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Beyond numbers: Assessing staff capacity and competence in the management of Indonesian marine protected areas

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ABSTRACT

Indonesia, recognized as a global marine biodiversity hotspot, has rapidly expanded its Marine Protected Area (MPA) network. However, management effectiveness continues to face challenges, partly due to limited staff capacity. This study presents the first evaluation of staff capacity in Indonesian MPAs, examining organizational structures, role clarity, required competencies, and staffing adequacy across 36 priority MPAs. Using document reviews, questionnaires, and focus group discussions, we found overlapping roles, broad job descriptions, and a mismatch between existing competencies and operational needs. Over two-thirds of the MPAs fell below the baseline of eight staff, and only three MPAs met the recommended staffing level of twenty staff to allow effective operations. Surprisingly, staff numbers were not correlated with MPA size and ecological characteristics (coverage of coral, seagrass, and mangrove), though they were positively associated with cumulative human pressure. Our analysis identified 20 role-specific competencies, four of which are not covered by the national certification scheme. Recognizing that each MPA has unique ecological characteristics, socioeconomic contexts, and management complexities makes staffing targets difficult to apply uniformly. Nevertheless, our proposed benchmarks offer a pragmatic reference to support planning and resource allocation when adapted to site-specific needs. Our results underscore the need for a structured, competency-based staffing strategy tailored to local contexts. We recommend establishing clear roles and job descriptions, aligning competencies with management needs, while also fostering partnerships with NGOs and local governments. These findings support Indonesian MPA planning and offer a scalable model for achieving SDG 14 and the '30 by 30' commitment globally.

1. Introduction

Marine Protected Areas (MPAs) are a common management tool for protecting coastal and marine ecosystems [14,15,50]. When well-managed over the long term, MPAs are expected to deliver positive outcomes by reducing stressors, conserving biodiversity, supporting

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environmental resilience, and enhancing human well-being [8,19,26,31,52]. These positive outcomes have prompted the designation of MPAs worldwide, especially after the United Nations (UN) Sustainable Development Goals (SDGs) mandated that at least 10 % of the planet's coastal and marine areas be protected by 2020 (SDG 14: Life below water) [45]. MPA expansion continues to be a priority on the international agenda, especially under the Convention on Biological Diversity (CBD), where 196 countries agreed to conserve 30 % of land, water, and seas by 2030, a goal commonly referred to as 30 by 30 (CBD, 2024). The commitments under SDG 14 and the 30 by 30 target have further accelerated global MPA expansion, with 9.61 % of the ocean under protection as of July 2025 [47]. However, the management effectiveness of most MPAs worldwide remains inadequately assessed or uncertain [46].

Among the various factors influencing MPA effectiveness, staff capacity has emerged as one of the most critical predictors of conservation success in terrestrial and marine areas [12,17]. Staff capacity is defined as the number of staff possessing the necessary knowledge, skills, and attitude (i.e., competency) required to effectively manage an MPA, with clearly defined roles that align with conservation objectives at both organizational and individual levels. Insufficient staff capacity has been identified as a key barrier to effective management, hindering the performance of MPAs globally [17]. Ensuring adequate staff capacity involves clearly defining roles and responsibilities, validating competencies (e.g., through certification programs), and providing sufficient staff within each MPA management unit. A lack of clarity in staff roles and responsibilities during the design or implementation of management activities can lead to indistinct operational tasks, overlapping duties, and, ultimately, weakened conservation efforts [41]. Moreover, MPA staff are expected to demonstrate their ability to perform conservation tasks effectively [7]. Typically validated through certification schemes that assess conservation-related competencies [43]. In addition to competency gaps, insufficient staffing remains a widespread challenge, further constraining the ability of MPAs to meet their objectives [17].

Indonesia has been recognized as a global marine conservation priority because it harbors some of the most diverse coral and reef fish species worldwide [1,27]. Notably, Indonesia hosts the largest tropical coral reef systems within the Coral Triangle, covering approximately 4 million hectares [2,9]. Additionally, Indonesia's extensive mangrove forests, which span 3.3 million hectares, represent 23 % of the global mangrove area [33]. The nation also harbors the largest seagrass meadows in Southeast Asia and potentially ranks among the largest globally [44]. However, despite these ecological treasures, over 70 % of Indonesia's 270 million population resides in coastal areas [48], subjecting marine ecosystems to numerous anthropogenic stressors [9,40,49].

