ECSOFiM: Journal of Economic and Social of Fisheries and Marine. 2025. 13(01): 40-52 e-ISSN: 2528-5939
Permalink/DOI: http://dx.doi.org/10.21776/ub.ecsofim.2025.013.01.04

EVENT-BASED ECOTOURISM INTEGRATED WITH DIGITAL CITIZEN SCIENCE FRAMEWORK FOR BLUE CARBON ECOSYSTEM MANAGEMENT IN INDONESIA

EKOWISATA BERBASIS EVENT TERINTEGRASI DENGAN KERANGKA KERJA SAINS WARGA DIGITAL UNTUK PENGELOLAAN EKOSISTEM KARBON BIRU DI INDONESIA

Bambang Semedi[1,7], Muhammad Arif Asadi[1,7], Citra S.U. Dewi[1,7], Wike[2], Akhmad Zainuri[3], Dano Purba[4], Frida Sidik[5], Oktiyas Muzaky Luthfi[6,7] and Dhira K. Saputra[*1,4,7]

[1] Faculty of Fisheries and Marine Science, Brawijaya University, Malang, Indonesia
[2] Faculty of Administrative Science, Brawijaya University, Malang, Indonesia
[3] Faculty of Engineering, Brawijaya University, Malang, Indonesia
[4] Doctoral Program of Environmental Science, Brawijaya University, Malang, Indonesia
[5] Oceanography Research Center, National Research and Innovation Agency, Jakarta, Indonesia
[6] Institute of Marine and Environmental Sciences, University of Szczecin, Szczecin, Poland
[7] Coastal Resilience and Climate Change Adaptation Research Group, Brawijaya University, Malang, Indonesia

Received: March 18, 2025 / Accepted: October 28, 2025

ABSTRACT

This study examines two critical challenges in the management of blue carbon ecosystems through marine ecotourism in small island contexts: a lack of educational value and limited economic impact. We developed an integrated digital citizen science framework for Bawean Island, one of the most important blue carbon ecosystems in East Java. Daun Village in Bawean has a coastal area with 78.8 hectares of mangrove ecosystem (22 species), seagrass (7 species), and various protected marine species, including hawksbill sea turtle and dugong. FGD were designed to assess six variables: (1) current state of ecotourism, (2) local ecological knowledge and scientific understanding, (3) perceptions of educational needs, (4) preferences for ecotourism development models, (5) technology comfort levels, and (6) potential market targeting. Results are then used to design a system that aligns with local capacity, while also generating valuable information. Analysis of community perceptions shows uniformly underperformed existing attractions (1.35±0.49), low educational content (1.50±0.51), and economic impact (1.70±0.66), despite strong conservation activities (4.25±0.55). The technology comfort level shows moderate values, which results in a web-based technical system architecture using Google services. These findings indicate that Bawean Island has potential for integrating ecotourism with citizen science.

Keywords: Bawean Island, dugong, mangrove management, marine tourism, seagrass.

ABSTRAK

Penelitian ini membahas dua tantangan utama dalam pengelolaan ekosistem karbon biru berbasis ekowisata bahari di pulau kecil, yaitu kurangnya value edukasi dan minimnya dampak ekonomi. Untuk itu, pengembangan framework sains warga terintegrasi berbasis digital dilakukan di Pulau Bawean, yang merupakan ekosistem karbon biru terpenting di Jawa Timur. Desa Daun di Bawean memiliki wilayah pesisir seluas 78,8 ha, terdiri dari ekosistem mangrove (22 spesies), padang lamun (7 spesies), dan beragam biota laut yang dilindungi, termasuk penyu sisik dan dugong. FGD dilakukan untuk mengevaluasi enam variabel: (1) kondisi ekowisata terkini, (2) tingkat pengetahuan ekologi masyarakat, (3) persepsi terhadap kebutuhan atraksi edukasi, (4) preferensi model bentuk atraksi, (5) tingkat penguasaan teknologi, dan (6) target pasar potensial. Hasil FGD dimanfaatkan untuk merancang sistem yang sesuai dengan kemampuan masyarakat, sekaligus menghasilkan informasi yang baik. Analisis persepsi masyarakat menunjukkan daya tarik wisata belum optimal (1,35±0,49), kurangnya konten edukasi (1,50±0,51), dan kurangnya dampak ekonomi (1,70±0,66), meskipun value konservasi tinggi (4,25±0,55). Tingkat kenyamanan teknologi menunjukkan nilai sedang, yang berdampak pada perancangan arsitektur sistem berbasis web menggunakan layanan Google. Temuan ini menunjukkan bahwa Pulau Bawean memiliki potensi untuk mengintegrasikan ekowisata dengan ilmu pengetahuan warga.

Kata kunci: Pulau Bawean, dugong, pengelolaan mangrove, pariwisata laut, rumput laut.

[*] *Corresponding author: Dhira K. Saputra, saputra.dhira@ub.ac.id*
Institution and its address: Faculty of Fisheries and Marine Science, Brawijaya University, Malang, Indonesia

INTRODUCTION

Blue carbon ecosystems (BCE) mainly consist of mangrove and seagrass, which provide critical ecosystem services including carbon sequestration, shoreline stabilization, and fisheries habitat (Alongi, 2012; Donato et al., 2011; McLeod et al., 2011). Bawean Island is considered the most important BCE in East Java. Located 120 km north of the Gresik Regency, Bawean spans 196.27 km^2, categorized as a small island. This area consists of two administrative subdistricts: Sangkapura (118.72 km²) and Tambak (77.55 km²), with a total population of around 84,218 (BPS, 2024; Saputra et al., 2024). Most of its coastal areas featuring intact BCE serve as crucial habitat for marine ecosystems as well as potential tourist destinations. This location exhibits rich marine biodiversity, including protected marine mammals and reptiles, including dugongs and marine turtles, which utilize seagrass as foraging areas (Dewi et al., 2024).

