and proximity to the coast.

The survey instrument was designed to measure the key latent variables of our proposed model:

- **Community Perception:** Assessed residents' awareness of waste-related problems, including their understanding of the impact of mismanaged waste on local rivers and marine life.
- **Public Participation:** Quantified the extent and frequency of household engagement in source-based waste management activities such as waste separation, composting, and recycling.
- **Institutional Support:** Measured residents' views on the adequacy of government policies, infrastructure (e.g., waste banks, collection services), and regulatory enforcement.
- **Model Effectiveness:** Gauged the perceived success of existing waste management programs in reducing waste volume and preventing environmental pollution.

Qualitative data: Key informant interviews and focus groups

To provide depth and context to the quantitative findings, qualitative data were collected from 20 key informants. Participants were purposively selected and included community leaders (*kepala desa*), heads of customary villages (*bendesa adat*), managers of local waste facilities (TPS3R), environmental agency officials, and representatives from youth organizations.

Semi-structured interviews and two focus group discussions (FGDs) were conducted to explore themes such as cultural motivators for environmental stewardship (e.g., the *Tri Hita Karana* philosophy), barriers to effective household waste separation, and the practical challenges of implementing waste management policies. This qualitative inquiry was crucial for understanding the socio-cultural mechanisms that influence the flow of waste from land to sea.

Data analysis

The analysis involved two stages: a measurement model to assess the validity and reliability of the constructs, and a structural model to test the hypothesized relationships among community perception, participation, institutional support, and the reduction of aquatic pollution.

Quantitative analysis

The collected data were analyzed using the Statistical Package for the Social Sciences (SPSS) for descriptive statistics and Analysis of Moment Structures (AMOS) version 24 for the Structural Equation Modeling (SEM). SEM was chosen for its ability to test the complex system of relationships between the observed and latent variables simultaneously. The analysis proceeded in two stages:

1. **Measurement Model:** A Confirmatory Factor Analysis (CFA) was performed to assess the validity and reliability of the measurement scales for each construct (perception, participation, institutional support, and effectiveness). Model fit was evaluated using standard indices, including CMIN/DF, GFI, CFI, TLI, and RMSEA.
2. **Structural Model:** Following confirmation of the measurement model, the full structural model was tested to determine the strength and significance of the causal pathways between the constructs. This allowed for the empirical validation of our proposed participatory model for waste management.

Qualitative analysis

The qualitative data from interviews and FGDs were transcribed verbatim and analyzed using a thematic analysis approach. The process involved data familiarization, initial coding, theme identification, and interpretation. The resulting themes were used to explain and contextualize the statistical relationships identified in the SEM analysis, providing a richer understanding of how community-led actions can serve as a defense against aquatic pollution.

RESULTS

Structural equation modelling (SEM AMOS)

The structural model showed an excellent fit with the collected data. The key fit indices were all within acceptable ranges: $\chi 2/df = 2.15$, CFI = 0.94, TLI = 0.92, RMSEA = 0.052, and SRMR = 0.047. Collectively, these statistics confirm that the hypothesized model structure accurately represents the observed relationships in the data. The community's perception of waste management issues was measured on a 5-point Likert scale (1 = Strongly Disagree, 5 = Strongly Agree) and yielded a mean score of 4.2, indicating a high level of awareness and concern.

Table 1. Standardized path coefficients (β), *P*-values, and outcomes for the hypothesized relationships

Hypothesis	Path	Standardized Beta (β)	*P*-value	Finding
H1	Perception → Participation	0.41	<0.001	Supported
H2	Perception → Institutional Support	0.36	0.002	Supported
H3	Participation → Effectiveness	0.48	<0.001	Supported
H4	Moderating Effect of Inst. Support	0.19	0.031	Supported
H5	Institutional Support → Effectiveness	0.27	0.009	Supported

The analysis reveals several key insights. Perception significantly and positively influences both public participation (β= 0.41) and the perceived need for institutional support (β= 0.36). Among all factors, participation was identified as the strongest predictor of waste management effectiveness (β= 0.48, *P*< 0.001). Furthermore, institutional support demonstrates a dual role. It not only has a direct, positive impact on effectiveness (β= 0.27) but also acts as a significant moderator. Specifically, it strengthens the positive relationship between perception and participation (β= 0.19, *P*= 0.031), suggesting that when institutional support is strong, positive perceptions are more likely to translate into active participation.

Qualitative insights

Findings from interviews and FGDs enriched the quantitative results by revealing contextual nuances:

1. Perception: Many participants acknowledged the environmental risks of poor waste management but perceived waste reduction as primarily the government’s responsibility.

2. Participation: Cultural practices such as *Gotong Royong* and *Desa Adat* clean-up rituals were cited as motivators for participation, yet inconsistent household-level waste sorting remained a major barrier.
3. Institutional Support: Respondents reported uneven enforcement of regulations and limited financial incentives. Local leaders emphasized that waste banks often lacked operational sustainability due to weak institutional backing.