In response to widespread ecosystem degradation and the need to protect biodiversity, the Government of Indonesia has designated and established 411 MPAs, covering 28.4 million hectares, as of December 2021 [32,37]. These MPAs are managed using a zoning system under a partial protection scheme [5], aligned with IUCN Protected Area Category VI, which allows sustainable use of natural resources within MPAs. They vary widely in size, ranging from less than 100 to more than 3 million hectares, with an average of 133.52 ± 23.79 thousand hectares [16]. The government is further committed to expanding MPA coverage to 32.5 million hectares by 2030 (10 % of the nation's waters) and 97.5 million hectares by 2045 (30 % of the nation's waters) [34]. Despite this substantial spatial growth, no Indonesian MPA has achieved optimal management effectiveness [4]. According to the Evaluation of the Effectiveness of Conservation Area Management (EVIKA) [21,32], up to 61 % of Indonesian MPAs are classified as ineffectively managed [32].

Indonesian MPAs are governed under two legal frameworks administered by the Ministry of Marine Affairs and Fisheries (MMAF) and the Ministry of Environment and Forestry (MoEF). As of December 2021, ~85 % of MPA areas were managed by MMAF, while the remaining ~15 % fell under MoEF management [34]. MMAF MPAs are further categorized into two management authority levels: national and provincial. National MPAs are managed directly by MMAF, while provincial MPAs are overseen by the Fisheries and Marine Affairs Department at the provincial level (*Dinas Kelautan dan Perikanan Provinsi/DKP-Provinsi*) or through MPA management units such as Technical Implementing Unit (*Unit Pelaksana Teknis*/UPT) and Regional Public Service Agency - Regional Technical Implementing Unit (*Badan Layanan Umum Daerah-Unit Pelaksana Teknis Daerah*/BLUD UPTD).

The MPA governance system in Indonesia is government-led and operates under clearly defined standards for establishment and operational implementation. This system is guided by national regulations outlining legal, ecological, and institutional standards, including staff capacity and competency requirements, as written in the official regulations and EVIKA. The government has made progress in improving MPA staff capacity by providing training opportunities for MPA managers and staff [4]. However, these capacity-building programs are often limited to one-off training with no clear targets for participants, allowing any MMAF or provincial government staff member to participate regardless of their roles and needs [51]. Moreover, data on program outcomes and overall staff capacity at the site level are notoriously scarce, making evaluating staff capacity in MPA management in Indonesia challenging.

Given the considerable and ongoing expansion of Indonesian MPAs, there is an urgent need to understand the status of staff capacity across these protected areas. This study aims to (1) assess the current organizational structures, roles, and responsibilities of staff in MMAF-managed MPAs, (2) provide an overview of existing competencies and identify key competency needs, and (3) provide an overview of both current and required staff numbers. This study represents the first comprehensive national assessment of staff capacity within Indonesia's MPAs, and the findings aim to support adaptive MPA management, particularly from a human resources perspective.

2. Materials and methods

2.1. Study areas

We sampled a subset of 36 MPAs managed by the Ministry of Marine Affairs and Fisheries (MMAF) out of the 411 Indonesian MPAs of December 2021. These MPAs were selected because they are nationally recognized as priority MPAs by the Indonesian government (Presidential Regulation of the Republic of Indonesia No. 2/2015), allowing lessons learned, such as from this study, to be applied to other MPAs [23]. The 36 MPAs comprise 10 national MPAs and 26 provincial MPAs (Fig. 1). They are located across 20 provinces in Indonesia, with 1–6 MPAs sampled per province.