The primary BCE in Bawean comprises mangrove and seagrass meadows. Though limited in size, the island's coastal vegetation ranks among East Java's finest conditions. Daun Village is one of the largest coastal villages on Bawean Island. The village's intertidal coastline is covered by 78.8 ha of mangrove, bordered by seagrass ecosystems in the subtidal area, extending seaward along with a coral reef. The marine ecosystem’s health condition is reasonably preserved (Asadi et al., 2024; Dewi et al., 2024; Luthfi et al., 2024), with high local community awareness that always ensures its marine resources conservation and sustainable use. The preservation of marine biodiversity is inseparable from the historical lessons of coastal resource destruction that occurred decades ago. In 2004, severe coastal erosion damaged 43 ha of coastal area, resulting in both environmental and socioeconomic damage, including reduced agricultural productivity due to saltwater intrusion (Saputra et al., 2024). The disaster triggered a local youth group, led by Subhan, to carry out voluntary mangrove restoration. After one decade, this initiative has resulted in significant mangrove ecosystem recovery (Figure 3). Then, the community group began to develop a mangrove-based livelihood. Mangrove ecotourism activities began to be initiated by making mangrove tracks and viewing posts, as is common for mangrove ecotourism in Indonesia (Hakim et al., 2017).

Ecotourism consists of three major components, including conservation, economic benefits for the locals, and education or interpretation of natural resources (TIES, 2015). Along with the MPA policy, it has emerged as a primary conservation strategy in Indonesia (Meilana et al., 2023) MMAF and MoEF consider marine tourism to be a sustainable funding mechanism to provide livelihoods for local communities within MPAs (Tranter et al., 2022). However, traditional ecotourism practices focus primarily on recreational attractions (Muhammad Al Giffari et al., 2025), do not integrate educational and conservation values adequately (Pham, 2020). This limits both visitor interest and substantial benefits for local communities. From the educational perspectives, knowledge gaps among students regarding their surrounding coastal ecosystems further undermine long-term conservation sustainability.

This research addresses these challenges through an integrated framework that combines three theoretical foundations. First, community-based ecotourism – in this context: mangrove

ecotourism—emphasizes active local participation in planning, implementation, and monitoring (Abidin et al., 2023; Hakim et al., 2017). Second, citizen science involves visitors in scientific data collection, analysis, or research tasks during their trips (Bryson et al., 2013; Cooper et al., 2007), which could raise environmental awareness and provide meaningful travel experiences (Schaffer & Tham, 2019). Third, the event-based tourism approach. In regions with limited population and access, actively offering events or packages is more promising than just "waiting" for tourists to come. Hosting event-based tourism will attract visitors and boost destination visibility (Getz, 2008).

Citizen science and ecotourism can benefit both conservation and education. However, three critical gaps remain. First, studies integrating citizen science with event-based ecotourism in small island coastal regions are scarce. Second, need to incorporate local marine biodiversity into the school curriculum. Third, stakeholders rarely use technologies for coastal ecosystem monitoring and education. This study addresses these gaps directly. We developed and implemented a digital citizen science framework that integrates educational enhancement with economically viable ecotourism activities. The framework uses Google services and smartphone interfaces with gamification elements. It creates three key benefits: (1) it enhances marine biodiversity education through locally developed curriculum content, (2) it diversifies ecotourism attractions through citizen science, and (3) it generates valuable ecological monitoring data.

RESEARCH METHODS

This research was conducted on Bawean Island, East Java Province, Indonesia, with field activity carried out from June to November 2024. This location was selected due to its BCE and marine biodiversity, strong community-based practice, but limited educational resources regarding marine ecosystems. Mixed-methods approach (Creswell, 2015) performed to develop an integrated digital citizen science framework (Chase & Levine, 2016) for BCE monitoring. Before stakeholder engagement, we conducted baseline ecological surveys to observe the mangrove (Dharmawan et.al., 2020) and seagrass (Nurdiansah & Dharmawan, 2021) biodiversity, and marine protected species inventory.

The results from the baseline survey were then analyzed to produce citizen science framework scenarios. First, the documented species list was used to create simplified identification guides for each monitoring module. Second, the ecological characteristics observed at different stations determined the placement of monitoring points. Third, the recorded biodiversity data established baseline parameters that citizen scientists would track over time. The results of ecological observations were then discussed in FGD to obtain a suitable alternative ecotourism attraction model. The framework of the research is presented in Figure 1.