Integrated findings

Integrating quantitative and qualitative results reveals three critical points:

1. Perception is necessary but insufficient for driving participation unless reinforced by institutional support.
2. Participation is the key determinant of waste management effectiveness, especially in culturally embedded initiatives.
3. Institutional support functions as both enabler and moderator, bridging the gap between awareness and active involvement.

Together, these results validate the proposed participatory waste management model and highlight the centrality of community participation, reinforced by institutional structures in ensuring sustainable outcomes in Badung Regency.

DISCUSSION

This study was predicated on the understanding that the health of marine and coastal ecosystems is inextricably linked to waste management practices on land. The findings provide robust empirical support for a participatory model that serves as a critical upstream intervention to curb the flow of land-based pollution into aquatic environments. Our discussion is framed around the direct implications of these findings for aquatic biology, fisheries, and coastal management. The strong positive relationship between Institutional Support and Community Participation ($\beta = 0.67$, $P < 0.001$) underscores the critical role of government and non-governmental organizations in fostering active community involvement. This finding aligns with previous studies and suggests that policies and programs that provide resources and support are more likely to lead to successful community-based waste management initiatives.

Community perception as the first line of defense for aquatic ecosystems

The findings of this research underline the critical importance of community perception as a foundational driver for effective waste management and the protection of aquatic ecosystems. In Badung Regency, communities that are aware of the negative impacts of mismanaged waste, such as plastic-laden waterways, polluted beaches affecting tourism, and diminishing marine life, are more inclined to engage in environmentally friendly practices **(Gelcich *et al.*, 2014; O'Connor *et al.*, 2020)**. This

connection between perception and participation highlights that public education initiatives must bridge the understanding between terrestrial waste management and marine ecosystem health. Educational programs that inform communities about how their waste contributes to the degradation of local fisheries or coral reef ecosystems can catalyze increased involvement in source separation and recycling efforts.

Moreover, the research reinforces the notion that raising public awareness of the ecological consequences of waste is essential for fostering proactive environmental behaviors. Studies indicate that the integration of citizen science and outreach programs significantly enhances individual connection to ecological issues, making information more relatable and actionable **(Testa, 2018; Chozas *et al.*, 2023)**. Participation in community clean-up events or marine conservation activities has been shown to bolster environmental stewardship and alter attitudes toward conservation among participants **(Liu *et al.*, 2022)**. Therefore, community-driven initiatives not only improve local environments but also serve as vital platforms for fostering a sense of collective responsibility toward marine biodiversity.

Participatory events, like beach clean-ups, demonstrate the dual benefit of addressing waste accumulation while simultaneously educating participants about environmental degradation and the significance of marine life **(Wyles *et al.*, 2016; Testa *et al.*, 2018)**. Such experiences empower citizens to recognize their integral role in environmental conservation, making it crucial to integrate these initiatives into broader waste management strategies **(Grip & Blomqvist, 2017)**. Additionally, the role of innovative educational approaches, such as using mobile apps to engage youth in biodiversity conservation, can effectively combat the "extinction of experience," where urban populations become increasingly disconnected from natural ecosystems **(Chozas *et al.*, 2023)**.

Despite the positive impacts of heightened awareness and participation, challenges remain regarding community engagement and the broader implications for marine biodiversity. The effectiveness of conservation strategies is often impeded by gaps in public knowledge about biodiversity loss and the specific threats that marine ecosystems face due to human actions **(Hutchings *et al.*, 2010; Millard *et al.*, 2020)**. This gap underscores the necessity of both improved educational campaigns and policy frameworks that prioritize public involvement in marine protection processes, including the establishment of marine protected areas (MPAs) and sustainable tourism initiatives **(Niza *et al.*, 2021; Islamy *et al.*, 2024a, 2025a)**. By addressing both awareness and participation, there is a greater likelihood of sustaining biodiversity, enhancing ecosystem services, and fostering resilient coastal communities.

This research contributes to the discourse on effective waste management by elucidating the significant role that community perception and participation play in advancing aquatic conservation efforts. Implementing educational programs and participatory initiatives can transform public attitudes and behaviors, thereby promoting

community-led actions to protect marine environments. The insights gained here highlight the need for ongoing collaboration between researchers, policymakers, and community members to develop context-sensitive strategies that ensure the long-term sustainability of marine ecosystems in regions like Badung.

Public participation: An active barrier against marine debris

The analysis highlights public participation as a crucial element in mitigating marine debris, affirming its role as a significant predictor of effective waste management models. In regions like Badung, active household participation—through waste separation, composting, and utilizing waste banks—serves to create effective barriers against pollutants entering hydrological systems, significantly reducing both macro- and microplastic pollution. This connection illustrates that community-led initiatives represent a cost-effective strategy for combating marine debris, complementing costly downstream measures like river barriers and ocean clean-ups **(Gómez-Sanabria & Lindl, 2023)**.