For each sampled MPA, the following information was recorded: MPA name, management authority (national or provincial), size (in hectares), habitat coverage (coral, mangrove, and seagrass, in hectares), and cumulative impact of stressors/pressures (including fishing, sediment, nitrogen pollution, coastal population, industrial development, and tourism) within MPA boundaries (Table S1). MPA size data were obtained from the official MMAF database (www.sidakokkhl.kkp.go.id). The size of the MPAs ranges from 4 to over 3 million hectares. Ecological data, including habitat coverage of coral reefs, seagrass, and mangrove, and cumulative stressor impacts in Indonesia, were compiled from peer-reviewed literature [6,16]. MPA size and ecological variables were included in the analysis to assess whether they are associated with variations in staff allocation across MPAs. MPAs with larger spatial coverage, higher habitat coverage, or greater exposure to cumulative anthropogenic stressors, are hypothesized to require increased institutional capacity to support MPA management.

National MPAs
4. Pulau Pieh
6. Kepulauan Anambas
14. Gili Matra
19. Kepulauan Kapoposang
22. Laut Sawu
27. Laut Banda
28. Kepulauan Waigeo Sebelah Barat
29. Kepulauan Raja Ampat
35. Kepulauan Aru Bagian Tenggara
36. Kepulauan Padaido

Provincial MPAs
1. Pesisir Tiimur Pulau Weh
2. Sawo-Lahewa
3. Selat Bunga Laut
5. Teluk Kiluan
7. Maritim HMAS Perth
8. Pantai Penyu Pangumbahan
9. Gugusan Pulau-Pulau Momparang
10. Ujungnegoro Roban
12. Teluk Benoa
13. Nusa Penida
11. Gosong Senggora, Sepagar, & Sekitarnya
15. Angsana, Sungai Lobat, Pulau Laut Sembilan
16. Gili Tangkong, Nanggu, dan Sudak
17. Gili Sulat, Lawang
18. Kepulauan Derawan
20. Donggala, Buol, Tolitoli
21. Parigi Muotong, Poso, Tojo Una
24. Banggai, Banggai Laut, dan Banggai Kepulauan
25. Selat Pantar
26. Kepulauan Tatoareng
23. Morowali, Morowali Utara
30. Kepulauan Raja Ampat Kabupaten Raja Ampat
31. Pulau Kei Kecil
32. Teluk Berau dan Teluk Nusalasi-van den Bosch33. Jeen Womom Tambrauw
34. Buruway, Arguni, Kaimana, Teluk Etna

Fig. 1. The spatial distribution of Indonesian Marine Protected Areas (MPAs) is shaded in blue. The numbers correspond to the 36 sampled MPAs, numbered from west to east, with detailed names provided in the accompanying legend.

2.2. Data collection

All data collection for this study was conducted as part of a routine Indonesian government program to assess staff capacity in MPAs, carried out in collaboration with NGO partners. All participant responses were gathered through questionnaires and Focus Group Discussions (FGDs), collected voluntarily with informed consent and the right to decline or withdraw at any time, and were rigorously anonymized.

2.2.1. Organizational structures, roles, and job descriptions

The current organizational structures and staff roles for each management unit were identified through a four-step process (Fig. 2A). *First*, we reviewed Government Regulation 41/2007 via the MMAF website (www.jdih.kkp.go.id) to create a list of organizational structures and roles. *Second*, an online questionnaire was distributed to MMAF MPA managers and staff to collect direct input on organizational structures, roles, and job descriptions (Table S2). This questionnaire was disseminated randomly to 100 individuals (managers and staff) managing national or provincial MPAs. *Third*, we received only 90 responses, which were subsequently compiled for analysis. *Fourth*, a Focus Group Discussion (FGD) was held in January 2020 to gain deeper insights about organizational structures and roles. This FGD involved 39 participants from MMAF, the Human Resources Research Agency – MMAF (*Badan Riset Sumber Daya Manusia Kementerian Kelautan dan Perikanan*/BRSDM-KP), the Training and Counseling Center (*Pusat Pelatihan dan Penyuluhan*/ Puslatluh), MPA managers and staff, and 10 NGO representatives. The FGDs started with a statement of objectives, followed by semi-structured discussions guided by a set of open-ended questions. These questions focused on participants' roles and job descriptions. Key themes included current job roles, alignment between actual duties and formal job descriptions, and perceived gaps or overlaps in responsibilities (Table S5).