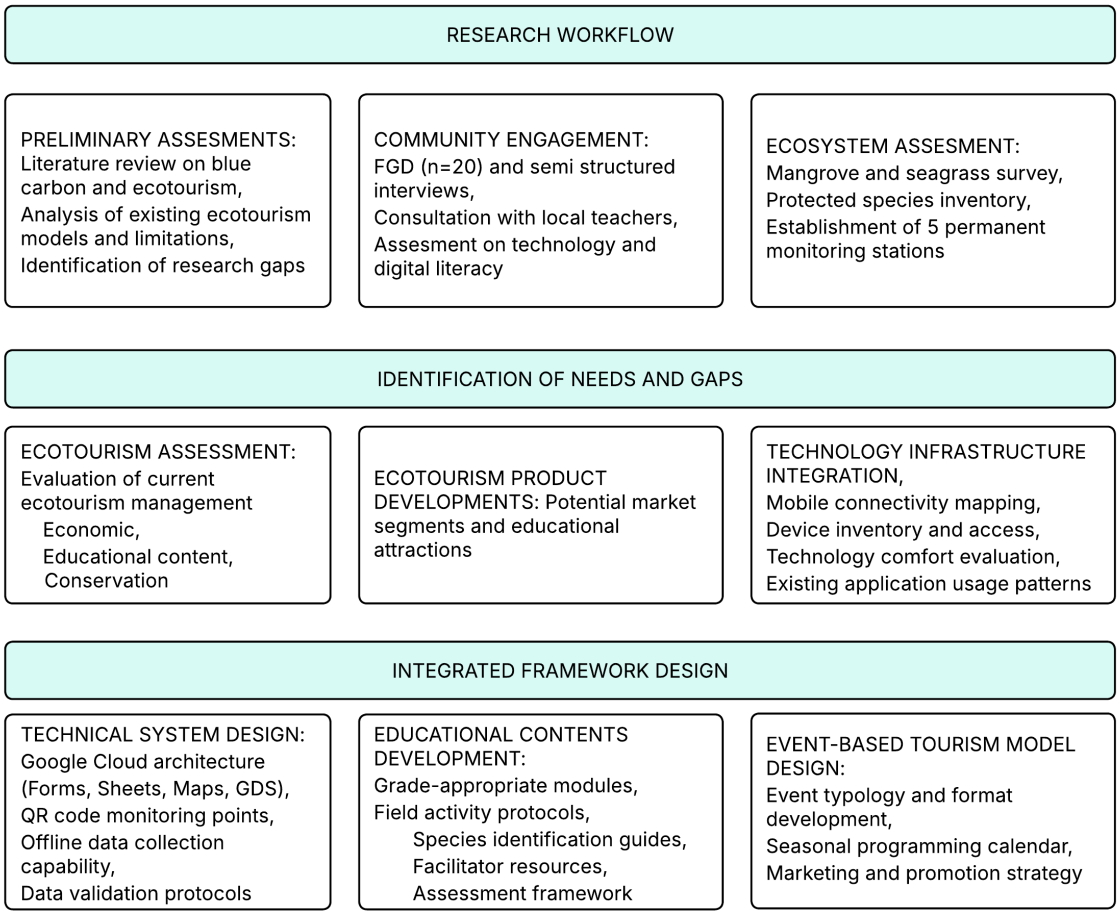


Figure 1. Research Framework

Social Mapping and Community Engagement

A Focus Group Discussion (FGD) was conducted with 20 key stakeholders involved in ecotourism management, representing various occupational backgrounds: fishermen (12), aquaculture farmers (5), teachers (2), and tourism operators (1). This FGD was designed to assess (1) the current state of ecotourism activities, (2) local ecological knowledge and scientific understanding, (3) perceptions of educational and conservation needs, (4) preferences for ecotourism development models, (5) technology comfort levels and accessibility, and (6) potential partner and market targeting (Figure 2). FGDs were followed by in-depth interviews, with questions given to be answered on a 1-5 Likert scale. Responses were analyzed using descriptive statistics, including mean scores, standard deviations, and percentage distributions. A threshold value was set for each variable to determine the standard level, with scores below 3.0 considered less optimal.



Figure 2. FGD with Local Stakeholders

RESULT AND DISCUSSION

Blue Carbon Ecosystem in Bawean Island

Daun Village has 78.8 ha of natural mangrove stands, of which 43 ha have undergone recovery over the past decade following significant degradation (Figure 3). There are 22 major and minor mangrove species, including *Sonneratia alba, Sonneratia ovata, Sonneratia caseolaris, Nypa fruticans, Acanthus ilicifolius, Xylocarpus mollucensis, Rhizophora mucronata, Rhizophora stylosa, Rhizophora apiculata, Avicennia alba, Avicennia marina, Heritiera littoralis, Acanthus illicifolius, Acrostichum aureum, Ceriops tagal, Bruguiera gymnorrhiza, Lumnitzera racemosa, Aegiceras corniculatum, Excoecaria agallocha,* and *Pemphis acidula* (Saputra et al., 2024). Mangrove in the intertidal area transitions into seagrass meadows in the subtidal area. There are 7 species of seagrass found, including *C. rotundata, C. serrulata, E. acoroides, H. pinifolia, H. uninervis, H. ovalis, and T. hemprichii* (Dewi et al., 2024).

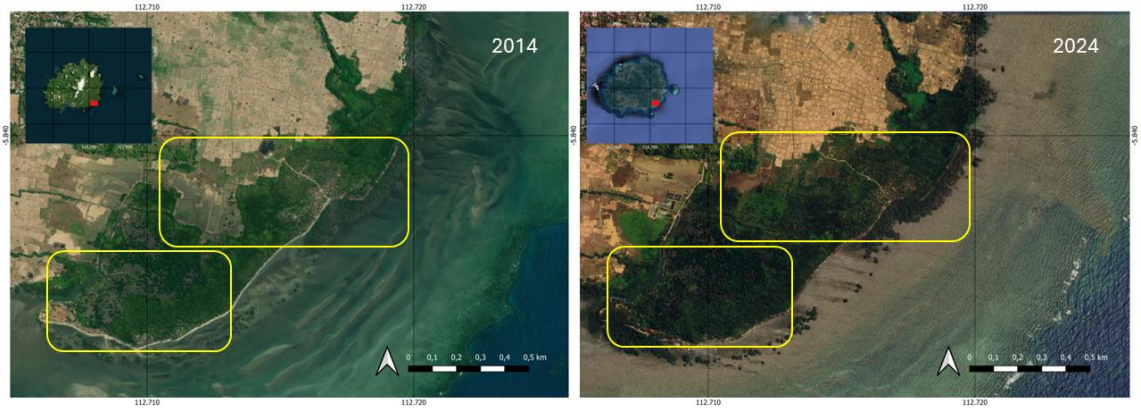


Figure 3. Temporal Image Shows Recovered Mangrove in Daun Village from Restoration Activity

BCE in Bawean supports various protected species, including marine species, hawksbill sea turtle (*E. imbricata*), dugong (*Dugong dugon*), giant clams (*Tridacna spp.*), Humphead wrasse (*Cheilinus undulatus*), Sea bamboo (*Isis hippuris*), and cetaceans. These animals utilize mangrove and seagrass habitats along the coastal areas of Daun Village, with their presence categorized as either seasonal (fruit bats, sea turtles, eels, and dolphins) or permanent (sea bamboo, Napoleon wrasse, dugongs, and egrets). The following diagram (Figure 4) illustrates the correlations between protected species and the marine ecosystems of Daun Village.