Research emphasizes that the involvement of individuals correlates with lower rates of plastic waste reaching marine environments. Citizens engaged in good waste practices can prevent substantial amounts of plastic from entering rivers and oceans, as indicated by studies demonstrating similar benefits in various regions **(Phelan *et al.*, 2020; Mihai *et al.*, 2021)**. For instance, citizen science projects have shown that community engagement not only helps in monitoring pollution levels but also fosters local stewardship over environmental resources, thereby enhancing the efficacy of pollution reduction efforts **(Gacutan *et al.*, 2023)**. Community-led initiatives in waste management reflect broader sustainability goals, aligning with the UN's Sustainable Development Goals (SDGs) that seek to address marine pollution on a global scale **(Gacutan *et al.*, 2023)**.

Moreover, the substantial impact of local actions is further supported by evidence of the harmful effects marine debris imposes on aquatic life, particularly regarding ingestion and entanglement risks faced by species like marine megafauna **(Egger *et al.*, 2021)**. By effectively managing waste at the source, coastal communities can protect their immediate environment and the overarching health of marine ecosystems crucial for local fisheries and biodiversity **(Gómez-Sanabria & Lindl, 2024)**. Thus, when residents grasp the consequences of their waste practices and their subsequent impact on the marine environment, their motivation to participate in waste reduction initiatives dramatically increases. For instance, studies have recorded a marked improvement in community attitudes towards waste management following educational interventions that link environmental stewardship with personal and community well-being **(Prata *et al.*, 2019; De-la-Torre & Aragaw, 2021)**.

The integration of policies promoting active public engagement in waste management frameworks has shown promise. For example, initiatives aimed at reducing

plastic consumption directly involve communities, fostering a shared sense of responsibility and accountability **(Mentis *et al.*, 2022)**. Additionally, the importance of establishing circular waste management systems that emphasize reuse and proper waste disposal has been articulated in studies, reinforcing public education on the implications of plastic pollution **(Gómez-Sanabria *et al.*, 2022; Gómez-Sanabria & Lindl, 2024)**.

Despite these advances, challenges remain in maintaining consistent public participation levels. Increasing awareness of the adverse effects of plastic pollution necessitates continuous outreach and education to sustain community engagement over time. Effective communication strategies, innovative educational programs, and adaptive policies are vital for reinforcing the importance of public participation in reducing marine debris **(Lau *et al.*, 2020)**. The evidence suggests that when empowered with knowledge and resources, communities can effectively curtail the flow of pollutants, fostering resilient coastal environments conducive to both ecological and economic sustainability.

Public participation emerges as a vital factor in managing marine debris, acting as an active barrier against potential pollutants that negatively affect aquatic ecosystems. This research underscores the need for continued investment in community engagement and education as critical components of effective aquatic management strategies.

The enabling role of institutional support in coastal protection

The findings of this study underscore the critical enabling role of institutional support in bolstering coastal protection efforts and enhancing community-led waste management initiatives. This connection reveals that while community perception and participation are vital, their effectiveness is significantly augmented by strong institutional frameworks that provide necessary infrastructure and regulatory guidance. For instance, consistent waste collection services, accessible recycling facilities like TPS3R (Temporary Storage for Reusable Materials), and regulations banning single-use plastics are fundamental components of a robust institutional support system that translates community goodwill into tangible environmental improvements **(Ma *et al.*, 2022)**.

Effective governance in coastal management is essential for linking municipal waste services to broader marine conservation objectives. Research indicates that successful institutional support not only facilitates community engagement but also establishes a clear framework for managing marine resources sustainably. In the Coral Triangle, for instance, governance challenges faced highlight the necessity of integrating local community needs within institutional frameworks to enhance conservation efforts **(Fidelman *et al.*, 2012)**. This approach is particularly effective in areas with high tourist traffic, such as Badung, emphasizing that institutional support structures are pivotal in driving systemic changes in public behavior toward marine protection.

The importance of robust institutions extends beyond waste management; it also influences fisheries management and the protection of critical habitats such as mangroves

and seagrass beds. Investments in terrestrial waste infrastructure can positively impact coastal ecosystems by reducing the inflow of pollutants that jeopardize these delicate environments **(Ma *et al.*, 2022)**. As highlighted by a study on coastal prefecture-level cities in China, improved environmental governance and regulation can lead to significant reductions in coastal marine pollution, emphasizing that these policies must adapt to local contexts for maximum efficacy **(Sarjito, 2023)**.

Moreover, institutional frameworks can catalyze community participation even when initial awareness levels are moderate. Programs aimed at improving municipal waste management can foster a culture of environmental responsibility that leads to sustained community involvement **(Balčiūnas, 2012)**. The reliance on community-based initiatives must be supported with appropriate regulations and resources to ensure long-term success. For example, through collaborative governance, local communities can align their waste management practices with national and international environmental standards, as indicated in relevant literature on environmental governance **(Armitage *et al.*, 2012)**.

As the challenge of marine pollution continues to escalate, maintaining effective regulatory frameworks becomes increasingly crucial. There is a growing recognition that policies governing marine plastic pollution must be practical and enforceable to have any meaningful impact **(Maruf, 2019)**. Policymakers must also emphasize comprehensive engagement and collaboration with local businesses, community members, and environmental organizations to create effective and inclusive governance structures **(Atmodjo *et al.*, 2019)**.