2.2.2. Key competencies for current MPA staff members

To assess the current conservation and required conservation competencies for MPA staff, we followed a five-step process (Fig. 2B). The *first* step involved a series of activities. We reviewed relevant documents provided by BRSDM-KP, i.e., the MMAF Ministerial Regulation No. 9/2014 and the Administrative and Bureaucratic Reform Ministerial Decree No. 44/2014, to develop an initial list of existing conservation competencies. Furthermore, we examined the national certification schemes through two official online platforms: https://skkni.kemnaker.go.id (managed under the Ministry of Manpower of the Republic of Indonesia/Kemnaker) and bnsp.go.id (National managed under the Professional Certification Board of Indonesia, *Badan Nasional Sertifikasi Profesi*/BNSP) to identify all available certification schemes related to conservation in Indonesia. After compiling the initial list, two co-authors (AC and ST) independently cross-checked each competency to ensure accuracy, consistency, and alignment with the official source documents and national guidelines.

Second, we conducted the second FGD in mid-April 2020 to discuss the available conservation competencies. This FGD involved 12 participants from MMAF, four MPA managers from national and provincial levels, and six NGO participants. *Third*, we distributed an online questionnaire to MPA managers and staff members of the 36 MPAs to determine whether current MPA staff held certification in the identified competencies. The questionnaire comprised 36 open-ended questions designed to capture information on the types of certifications held by staff (Table S2). *Fourth*, we organized the data from the questionnaire for further analysis. *Fifth*, we conducted the third FGD at the end of April

Fig. 2. Overview of our approach. A. Four-step approach to obtain data on organizational structures, roles, and job descriptions in national and provincial MPAs. Step A1 included a review of Government Regulation No. 41/2007. B. Five-step approach to assess current staff certification competencies and national certification schemes. Step B1 involved reviewing documents from BRSDM-KP, MMAF Ministerial Decrees No. 9/2013 and No.15/2018, Administrative and Bureaucratic Reform Ministerial Decree No. 44/2014, and online portals from the Ministry of Manpower and BNSP (https://skkni.kemnaker.go.id/ and https://bnsp.go.id/skkni, respectively. C. Four-step approach to assess current staff numbers and estimate staffing needs. Step C1 included LSP, CTC, and LIPI/BRIN certification documents between 2016 and 2019. An online questionnaire was sent to 100 MPA managers and staff covering staff roles, numbers, and certifications. Four FGDs were held for validation, each with different aims and participants. Grey boxes represent data collection, yellow boxes represent data validation, and green boxes represent outcomes.

2020 to discuss the key conservation competencies required for effective MPA management (Table S5).

2.2.3. Current and required staff numbers

The current staff numbers were documented based on individuals employed within MPA management units, either as civil servants or permanent staff, as well as those possessing at least one certificate of competence in marine conservation issued by the National Professional Certification Bureau (*Lembaga Sertifikasi Profesi*/LSP) or other recognized certification institutions. Data collection on current staff numbers was obtained following four steps (Fig. 2C). *First,* we collected data on the current MPA managers and staff based on certification documents provided by LSP, Coral Triangle Center (CTC), and Indonesian Science Institute (*Lembaga Ilmu Pengetahuan Indonesia*/LIPI, later became the National Research and Innovation Agency, *Badan Riset Inovasi Nasional*/BRIN), covering the period from 2016 to 2019. *Second*, we distributed an online questionnaire to MPA managers and staff to gather additional information on the number of staff possessing conservation-related certifications (Table S2). *Third*, we organized the collected data by province and by management authority. *Fourth*, we conducted the fourth FGD in March 2020 to discuss the findings by involving representatives of MPA managers and staff from national and provincial governments (19 participants) and NGOs (6 participants).

We used FGDs to reach consensus among participants and identify perceived staffing needs (Table S5). Participants were asked to estimate the number of staff required to manage a single MPA, regardless of size. During the discussions, participants collectively defined four operational staffing levels: Minimal (Level I), Medium (Level II), Near-Optimal (Level III), and Optimal (Level IV). Table 1 presents these FGD-derived staffing levels and their organizational structures, role descriptions, and core responsibilities. Participants were then asked to estimate the number of staff required to manage a single MPA under each level, regardless of its size.