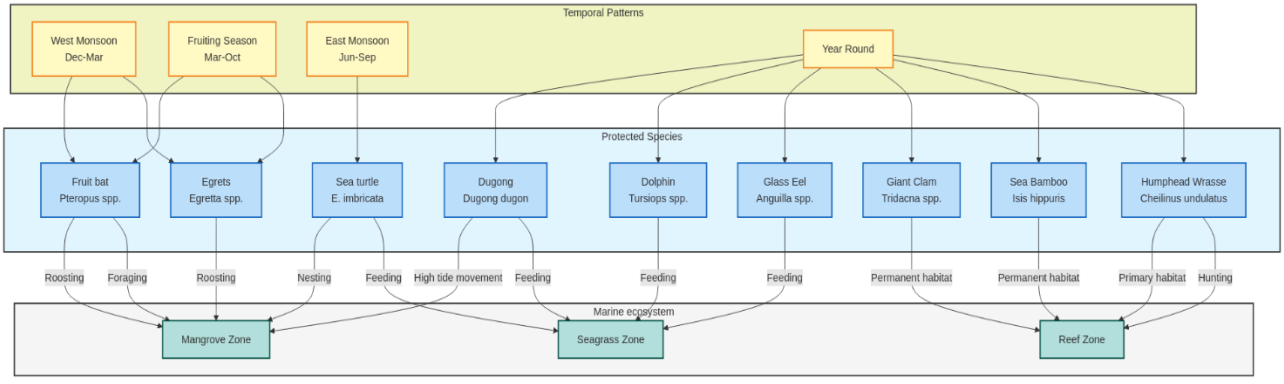
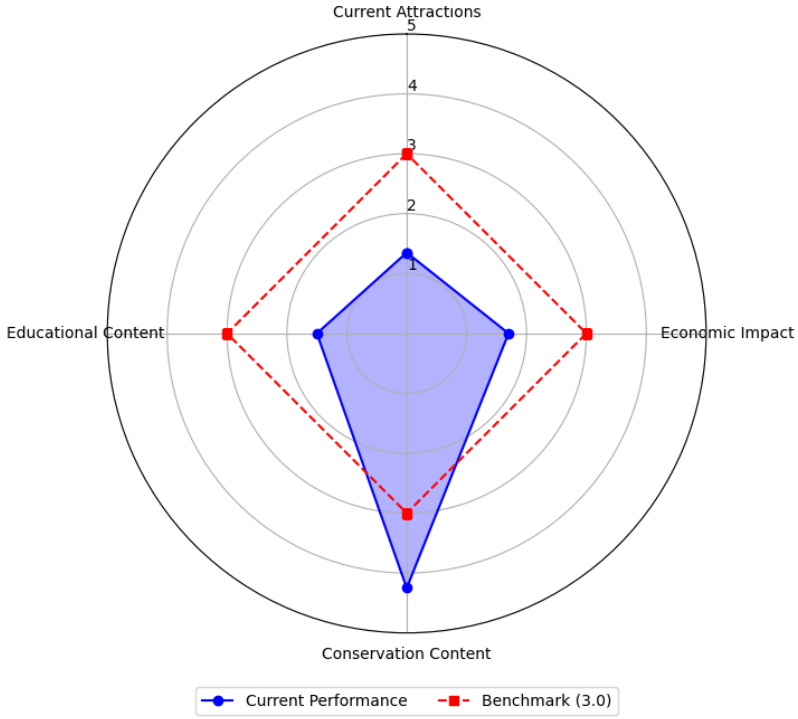


Figure 4. Appearance of Protected Species and Its Correlation with BCE in Daun Village Community Assessment and Ecotourism Perception

FGD involved participants characterized by a male-to-female ratio of 80:20, and working primarily in fishing and aquaculture (85%). Most participants had completed middle school education (45%), followed by high school (30%), elementary school (20%), and bachelor's degree holders (5%). Analysis of community perceptions regarding current ecotourism performance demonstrated uniformly underperformed existing attractions (1.35±0.49), educational content (1.50±0.51), and economic impact (1.70±0.66). Notably, 100% of respondents rated current attractions and educational value below benchmark thresholds of 3, while 90% indicated less satisfaction with economic impact. In contrast, conservation content received relatively positive ratings (4.25±0.55), suggesting that existing conservation practices are viewed favourably (Figure 5).



Variable	Mean Score	Median	Std Dev	Below Benchmark (%)
Current attractions	1.35	1.0	0.48	100.0
Educational content	1.50	1.5	0.51	100.0
Conservation content	4.25	4.0	0.54	0.0
Economic impact	1.70	2.0	0.64	90.0

Figure 5. Stakeholder Perception in the Current Ecotourism Condition

Respondents identified limitations in current visitor experiences, which primarily consist of mangrove track and canoeing. Ecotourism managers are still unaware of the extraordinary asset from the surrounding biodiversity, which could be developed into educational material for marine conservation. As one participant noted, "*Visitors come, but they don't learn anything about our ecosystems, or why we work so hard to protect them."* The community expressed strong motivation to develop educational components within ecotourism attractions, driven by their historical experience with ecosystem degradation (Saputra et al., 2024) and subsequent recovery. Their lived experience with mangrove restoration and its positive impacts on local livelihoods creates a lesson learned that respondents wished to share, particularly with younger generations.

Potential Visitor Prioritization

Market assessment revealed strong agreement on prioritizing local schools as the primary target audience for enhanced ecotourism offerings. Local schools (K12 level education) received the highest score (4.25), with university students and researchers also scoring highly (4.65). General visitors received lower prioritization scores (3.40). This prioritization aligns with the community's expressed desire to focus on educational outcomes, particularly for local youth who may have a limited understanding of their surrounding ecosystems despite living adjacent to them. The preference for school partnerships is particularly significant in the context of Indonesia's P5 (*Pembelajaran Praktek Pengembangan Profil Pelajar*) curriculum (Purtina et al., 2024), which emphasizes experiential and contextual learning. As one teacher participant noted, "*The current curriculum encourages students to connect with their environment, but we lack structured activities related to our coastal ecosystems. This creates a major knowledge gap*."

In Sangkapura Subdistrict, there are 38 elementary schools with 3,245 elementary students, 5 junior high schools with 733 students, and 5 high schools with 812 students. In total, 43 formal schools could potentially participate in citizen science activities. By implementing a one-day field trip learning package, ecotourism activities are expected to increase significantly.

Preferred Attraction Analysis

When assessing potential ecotourism attractions, citizen science events received full support, with all respondents rating this approach at the maximum value of the Likert Scale (5±0.00). The strong preference for citizen science activities correlates with the community's conservation values and desire to increase educational values. Interestingly, wildlife photography received significantly lower preference scores (2.7±0.47) compared to other potential attractions in the assessment (Figure 6). This is in contrast with the reality that Bawean Island has rich biodiversity and beautiful scenery. Low scores in wildlife photography can be attributed to the limited availability of proper photo equipment among community members and their low engagement with social media.