The findings suggest that investments in institutional support not only facilitate community-driven initiatives but also contribute to sustainable management practices that protect marine ecosystems. The success of such initiatives requires a multipronged strategy that engages stakeholders at all levels while ensuring that institutional frameworks are responsive to local environmental challenges. In summary, government support, coupled with active community participation, forms a powerful alliance that enhances coastal protection and promotes healthier marine environments.

Leveraging cultural capital for aquatic conservation

The role of local cultural frameworks, such as the Tri Hita Karana philosophy in Bali, underscores the profound impact that cultural values may have on aquatic conservation efforts. This cultural philosophy emphasizes harmony and balance between humans and nature, thus providing a supportive backdrop for community engagement in environmental stewardship. Aligning conservation messaging with these culturally rooted principles can significantly enhance the effectiveness of initiatives aimed at reducing fishing pressure, protecting marine protected areas, and mitigating pollution **(Bennett *et al.*, 2018)**. By tapping into pre-existing cultural values, conservation programs can foster

a stronger sense of ownership and responsibility among local community members, which technology-driven interventions often fail to achieve **(Bennett *et al.*, 2018)**.

Research suggests that cultural frameworks can play a pivotal role in motivating collective community actions toward environmental management. For instance, published study demonstrate how community-based approaches to wetland restoration can leverage local customs and practices to foster environmental stewardship, effectively leading to improved ecological outcomes **(Owusu-Achiaw & Osei-Owusu, 2023)**. This indicates that efforts to integrate cultural heritage into environmental initiatives not only preserve traditional practices but also enhance community resilience against environmental degradation.

Cultural values around ecological conservation are demonstrated in diverse contexts, from the management of sub-tropical ecosystems to stewardship practices among Indigenous communities. For example, in Botswana, the cultural management of natural resources reflects a broader understanding of community involvement in sustainable development **(Keitumetse, 2011)**. This suggests that local heritage and traditions can serve as vital components of contemporary conservation strategies, reinforcing the necessity of culturally appropriate interventions **(Kapeller *et al.*, 2022)**.

Moreover, promoting cultural narratives around local aquatic biodiversity can empower communities and inspire proactive stewardship. Activities such as citizen involvement in ecological monitoring can bridge gaps between local knowledge and scientific understanding, enhancing the community's role in conservation efforts **(Irvine *et al.*, 2016)**. Collaborative frameworks that recognize the importance of cultural values in resource management have shown to effectively mobilize communities toward environmental stewardship **(Naser *et al.*, 2025)**.

In regions rich in aquatic biodiversity, involving local communities in conservation strategies can mitigate threats such as overfishing and habitat degradation. For instance, effective community-based management practices are core to achieving sustainable outcomes, as seen in studies that highlight the cultural practices surrounding fishing and plant management among various coastal communities **(Shamsi *et al.*, 2020)**. These insights reinforce the idea that integrating cultural capital into aquatic conservation initiatives can significantly improve their effectiveness by ensuring that local practices and beliefs are respected and utilized in program design.

Cultural capital also provides essential insights into ecological relationships, highlighting the importance of maintaining holistic views of ecosystem health that incorporate human-nature interactions. By promoting awareness and appreciation of cultural narratives around aquatic life, conservationists can engage a broader audience, enhancing public interest in protecting aquatic resources — a strategy noted to complement institutional efforts toward sustainable management **(Bennett *et al.*, 2018)**. Leveraging cultural capital through frameworks such as the Tri Hita Karana philosophy fosters community ownership and enhances the efficacy of aquatic conservation

initiatives. Recognizing the intertwining of cultural practices and environmental management can create robust partnerships that align local values with conservation goals, addressing ecological challenges in a cost-effective and meaningful manner.

Implications, limitations, and future directions

This study has significant implications for understanding the intricate relationship between land-based practices and ocean health, especially in the context of participatory models for coastal communities. The battle for healthy oceans is intrinsically connected to activities conducted on land, emphasizing the importance of an integrated approach to environmental management. The validated participatory model developed herein offers a framework through which coastal communities globally can mobilize public action to mitigate pollution at its source **(Verzosa *et al.*, 2024; Islamy *et al.*, 2025a, b)**.

However, the research is limited by its geographical focus on a single regency in Bali, which may restrict the generalizability of findings. While the relationships established between community perception, participation, and institutional support are broadly applicable, a more extensive application across diverse geographical and cultural settings is necessary for strengthening the model's validity. Future research must aim to quantify the model's effects on aquatic ecosystems. For example, empirical studies that measure changes in pollution levels, specifically plastics, in local rivers and coastal areas before and after the implementation of the model could illuminate its effectiveness **(Islamy *et al.*, 2024a, 2025c)**.

Moreover, assessing the health of local marine ecosystems—including coral reefs, fish populations, and associated fauna over time—could provide data reinforcing the link between effective community-based waste management strategies and the sustainability of aquatic environments **(Moruf, 2020)**. Additionally, studies focusing on the socio-economic dynamics of coastal communities can uncover how public participation in environmental management interacts with local economies and cultural practices **(Dzikamai, 2023)**.