- Level I - Minimal: The minimum staffing required for basic MPA operations, covering essential roles for regulatory enforcement and administration. It serves as a baseline for new or resource-limited MPAs.
- Level II - Medium: Provides moderate operational capacity, allowing more regular field activities, basic ecological monitoring, and improved administration, moving beyond mere survival towards functional management.
- Level III - Near-Optimal: Supports broader conservation objectives, including community engagement and systematic data collection.
- Level IV - Optimal: Represents full operational capacity for comprehensive MPA management, including extensive monitoring, enforcement, outreach, financing, and support for specialized

Table 1
Organizational structure, roles, job descriptions, and required staff numbers for MPA management, as identified through FGDs. Participants collaboratively defined four staffing capacity levels. Level I: Minimal - the minimum number needed for basic operations, including regulatory enforcement and administration. Level II: Medium – allows for intermediate capacity with more consistent field presence, basic ecological monitoring, and improved administration. Level III: Near-Optimal - supports broader objectives such as community engagement, systematic data collection, and comprehensive conservation programs. Level IV: Optimal - enables full implementation of mandates, including extensive monitoring, enforcement, outreach, sustainable financing, and scientific or policy support. Each row lists a role, associated responsibilities, and the number of staff required at each level.

Organizational roles	Job descriptions / Tasks	Required Staff Numbers			
		Level			
		I	II	III	IV
A. Coordinator	Coordinate field operations and supervise MPA staff.	1	1	1	1
B. Administration and Finance Officer	Manage financial records, procurement of goods and services, and documentation of MPA activities.	1	1	2	2
C. Biophysical Monitoring Officer	Conduct biophysical monitoring: collect data, write activity reports, assess long-term biodiversity indicators, track changes in critical marine habitats and species under protection, and provide real-time information for adaptive management.	1	2	3	4
D. Socioeconomic and Cultural Monitoring Officer	Conduct socioeconomic and cultural monitoring: collect data, write activity reports, assess long-term indicators, and provide real-time information for adaptive control to ensure local stakeholders benefit appropriately from MPA management.	1	2	2	2
E. Service and Partnership Officer	Monitor resource use, collaborate with local communities, process permits for fisheries and tourism, facilitate partnerships with communities, fishers, and private sectors, and oversee licensing, permitting, and service-related activities.	1	1	2	2
F. Surveillance Officer	Coordinate surveillance with relevant stakeholders, monitor resource use patterns, report violations, and patrol patrols and monitoring within the MPA.	1	2	4	5
G. Community Outreach and Awareness Officer	Develop awareness materials, conduct outreach activities to engage and educate local communities and stakeholders, and promote compliance with MPA regulations.	1	1	2	2
H. Information and Technology Officer	Manage data collection, analysis, storage, and visualization using relevant digital tools and applications.	1	1	1	2
I. Environmental Impact Assessment Officer	Conduct regular monitoring, carry out capacity assessments, and evaluate environmental impacts, including mitigating damage to resources from wastewater, plastic, sewage, and others.				1
Total required staff		**8**	**11**	**17**	**20**

expertise or policy, ensuring the long-term ecological and socio-economic benefits.

2.3. Data analysis

The organizational structures and staff roles within MPA management units were visualized using a flowchart maker. For the competencies analysis, we recapitulated the existing conservation

competencies and summarized additional competencies proposed by FGD participants. We used descriptive statistics, including summary measures and frequency distributions, to analyze: 1) the number of current staff members per province and management authority and 2) the number of staff required per MPA based on stakeholder-defined capacity levels. To examine the relationships between average staff numbers per MPA and ecological or spatial characteristics – namely MPA size, coral cover, mangrove cover, seagrass cover, and cumulative stressors impacts – we used Spearman's rank correlation test, selected due to non-normal data distribution. Data analysis and visualization were performed in R, version 4.4.1 (R Core Team, 2025), while maps were created in QGIS *Geographic Information System (version 3.18). QGIS is developed by the* Open Source Geospatial Foundation and is available at http://www.qgis.org.