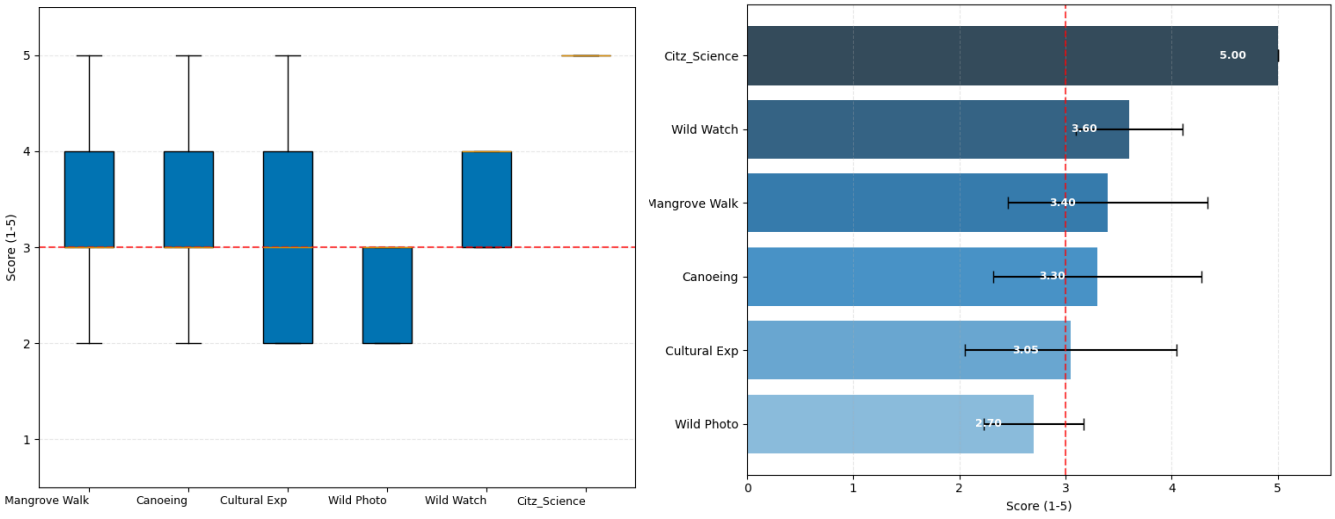
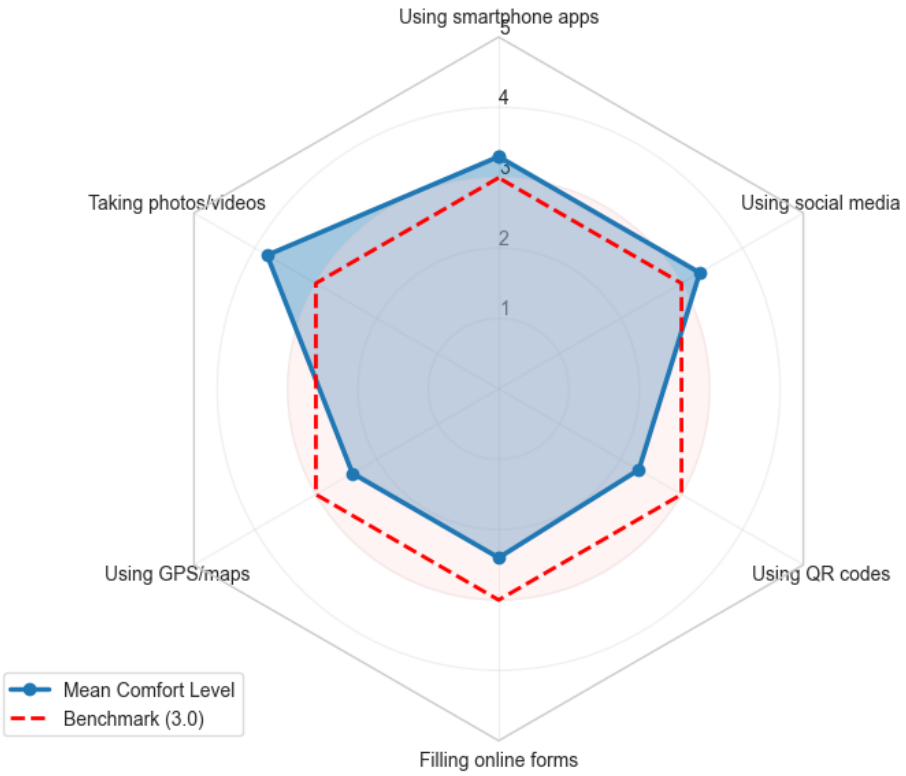


Figure 6. Potential Attractions Preferred by Community

When asked to specify preferred citizen science event formats, respondents provided diverse suggestions, including seasonal monitoring festivals, biodiversity challenges, ecosystem health checks, species documentation days, and community assessment events. These suggestions revealed three key categories of thematic events: monitoring events, competition events, and school-related events.

Technical Framework Development

Based on the community assessment and preference analysis, we developed a citizen science framework that is suitable for the context of the Bawean community. Rather than developing a standalone application that would require additional smartphone storage, we implemented a web-based system accessible via WhatsApp and mobile browsers. This approach is motivated by technology comfort assessment results (Figure 5), which indicate moderate comfort with smartphone apps (3.3±1.03) and photo or video functions (3.8±0.77). The community has lower comfort with more advanced functions such as operating GPS or maps (2.4±1.05), filling online forms (2.4±1.14), and using QR codes (2.3±1.08).



Technology Function	Mean Comfort Level (1-5)	Standard Deviation	Below Benchmark (%)	Design Implication
Taking photos/videos	3.8	0.77	14.9	Primary Interface
Using smartphone apps	3.3	1.03	38.5	Standard Interface
Using social media	3.3	1.03	38.5	Standard Interface
Using GPS/maps	2.4	1.05	71.6	Assisted Interface
Filling online forms	2.4	1.14	70.1	Assisted Interface
Using QR codes	2.3	1.08	74.2	Assisted Interface

Figure 7. Technology Comfort Levels Among Community Members

The technical system architecture (Figure 8) leverages existing technology infrastructure while accommodating connectivity limitations. The framework implementation centered on two core components:

1. The data collection system consists of 5 monitoring points across Hijau Daun mangrove ecosystems, each marked with weatherproof QR codes. These codes, when scanned, directed users to specific Google Forms for standardized data collection.
2. Data management infrastructure, where submissions flow into structured Google Sheets databases that are visualized in Google My Maps. Dashboard provides access to aggregated monitoring data for educational purposes and scientific reviews.