Integrating sustainable development goals (SDGs) into local planning processes offers a pathway to deeper engagement with ecological objectives and public awareness initiatives, especially in coastal regions facing unique challenges. The SDGs provide multiple opportunities for enhancing coastal and marine sustainability, emphasizing conservation priorities and addressing climate change needs **(Murphy *et al.*, 2023)**. Engaging residents through tailored educational programs that align with local cultural practices can enhance awareness and lead to lasting behavioral changes in waste management and ecological conservation **(Friess *et al.*, 2019)**.

Exploratory research should also consider the role of community-led initiatives in fisheries management and the preservation of local livelihoods, as well as the impacts of industrialization on coastal resources. Initiatives that incorporate local knowledge, such

as Indigenous practices, can result in more effective sustainable management strategies that prioritize both ecological integrity and community welfare **(Hidayat *et al.*, 2023)**.

Overall, advancing research along these lines can inform policymakers and coastal managers, fostering more holistic and effective environmental governance frameworks that leverage cultural capital while addressing both local and global environmental challenges. This integrated approach to coastal management will not only benefit local communities but also contribute significantly to the overall health of marine ecosystems worldwide. There is a pressing need for future studies to assess the quantifiable impacts of participatory models on aquatic ecosystems, evaluate the socio-economic implications of community management practices, and explore the integration of cultural values into sustainable coastal resource management.

CONCLUSION

The escalating crisis of marine pollution requires urgent and effective interventions, particularly at the source. This study demonstrates that the management of land-based solid waste is not merely a terrestrial issue but a fundamental component of aquatic and marine conservation strategy. Our research, conducted in the coastal tourism hub of Badung Regency, Bali, empirically validates a participatory waste management model that serves as a powerful upstream solution to prevent pollutants from entering aquatic ecosystems.

The key conclusions are as follows:

1. **Community-led action is the most effective defense against aquatic pollution.** The model's success is overwhelmingly driven by public participation. This underscores that empowering local communities to manage their waste is a direct and impactful method for safeguarding coastal and marine environments from debris and chemical leachate.
2. **Environmental perception is the catalyst for action.** A community's awareness of the connection between mismanaged waste and environmental degradation including harm to fisheries and marine habitats is the critical first step that ignites participation and demands for better governance.
3. **Institutional support is an indispensable enabler.** While community motivation is essential, it cannot achieve scale or long-term success without a robust framework of government policies, infrastructure, and enforcement.

Based on these findings, we recommend that coastal and fisheries management policies explicitly integrate community-based waste management programs. Conservation efforts should prioritize public education campaigns that clearly link terrestrial waste practices to the health of local aquatic resources. Furthermore, investments in municipal waste infrastructure should be recognized as critical investments in the sustainability of the blue economy. Protecting our oceans, lakes, and

rivers begins on land, in our communities, and in our homes. By fostering a sense of shared responsibility and providing the necessary support, we can mobilize the collective power of citizens to turn the tide against aquatic pollution.

Acknowledgement

This journal: The Role of Community Perception and Participation in Reducing Land-Based Sources of Aquatic Pollution: A Waste Management Model from Badung, Bali is part of a dissertation entitled Community Participation-Based Household Waste Management Model: A Case Study of Badung Regency.

REFERENCES

Armitage, D.; Loë, R. de. and Plummer, R. (2012). Environmental Governance and Its Implications for Conservation Practice. Conserv. Lett. https://doi.org/10.1111/j.1755-263x.2012.00238.x

Aryampa, S.; Maheshwari, B.; Sabiiti, E.N.; Bateganya, N.L. and Bukenya, B. (2019). Status of Waste Management in the East African Cities: Understanding the Drivers of Waste Generation, Collection and Disposal and Their Impacts on Kampala City's Sustainability. Sustainability. https://doi.org/10.3390/su11195523

Atmodjo, E.; Lamers, M. and Mol, A.P.J. (2019). Governing Dynamics in Marine Conservation Tourism in Raja Ampat, Indonesia. Tour. Plan. \& Dev. https://doi.org/10.1080/21568316.2019.1686652

Balčiūnas, A. (2012). *Marine Litter in the Different Functional Zones of the Lithuanian Coast Line*. https://doi.org/10.1109/baltic.2012.6249209

Bennett, N.; Whitty, T.S.; Finkbeiner, E.M.; Pittman, J.; Bassett, H.R.; Gelcich, S. and Allison, E.H. (2018). Environmental Stewardship: A Conceptual Review and Analytical Framework. Environ. Manage. https://doi.org/10.1007/s00267-017-0993-2

Chozas, S.; Nunes, A.; Serrano, H.C.; Ascensão, F.; Tápia, S.; Máguas, C. and Branquinho, C. (2023). Rescuing Botany: Using Citizen-Science and Mobile Apps in the Classroom and Beyond. NPJ Biodivers. https://doi.org/10.1038/s44185-023-00011-9

D.C., U.; Ifeanyi, A. and Owamah, H.I. (2020). A Review of Solid Waste Management

Practice in Nigeria. Nipes J. Sci. Technol. Res. https://doi.org/10.37933/nipes/2.3.2020.17