3. Results

3.1. Organizational structures, roles, and job descriptions of current MPA staff

According to Government Regulation No. 41/2007, Article 29(1), MPA management units are required to comprise at least three hierarchical layers: (1) *Head of the Technical Management Unit*, (2) *Secretariat*, and (3) *Four Divisions,* each of which may include up to three *Subdivisions* (Fig. 3A). However, the regulation does not specify detailed roles or job descriptions for these *Subdivisions*.

Based on the questionnaire, we identified a common organizational structure currently in practice, comprising six distinct roles or positions (Fig. 3B). This structure provides a more detailed differentiation of roles than outlined in the regulation. The data were drawn from 90 respondents. Specifically, we recorded that 15 % of respondents (n = 14) were *Contract Staff* – non-permanent employees typically hired through outsourcing, characterized by flexible roles and less job security, or members of *Functional Role Groups,* who are assigned to general institutional functions. The remaining respondents, identified as *Analysts* (38 %, n = 34), *Development* or *Management Officers* (38 %, n = 34), *Finance* or *Administration Officers* (8 %, n = 7), and *Head of Management Unit* (1 %, n = 1), indicate a diverse representation of operational roles (Table S6).

During the initial FGD, participants acknowledged that although organizational structure regulation exists, job descriptions for each role remain unclear. For instance, community outreach and education—typically assigned to *Development Officers*—are frequently undertaken by staff in *Functional Role Groups* or by *Contract Staff* due to unclear

Fig. 3. Overview of the organizational structures within MPA management in Indonesia. A. Structure mandated in the Government Regulation No. 41/2007. B. Structure with six roles reported by questionnaire respondents. Note that 15 % of respondents identified as Contract Staff and Functional Role Group members, who are not formally integrated into an official structure (grey boxes). C. The proposed organizational structure was developed during FGDs, with defined roles and job descriptions. White boxes indicate new roles proposed by FGD participants. The yellow, green, and blue boxes denote roles within the proposed structure that are positioned at the same hierarchical level, as outlined in A and B.

task allocations. Building on these observations, the FGD proposed a structure comprising one coordinator and eight supporting officer roles. Each of the supporting roles may also have its own divisions. The nine clearly defined roles are each accompanied by specific job descriptions (Fig. 3C, Table 1).

3.2. Conservation competencies

We found that existing conservation competencies required for MPA staff cover a diverse range of skill sets (Table S3). The MMAF Ministerial Regulation No. 9/2013 defines five core competencies for MPA staff, i.e., Community Education in MPAs, Enforcement of MPA Laws, Fisheries Management in MPAs, Tourism Management in MPAs, and Monitoring and Evaluation of MPA management. In contrast, BRSDM-KP has identified fourteen competencies (Table S3). However, many of these are too general or lack clear definitions. For instance, the competency labeled *Field Skills* in the BRSDM-KP document is either inadequately defined or overly broad.

During the second and third FGDs, all participants acknowledged the importance of clearly defined conservation competencies in successfully carrying out conservation efforts. The discussions underscored the need for formal competencies linked to each organizational role. Our analysis identified 20 conservation competencies tailored to distinct roles (Table 2, Table S4). For example, the *Coordinator* is expected to have proficiency in 11 conservation competencies (Table 2, Role A), while the *Biophysical Monitoring Officer* (Role C) requires nine different competencies. Further analysis revealed that the national certification scheme does not cover four of the 20 competencies: *Monitoring and Evaluation of MPA Effectiveness, Collaborative Management, Surveillance of Resource Use, and Sustainable Financing* (Table 2).

3.3. Current and required staff numbers per MPA across provinces

A total of 236 MPA staff members are responsible for managing 36 sampled MPAs across provinces in Indonesia. These staff members were unevenly distributed, ranging from 1 to 42 staff members per province, with an average of 11 ± 3 staff per province (Fig. 4A) and a median of 7 staff. The East Nusa Tenggara province has the highest staff number (42 staff across 2 MPAs), followed by West Nusa Tenggara (39 staff members across 3 MPAs). Conversely, East Kalimantan and North Sumatra had only one staff member to manage a single MPA (Fig. 4A). Since staffing data is reported by province, we calculated the average staff numbers per MPA for provinces managing more than one MPA to enable comparison.