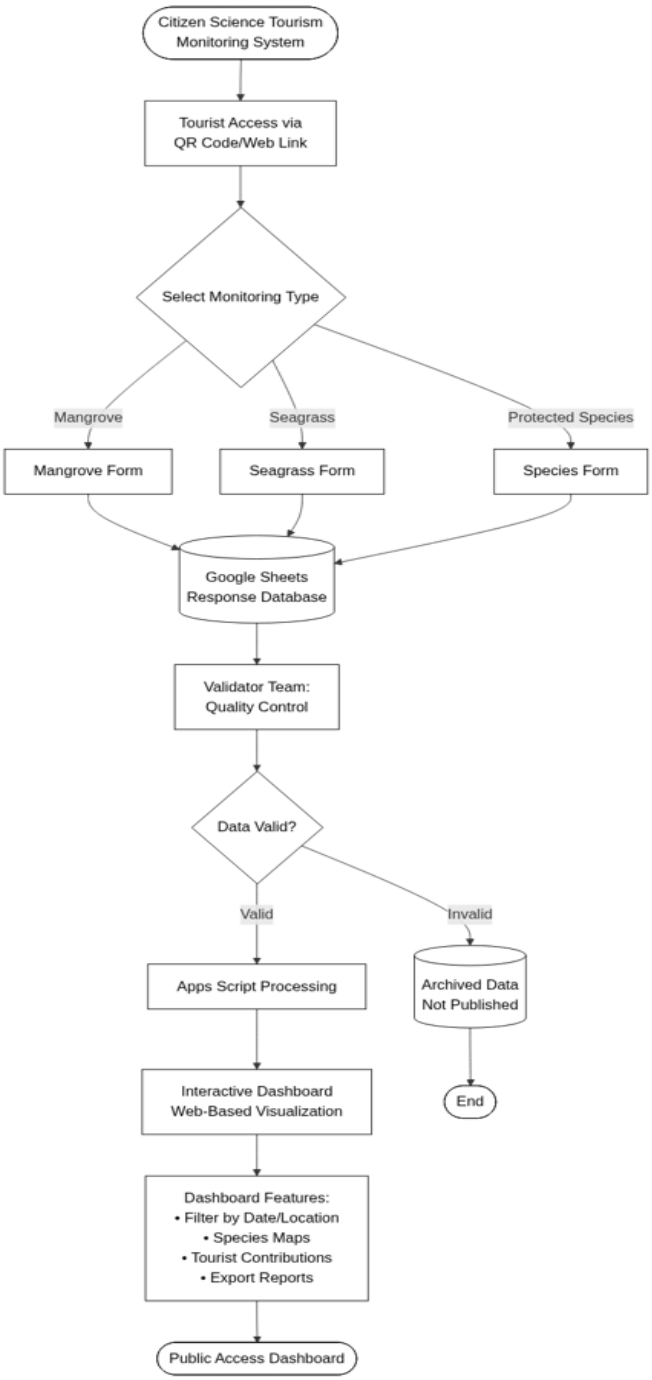


Figure 8. Design System Workflow

Learning Modules

This integrated citizen science framework combines three monitoring modules (mangrove, seagrass, and protected species) into a unified data collection and visualization system (Figure 9). This module contains the basics of species identification and monitoring techniques. Ecotourism managers have received training related to local guiding, enabling them to serve as local facilitators or guides for visitors in implementing citizen science initiatives.

Each monitoring session begins with QR code scanning at designated observation points, triggering module-specific data collection interfaces. Mangrove, seagrass, and marine protected species modules utilize Google Forms with customized interfaces, combining GPS logging and mandatory photographic documentation. All three modules feed into a centralized data management system built on Google Workspace.