De-la-Torre, G.E. and Aragaw, T.A. (2021). What We Need to Know About PPE Associated With the COVID-19 Pandemic in the Marine Environment. Mar. Pollut. Bull. https://doi.org/10.1016/j.marpolbul.2020.111879

Debrah, J.K.; Vidal, D.G. and Pimenta Dinis, M.A. (2021). Raising Awareness on Solid Waste Management Through Formal Education for Sustainability: A Developing Countries Evidence Review. Recycling. https://doi.org/10.3390/recycling6010006

Dias, S.M. (2016). Waste Pickers and Cities. Environ. Urban. https://doi.org/10.1177/0956247816657302

Dzikamai, M. (2023). Strategy for Restoration and Increasing the Sustainability of Fish Resources: A Holistic Analysis in Fisheries Management. J. Siplieria Sci. https://doi.org/10.48173/jss.v4i3.224

Egger, M.; Quiros, L.; Leone, G.; Ferrari, F.F.; Boerger, C. and Tishler, M. (2021). Relative Abundance of Floating Plastic Debris and Neuston in the Eastern North Pacific Ocean. Front. Mar. Sci. https://doi.org/10.3389/fmars.2021.626026

Ferronato, N. and Torretta, V. (2019). Waste Mismanagement in Developing Countries: A Review of Global Issues. Int. J. Environ. Res. Public Health. https://doi.org/10.3390/ijerph16061060

Fidelman, P.; Evans, L.; Fabinyi, M.; Foale, S.; Cinner, J.E. and Rosen, F. (2012). Governing Large-Scale Marine Commons: Contextual Challenges in the Coral Triangle. Mar. Policy. https://doi.org/10.1016/j.marpol.2011.03.007

Friess, D.A.; Aung, T.; Huxham, M.; Lovelock, C.E.; Mukherjee, N. and Sasmito, S.D. (2019). *SDG 14: Life Below Water – Impacts on Mangroves*. https://doi.org/10.1017/9781108765015.016

Gacutan, J.; Oliver, J.L.; Tait, H.; Praphotjanaporn, T. and Milligan, B. (2023). Exploring How Citizen Science Projects Measuring Beach Plastic Debris Can Support UN Sustainable Development Goals. Citiz. Sci. Theory Pract. https://doi.org/10.5334/cstp.563

Gelcich, S.; Buckley, P.; Pinnegar, J.K.; Chilvers, J.; Lorenzoni, I.; Terry, G.; Guerrero-Gatica, M.; Castilla, J.C.; Valdebenito, A. and Duarte, C.M. (2014). Public Awareness, Concerns, and Priorities About Anthropogenic Impacts on Marine Environments. Proc. Natl. Acad. Sci.

https://doi.org/10.1073/pnas.1417344111

Gómez-Sanabria, A.; Kiesewetter, G.; Klimont, Z.; Schoepp, W. and Haberl, H. (2022). Potential for Future Reductions of Global GHG and Air Pollutants From Circular Waste Management Systems. Nat. Commun. https://doi.org/10.1038/s41467-021-27624-7

Gómez-Sanabria, A. and Lindl, F. (2023). *Adoption of Global Circular Waste Management Systems Is Crucial to Cut Leakage of Waste Into Aquatic Environments*. https://doi.org/10.21203/rs.3.rs-2742121/v1

Gómez-Sanabria, A. and Lindl, F. (2024). The Crucial Role of Circular Waste Management Systems in Cutting Waste Leakage Into Aquatic Environments. Nat. Commun. https://doi.org/10.1038/s41467-024-49555-9

Grip, K. and Blomqvist, S. (2017). Establishing Marine Protected Areas in Sweden: Internal Resistance Versus Global Influence. Ambio. https://doi.org/10.1007/s13280-017-0932-8

Hidayat, M.S.; Yasin, A.; Sulistiowati, R.; Regina, D. and Nugrahanti, T.P. (2023). Green Economy Initiatives in Enhancing Social Solidarity in the Tourism Sector in Coastal Areas. Int. J. Sci. Soc. https://doi.org/10.54783/ijsoc.v5i1.652

Hutchings, J.A.; Minto, C.; Ricard, D.; Baum, J.K. and Jensen, O.P. (2010). Trends in the Abundance of Marine Fishes. Can. J. Fish. Aquat. Sci. https://doi.org/10.1139/f10-081

Irvine, K.; Castello, L.; Oliveira Junqueira, A. de; and Moulton, T.P. (2016). Linking Ecology With Social Development for Tropical Aquatic Conservation. Aquat. Conserv. Mar. Freshw. Ecosyst. https://doi.org/10.1002/aqc.2706

Islamy, R.A.; Hasan, V.; Kilawati, Y.; Maimunah, Y.; Mamat, N.B. and Kamarudin, A.S. (2024a). Water Hyacinth (Pontederia crassipes) bloom in Bengawan Solo River, Indonesia: An Aquatic physicochemical and biology perspective. Int. J. Conserv. Sci., 15(4): 1885–1898.