National MPAs have, on average, higher staff numbers per MPA than provincial MPAs (Fig. 4B). Surprisingly, there is no significant correlation between staff numbers per MPA and MPA size. The largest sampled provincial MPA in Central Kalimantan has only five staff members, while a national MPA in the Riau Islands, which is at least five times smaller, has 23 staff members (Fig. 4C). Furthermore, we found no significant correlation between the average staff number per MPA and ecological characteristics (coral, mangrove, seagrass cover) and a significant positive correlation between staff numbers and cumulative impacts (Figure S1).

Through FGDs, participants defined four distinct management capacity levels (Level I to IV) to guide staffing needs for MPA operationalization (Table 1). These levels represent increasing operational capacity, developed through consensus among diverse stakeholders. Each level corresponds to specific roles and associated staff numbers. Staffing was categorized into four levels based on MPA: Level I (8 staff), Level II (11), Level III (17), and Level IV (20). Surprisingly, data on staff numbers across 36 sampled MPAs showed a wide variation in staffing levels across provinces, with 70 % of MPAs failing to meet even the Level I threshold (Fig. 5). While more than one-third of the provinces meet the minimum requirement of 8 staff per MPA, higher staffing levels are rare. Only two provinces, East Nusa Tenggara and Riau Islands, meet the threshold for level IV staffing numbers (20 staff members) (Fig. 5).

4. Discussion

Despite Indonesia's significant progress in expanding its Marine Protected Areas (MPAs) to meet global biodiversity targets, our findings highlight persistent gaps in staff capacity that pose serious challenges to effective management. This is consistent with global trends, where MPA effectiveness often lags behind commitments [24], partly due to insufficient human resources. Staff capacity is widely recognized as one of the strongest predictors of MPA management effectiveness [17]. Through document review, questionnaires, and FGDs, we identified the staff

Table 2
Conservation competencies organizational role in MPA management, as proposed by FGDs involving MMAF, MPA managers and staff (national and provincial), and conservation NGOs. Organizational roles correspond to those in Table 1. A. Coordinator, B. Administrative and Finance Officer, C. Biophysical Monitoring Officer, D. Socioeconomic and Cultural Monitoring Officer, E. Service and Partnership Officer, F. Surveillance Officer, G. Community Outreach and Awareness Officer, H. Information and Technology Officer, I. Environmental Impact Assessment Officer. A plus symbol (+) indicates the competencies required for each role. Descriptions and certification availability of each competency are detailed in Table S4.

Conservation competencies	Organizational structures and roles									Availability status in the national certification scheme
	A	B	C	D	E	F	G	H	I	
MPA Management Planning – Basic		+	+	+	+	+	+	+		Available
MPA Management Planning – Intermediate	+		+	+					+	Available
MPA Management Planning – Advanced	+			+					+	Available
Biophysical Monitoring – Coral Reefs	+		+						+	Available
Biophysical Monitoring – Reef Fishes	+		+							Available
Biophysical Monitoring – Seagrass			+							Available
Biophysical Monitoring – Mangrove			+						+	Available
Biophysical Monitoring – Megabenthic			+							Available
Socio-Economy and Cultural Monitoring	+			+			+		+	Available
Marine Eco-Tourism		+		+	+		+			Available
Aquaculture Activities		+			+		+			Available
Management Operational	+	+			+					Available
Technology and Information		+	+	+	+	+		+		Available
Human Resource Management	+	+								Available
Community Engagement					+		+			Available
Outreach and Communication				+	+	+	+			Available
Surveillance of Resource Use	+			+		+			+	Not available
Monitoring and Evaluation of MPA Effectiveness	+		+		+	+	+		+	Not available
Collaborative Management	+				+	+				Not available
Sustainable Financing	+	+		+	+					Not available

Fig. 4. Distribution of staff numbers by province, management authority, and MPA size in Indonesia. A. Total staff numbers per province. The first y-axis represents province names, and the second y-axis represents the number of MPAs in that province. B. Average staff numbers per MPA for each management authority. Colored bars represent the mean number of staff for each authority type: navy blue for national MPAs, and light blue for provincial MPAs. Yellow regions highlight areas of higher density — i.e., where staff numbers are most concentrated within each management authority type. Error bars indicate the standard error; the white line inside the bar represents the median. The overlaid violin plot within each bar illustrates the distribution of staff numbers per MPA, illustrating variation within each management authority. C. Average staff numbers per MPA in relation to MPA size (in hectares). Each point (star and triangle) represents an individual MPA, color-coded by management authority. MPA numbers correspond to those listed in Fig. 1.