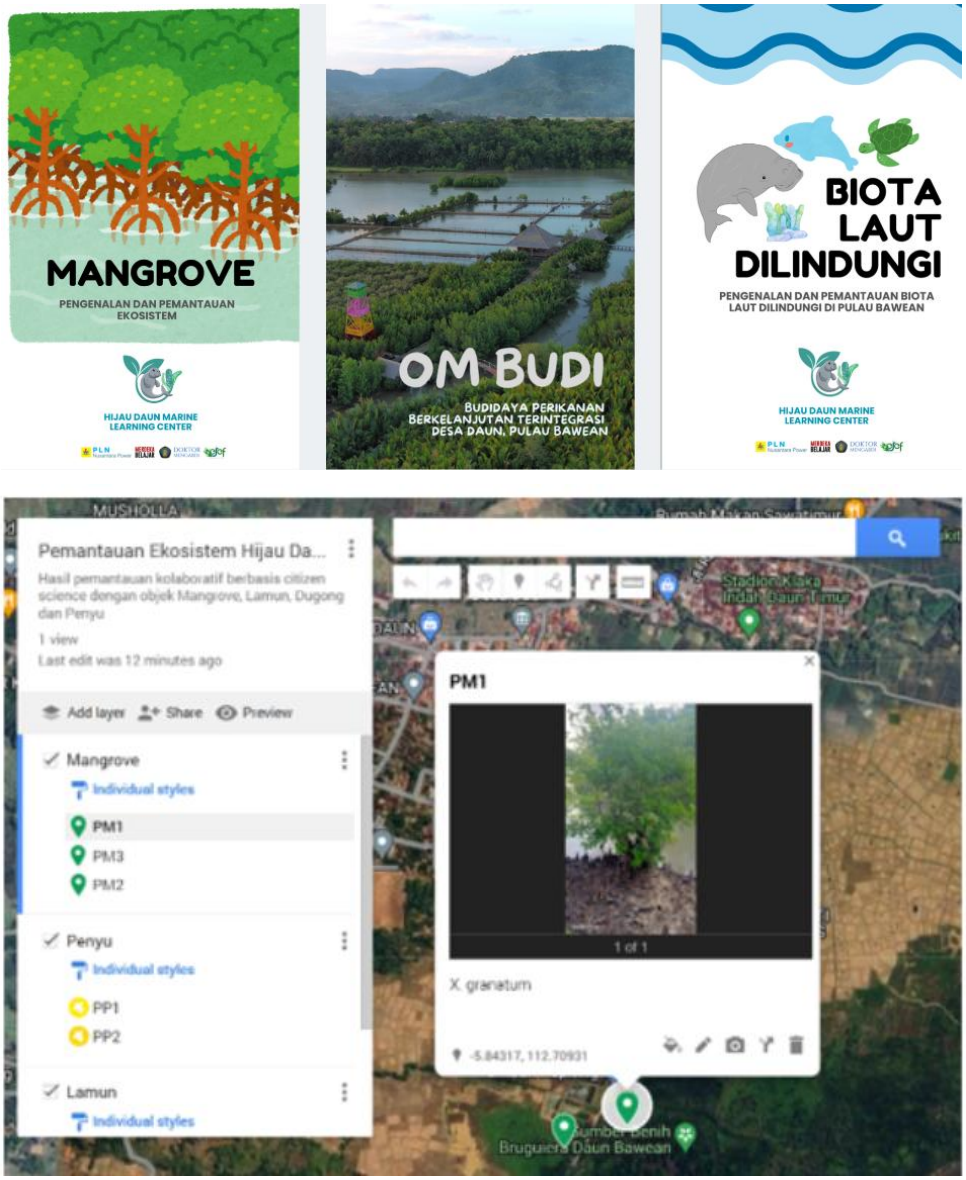


Figure 9. Learning Modules and User Interface in Google My Maps

Discussions

This framework demonstrates how digital technology can bridge traditional challenges (Simpson et al., 2020) in marine ecotourism development while enhancing educational and conservation outcomes. This aligns with recent trends in nature-based tourism where visitors seek active participation in conservation efforts (MuhammadAlGiffari et al., 2025; Schaffer & Tham, 2019). On the other side, integration of citizen science with formal education is expected to produce promising results, with local schools reporting increased student engagement in marine science topics.

Technology comfort assessment revealed both opportunities and challenges in digital tool adoption. While basic smartphone functions showed high acceptance (3.8±0.77 for photo or video usage), more complex features like GPS mapping and QR codes demonstrated lower comfort levels (2.4±1.05). This digital gap could be effectively addressed through a training approach and simplified data collection protocols. Using familiar platforms (Google Forms, WhatsApp) combined with offline-capable tools (MonMang app) proved effective in overcoming these challenges, though regular technical support remains necessary. In remote island settings, where traditional scientific monitoring faces logistical and financial barriers, a digital citizen science approach enables continuous data collection through community participation. This cost-effective solution generates reliable long-term datasets while building local capacity (Chase & Levine, 2016; Devictor et al., 2010; Goodchild, 2007). Simultaneously, the framework addresses the documented gap in marine science education, providing coastal students with structured, hands-on learning experiences about their local ecosystems.

The implementation of event-based citizen science in marine ecotourism addresses multiple challenges in Indonesia's BCE (Budi Arifanti et al., 2022; IOJI, 2022), while enforcing multi-stakeholder collaboration and socio-economic development. The event-based format proves particularly effective in attracting institutional support, such as regional agencies, universities, and CSR programs. Indonesia's high social media engagement, transforming scientific tourism events into shareable content that raises awareness and attracts participation. This multi-stakeholder collaboration strengthens monitoring capacity while ensuring sustainable resource allocation for conservation efforts.

The framework's reliance on widely available tools and simplified protocols makes it potentially replicable in other coastal communities, though local adaptations would be necessary. While the framework has scalability to be implemented in various places, even remote islands, some considerations emerge for broader implementation. Several aspects to be considered related to (1) standardized training protocols to ensure consistent data, (2) developing robust offline capabilities for zero connectivity areas, (3) integration with standard databases, and (4) enhancement of data visualization tools for different stakeholders.

CONCLUSION AND SUGGESTION

Conclusion

These findings demonstrate that careful analysis of community capabilities and preferences can inform the development of appropriate technological solutions for citizen science and ecotourism

integration. Technology comfort assessment revealed distinct patterns that shaped the framework design, resulting technical framework that prioritized user-friendly Google Workspace tools. This framework provides a model for other coastal communities, emphasizing the importance of social mapping in designing sustainable community-based BCE management.

Suggestion

Future research should explore the scalability of this model, assess its long-term impact, and develop adaptive strategies to address emerging conservation challenges.

ACKNOWLEDGEMENT

Directorate of Research and Community Services, Brawijaya University. Grant Doktor Mengabdi FY 2024.

REFERENCES

Abidin, Z., Nuryani, F. E., Saputra, D. K., Fattah, M., Harahab, N., & Kusumawati, A. (2023). Mangrove Potential Assessment For Determining Ecotourism Attraction and Strengthening Destination Branding And Marketing: ”Gunung Pithing Mangrove Conservation”, Indonesia. *GeoJournal of Tourism and Geosites*, *47*(2), 388–396. https://doi.org/10.30892/gtg.47204-1036

Alongi, D. M. (2012). Carbon sequestration in mangrove forests. *Carbon Management*, *3*(3), 313–322. https://doi.org/10.4155/CMT.12.20

Asadi, M. A., Al-kareem, A. S., Aprilianto, R. Y., Sartimbul, A., Yamindago, A., Saputra, D. K., & Riyadi, A. (2024). Assessment of mangrove structures and biomass on islands along the Java Sea: A case study on Bawean Islands and Karimunjawa Islands. *Frontiers in Ecology and Evolution*, *12*. https://doi.org/10.3389/fevo.2024.1422749

BPS, K. G. (2024). *Kecamatan Sangkapura Dalam Angka 2024*. https://gresikkab.bps.go.id/id/publication/2024/09/26/d56ed6e4f737f013f2dfdc0d/kecamatan-sangkapura-dalam-angka-2024.html

BPS, K. G. (2024). *Kecamatan Tambak Dalam Angka 2024*. https://gresikkab.bps.go.id/id/publication/2024/09/26/efc53f4c268ac3d15fea8636/kecamatan-tambak-dalam-angka-2024.html

Bryson, J., Quick, K., Slotterback, C., & Crosby, B. (2013). Designing Public Participation Processes. *Public Administration Review*, *73*, 23–34. https://doi.org/10.2307/23355431

Budi Arifanti, V., Sidik, F., Mulyanto, B., Susilowati, A., Wahyuni, T., Yuniarti, N., Aminah, A., Suita, E., Karlina, E., Suharti, S., Turjaman, M., Hidayat, A., Hendalastuti Rachmat, H., Imanuddin, R., Yeny, I., Darwiati, W., Sari, N., Surya Hakim, S., Yasmine Slamet, W., Osorio Ferreira, T. (2022). Challenges and Strategies for Sustainable Mangrove Management in Indonesia: A Review. *Forests 2022, Vol. 13, Page 695*, *13*(5), 695. https://doi.org/10.3390/F13050695

Chase, S. K., & Levine, A. (2016). A framework for evaluating and designing citizen science programs for natural resources monitoring. *Conservation Biology*, *30*(3), 456–466. https://doi.org/10.1111/cobi.12697

Cooper, C., Dickinson, J., Phillips, T., & Bonney, R. (2007). Citizen Science as a Tool for Conservation in Residential Ecosystems. *Ecology and Society*, *12*, 11. https://doi.org/10.5751/ES-02197-120211

Creswell, J. W. (2015). *A Concise Introduction to Mixed Methods Research*. SAGE Publications, Inc.