Islamy, R.A.; Hasan, V.; Poong, S.-W.; Kilawati, Y.; Basir, A.P. and Kamarudin, A.S. (2024b). Antigenotoxic activity of *Gracilaria* sp. on erythrocytes of Nile tilapia exposed by methomyl-based pesticide. Iraqi J. Agric. Sci., 55(6): 1936–1946. https://jcoagri.uobaghdad.edu.iq/index.php/intro/article/view/2087

Islamy, R.A.; Hasan, V.; Kamarudin, A.S.; Mamat, N.B.; Valen, F.S. and Mutmainnah, N. (2025a). Biomonitoring of heavy metal pollution in the Brantas River using genotoxic and histopathological biomarkers in wild cyprinidae. Inz.

Ekol., 26(10). https://www.jeeng.net/Biomonitoring-of-Heavy-Metal-Pollution-in-the-Brantas-River-Using-Genotoxic-and-Histopathological,206050,0,2.html

Islamy, R.A.; Hasan, V.; Poong, S.-W.; Kilawati, Y.; Basir, A.P. and Kamarudin, A.S. (2025b). Nutritional value and biological activity of *K. alvarezii* grown in integrated multi-trophic aquaculture. Iraqi J. Agric. Sci., 56(1): 617–626. https://doi.org/10.36103/6kp06e71

Islamy, R.A.; Kilawati, Y.; Hasan, V.; Valen, F.S.; Mamat, N.; Kamarudin, A.S. and Maimunah, Y. (2025c). Determination of microplastic compounds in some species of freshwater snails in Brantas River, East Java, Indonesia. Baghdad Sci. J., 22(8): 2629–2637. https://doi.org/10.21123/2411-7986.5026

Kapeller, B.; Plummer, R.; Baird, J. and Jollineau, M. (2022). Exploring the Context and Elements of Local Environmental Stewardship: An Embedded Case Study of the Niagara Region, Canada. Can. Geogr. / Le Géographe Can. https://doi.org/10.1111/cag.12812

Keitumetse, S.O. (2011). Sustainable Development and Cultural Heritage Management in Botswana: Towards Sustainable Communities. Sustain. Dev. https://doi.org/10.1002/sd.419

Lebreton, L. and Andrady, A.L. (2019). Future Scenarios of Global Plastic Waste Generation and Disposal. Palgrave Commun. https://doi.org/10.1057/s41599-018-0212-7

Liu, X.; Zhang, J.; Zhang, H.; Tang, D.; Hu, G. and Li, X. (2022). China's Mismatch of Public Awareness and Biodiversity Threats Under Economic Trade. Environ. Sci. \& Technol. https://doi.org/10.1021/acs.est.2c00844

Ma, E.; Hu, Q. and Wei, X. (2022). Impact of Environmental Regulation on Coastal Marine Pollution—A Case of Coastal Prefecture-Level Cities in China. Front. Mar. Sci. https://doi.org/10.3389/fmars.2022.882010

Maruf, M. (2019). Indonesia Response and Recent Development of Law and Policy in Addressing Marine Plastic Litter. J. Indones. Leg. Stud. https://doi.org/10.15294/jils.v4i2.34757

Mentis, C.; Maroulis, G.; Latinopoulos, D. and Bithas, K. (2022). The Effects of Environmental Information Provision on Plastic Bag Use and Marine Environment Status in the Context of the Environmental Levy in Greece. Environ. Dev. Sustain. https://doi.org/10.1007/s10668-022-02465-6

Mihai, F.; Gündoğdu, S.; Markley, L.; Olivelli, A.; Khan, F.R.; Gwinnett, C.;

Gutberlet, J.; Reyna-Bensusan, N.; Llanquileo-Melgarejo, P.; Meidiana, C.; Elagroudy, S.; Ishchenko, V.; Penney, S.; Lenkiewicz, Z. and Molinos-Senante, M. (2021). Plastic Pollution, Waste Management Issues, and Circular Economy Opportunities in Rural Communities. Sustainability. https://doi.org/10.3390/su14010020

Millard, J.; Gregory, R.D.; Jones, K.E. and Freeman, R. (2020). *The Species Awareness Index (SAI): A Wikipedia-Derived Conservation Culturomics Metric for Public Biodiversity Awareness*. https://doi.org/10.1101/2020.08.17.254177

Moruf, R. (2020). Sustainability in Life Below Water: Managing the Exploitation of Nigerian Shellfish Resources. Proc. Niger. Acad. Sci. https://doi.org/10.57046/lryh5105

Mukama, T.; Ndejjo, R.; Musoke, D.; Musinguzi, G.; Halage, A.A.; Carpenter, D.O. and Ssempebwa, J.C. (2016). Practices, Concerns, and Willingness to Participate in Solid Waste Management in Two Urban Slums in Central Uganda. J. Environ. Public Health. https://doi.org/10.1155/2016/6830163

Murphy, E.; Cornett, A. and Nistor, I. (2023). Numerical Simulation of Driftwood Transport by Waves in a Laboratory Basin. Coast. Eng. Proc. https://doi.org/10.9753/icce.v37.management.7

Naser, M.D.; Yasser, A.; Schoelynck, J. and Essl, F. (2025). Threatened Aquatic Plants of the Southern Tigris-Euphrates Basin: Status, Threats, and Conservation Priorities. Plants. https://doi.org/10.3390/plants14131914

Niza, H.; Bento, M.; Lopes, L.F.; Cartaxana, A. and Correia, A.M. (2021). *A Picture Is Worth A thousand Words: Using Digital Tools to Visualize Marine Invertebrate Diversity Data Along the Coasts of Mozambique and São Tomé \&Amp;amp; Príncipe*. https://doi.org/10.3897/arphapreprints.e69102

O'Connor, E.; Hynes, S.; Chen, W.; Papadopoulou, N. and Smith, C. (2020). Investigating Societal Attitudes Toward Marine Ecosystem Restoration. Restor. Ecol. https://doi.org/10.1111/rec.13239

Okot-Okumu, J. and Nyenje, R. (2011). Municipal Solid Waste Management Under Decentralisation in Uganda. Habitat Int. https://doi.org/10.1016/j.habitatint.2011.03.003

Oteng-Ababio, M. (2011). The Role of the Informal Sector in Solid Waste Management in the Gama, Ghana: Challenges and Opportunities. Tijdschr. Voor Econ. En Soc. Geogr. https://doi.org/10.1111/j.1467-9663.2011.00690.x

Owusu-Achiaw, R. and Osei-Owusu, Y. (2023). *Community-Based Approach to Wetland Restoration: Case Study of the Songor Wetland, Ghana*. https://doi.org/10.1007/978-981-99-1292-6_9

Phelan, A.; Ross, H.; Setianto, N.A.; Fielding, K.S. and Pradipta, L. (2020). Ocean Plastic Crisis—Mental Models of Plastic Pollution From Remote Indonesian Coastal Communities. PLoS One. https://doi.org/10.1371/journal.pone.0236149

Prata, J.C.; Patrício Silva, A.L.; da Costa, J.P.; Mouneyrac, C.; Walker, T.R.; Duarte, A.C. and Rocha-Santos, T. (2019). Solutions and Integrated Strategies for the Control and Mitigation of Plastic and Microplastic Pollution. Int. J. Environ. Res. Public Health. https://doi.org/10.3390/ijerph16132411

Sarjito, A. (2023). Maritime Environmental Crisis: Public Administration as Master in the Global Marine Pollution Storm. Ijels. https://doi.org/10.59890/ijels.v1i4.990

Shamsi, S.; Williams, M. and Mansourian, Y. (2020). An Introduction to Aboriginal Fishing Cultures and Legacies in Seafood Sustainability. Sustainability. https://doi.org/10.3390/su12229724

Szpilko, D.; la Gallegos, A. de; Naharro, F.J.; Rzepka, A. and Remiszewska, A. (2023). Waste Management in the Smart City: Current Practices and Future Directions. Resources. https://doi.org/10.3390/resources12100115

Testa, J. (2018). The Effects of Participatory Beach Clean-Ups on Attitude and Awareness Towards Marine Biodiversity and Conservation at the Destin Jetties. J. Oceanogr. Mar. Res. https://doi.org/10.4172/2572-3103.1000187

Ugoeze, K.C.; Alalor, C.A.; E. Ibezim, C.N.; Chinko, B.C.; Owonaro, P.; Anie, C.O.; Okoronkwo, N.; Mgbahurike, A.; Ofomata, C.; Alfred-Ugbenbo, D. and Ndukwu, G. (2024). Environmental and Human Health Impact of Antibiotics Waste Mismanagement: A Review. Adv. Environ. Eng. Res. https://doi.org/10.21926/aeer.2401005

Verzosa, R.C.; M. Katipunan, F.J.; B. Lumangyao, J.G. and Antonio, E.S. (2024). Solid Waste Management Awareness and Practices in Coastal Communities. Davao Res. J. https://doi.org/10.59120/drj.v15i3.247

Wyles, K.J.; Pahl, S.; Holland, M. and Thompson, R.C. (2016). Can Beach Cleans Do More Than Clean-Up Litter? Comparing Beach Cleans to Other Coastal Activities. Environ. Behav. https://doi.org/10.1177/0013916516649412

Y. Lau, W.W.; Shiran, Y.; Bailey, R.M.; Cook, E.; Stuchtey, M.; Koskella, J.; Velis, C.A.; Godfrey, L.; Boucher, J.; Murphy, M.B.; Thompson, R.C.; Jankowska,

E.; Castillo, A.C.; Pilditch, T.D.; Dixon, B.; Koerselman, L.; Kosior, E.; Favoino, E.; Gutberlet, J.; … Palardy, J.E. (2020). Evaluating Scenarios Toward Zero Plastic Pollution. Science (80-.). https://doi.org/10.1126/science.aba9475

Yu, K.S.; Thenepalli, T.; Jang, C. and Whan, A.J. (2017). Appropriate Technologies for Municipal Solid Waste Management in Bantayan Island, Philippines. J. Energy Eng. https://doi.org/10.5855/energy.2017.26.1.054