Devictor, V., Whittaker, R. J., & Beltrame, C. (2010). Beyond scarcity: Citizen science programmes as useful tools for conservation biogeography. *Diversity and Distributions*, *16*(3), 354–362. https://doi.org/10.1111/j.1472-4642.2009.00615.x

Dewi, C. S. U., Wahyudi, S., Widodo, Tarno, H., Ciptadi, G., & Wiadnya, D. G. R. (2024). Dugong dugon (Muller 1776) and Its Habitat in Coastal Areas and Small Islands of East Java Province, Indonesia. *IOP Conference Series: Earth and Environmental Science*, *1328*(1), 012003. https://doi.org/10.1088/1755-1315/1328/1/012003

Dharmawan, I. W. E., Suyarso, Ulumuddin, Y. I., & Pramudji. (2020a). *Panduan Monitoring Struktur Komunitas Mangrove Di Indonesia* (Issue September).

Dharmawan, I. W. E., Suyarso, Ulumuddin, Y. I., & Pramudji. (2020b). *Panduan Monitoring Struktur Komunitas Mangrove Di Indonesia*.

Donato, D. C., Kauffman, J. B., Murdiyarso, D., Kurnianto, S., Stidham, M., & Kanninen, M. (2011). Mangroves among the most carbon-rich forests in the tropics. *Nature Geoscience*. https://doi.org/10.1038/NGEO1123

Getz, D. (2008). Event tourism: Definition, evolution, and research. *Tourism Management*, *29*(3), 403–428. https://doi.org/10.1016/j.tourman.2007.07.017

Goodchild, M. F. (2007). Citizens as sensors: The world of volunteered geography. *GeoJournal*, *69*(4), 211–221. https://doi.org/10.1007/s10708-007-9111-y

Hakim, L., Siswanto, D., & Makagoshi, N. (2017). Mangrove Conservation in East Java: The Ecotourism Development Perspectives. *Journal of Tropical Life Science*, *7*(3), 277–285. https://doi.org/10.11594/jtls.07.03.14

IOJI. (2022). *Blue Carbon Ecosystem Governance in Indonesia: Threats & Opportunities—Inforial—The Jakarta Post*. https://www.thejakartapost.com/adv/2022/01/26/blue-carbon-ecosystem-governance-in-indonesia-threats-opportunities.html

Luthfi, O. M., Risjani, Y., Subramani, N., Rybak, M., Park, J., Bąk, M., & Witkowski, A. (2024). Diversity of epilithic diatoms from coral reef ecosystem of Bawean Island, Indonesia. *Biodiversitas Journal of Biological Diversity*, *25*(12), Article 12. https://doi.org/10.13057/biodiv/d251202

McLeod, E., Chmura, G. L., Bouillon, S., Salm, R., Björk, M., Duarte, C. M., Lovelock, C. E., Schlesinger, W. H., & Silliman, B. R. (2011). A blueprint for blue carbon: Toward an improved understanding of the role of vegetated coastal habitats in sequestering CO2. *Frontiers in Ecology and the Environment*, *9*(10), 552–560. https://doi.org/10.1890/110004

Meilana, L., Fang, Q., Susanto, H. A., Widiastutik, R., Syaputra, D. E., Ikhumhen, H. O., Sholihah, R., Hakim, A., Yang, S., & Liu, Z. (2023). How Indonesian marine protected areas (MPAs) are doing: A management performance-based evaluation. *Biological Conservation*, *282*, 110033. https://doi.org/10.1016/j.biocon.2023.110033

MuhammadAlGiffari, Febriamansyah, R., & Yuerlita. (2025). The Creative Economy Development Strategy on Marine Tourism: A Systematic Literature Review and Future Agenda. *Tourism in Marine Environments*, *20*(1), 51–67. https://doi.org/10.3727/216901925X17367756790656

Handayani, R. (2020). *Pengembangan Wisata Bahari yang Berkelanjutan*. Deputi Bidang Produk Wisata Dan Penyelenggara Kegiatan Events - Kemenparekraf RI.

Pham, T. T. T. (2020). Tourism in marine protected areas: Can it be considered as an alternative livelihood for local communities? *Marine Policy*, *115*, 103891. https://doi.org/10.1016/j.marpol.2020.103891

Purtina, A., Zannah, F., & Syarif, A. (2024). Inovasi Pendidikan Melalui P5: Menguatkan Karakter Siswa dalam Kurikulum Merdeka. *Pedagogik: Jurnal Pendidikan*, *19*(2), Article 2. https://doi.org/10.33084/pedagogik.v19i2.7947

Saputra, D. K., Maftuch, Riyanto, F. A. D., Septiani, A., Luqmania, D., Anjum, Sudiro, M. G., & Tsaabitah, Z. (2024). *Om Budi: Budidaya Perikanan Berkelanjutan Terintegrasi Desa Daun, Pulau Bawean*. Media Nusa Creative (MNC Publishing).

Schaffer, V., & Tham, A. (2019). Engaging tourists as citizen scientists in marine tourism. *Tourism Review*, *75*(2), 333–346. https://doi.org/10.1108/TR-10-2018-0151

Simpson, G., Parker, J., Gibbens, E., & Ladd, P. (2020). A Hybrid Method for Citizen Science Monitoring of Recreational Trampling in Urban Remnants: A Case Study from Perth, Western Australia. *Urban Science*, *4*, 72. https://doi.org/10.3390/urbansci4040072

TIES. (2015). *What is ecotourism? Ecotourism Principles.*

Tranter, S. N., Estradivari, Ahmadia, G. N., Andradi-Brown, D. A., Muenzel, D., Agung, F., Amkieltiela, Ford, A. K., Habibi, A., Handayani, C. N., Iqbal, M., Krueck, N. C., Lazuardi, M. E., Muawanah, U., Papilaya, R. L., Razak, T. B., Sapari, A., Sjahruddin, F. F., Veverka, L., Beger, M. (2022). The inclusion of fisheries and tourism in marine protected areas to support conservation in Indonesia. *Marine Policy*, *146*, 105301. https://doi.org/10.1016/j.marpol.2022.105301