capacity requirements to manage Indonesian MPAs effectively. We contrasted these with the current staff capacity in 36 MPAs, considering organizational structures, roles, job descriptions, requisite competencies, and staff numbers. Although national regulations have formalized MPA governance structures, many MPAs operate with unclear or undefined job descriptions and a limited match between staff competencies and conservation responsibilities. Furthermore, our study reveals a disconnect between MPA staffing and these areas' ecological, spatial, and governance complexities. This disconnect suggests that staffing decisions are not guided by ecological or management needs, undermining efforts to deliver the expected outcomes of biodiversity protection, resilience, and sustainable use. Addressing these capacity shortfalls is particularly urgent, given Indonesia's prominent role within the Coral Triangle and its commitment to expand MPA coverage to 97.5 million hectares by 2045. The following sections discuss our findings and potential strategies to strengthen current MPA management, focusing on staff capacity.

4.1. The significance of defining clear roles, tasks, and staff competencies in MPA management

We found a lack of clarity in the assignments of specific responsibilities for conservation management tasks (Fig. 3A-B). This ambiguity can result in overlapping duties or the delegation of tasks to individuals lacking appropriate expertise, ultimately hampering conservation efforts [41]. Similarly, Gleeson et al. [18] emphasize the importance of clearly defined roles and tasks to ensure effective MPA management. In the Indonesian context, such ambiguity could be

Fig. 5. Comparison of current versus required staff numbers for managing a single MPA across Indonesian provinces. Bars represent the current average staff numbers per MPA in each province, with colors indicating staffing adequacy relative to four capacity levels identified during FGDs. Grey: below Level I (fewer than 8 staff); red: meets Level I (8 staff); orange: 11 – 16 staff; green: 17 – 19 staff; and blue: meets or exceeds Level IV (20 or more staff). Dashed lines on the x-axis represent the thresholds for each staffing level. Note that the required staff numbers per MPA serve as benchmarks for MPA operational capacity (Table 1).

attributed, in part, to human resource constraints following the recentralization of marine governance under Law No. 23/2014, which shifted management authority from district to provincial governments. This transition has introduced institutional discontinuities, particularly in staffing, funding, and infrastructure, which have created gaps between district and provincial responsibilities. One outcome has been the disruption of the surveillance programs previously managed at the district level. Due to limited staff at the provincial level, many MPAs now lack consistent monitoring and enforcement activities [29,55].

Despite these challenges, the Indonesian government has taken steps towards establishing MPA staffing structures and roles at the national and provincial levels [35]. A key step has been the implementation of EVIKA, a diagnostic tool that systematically evaluates existing staffing levels and identifies capacity gaps across MPAs [21]. This evaluation informs targeted interventions to address specific shortages in human resources. Building on these, the government, working in collaboration with ministries, institutions, and NGOs, has developed a national roadmap for the MPA capacity-building program [20].

Our study underscores that while the organizational structure and roles in MPA management appear clear on paper (Fig. 3C, Table 1), implementation at the site level often leads to individuals performing responsibilities outside their formal roles in practice. This indicates that the challenge lies not only in overlapping roles within the organizational structure but rather in how roles and responsibilities are carried out on the ground. This suggests a need for better alignment between assigned roles and actual duties. Moreover, our results showed that the FGD participants clearly preferred a two-tier organizational structure, diverging from the three-tier model mandated by regulation. This preference was grounded in the perceived inefficiencies introduced by an additional administrative layer, particularly in MPAs with limited resources. The simplified structure was seen as reducing bureaucratic delays. Changes in role titles—for example, replacing "head" with "coordinator"—reflected a deliberate move toward more collaborative and less hierarchical management models. Such shifts were understood to support more fluid communication and align more closely with local governance practices. Collectively, these adaptations were viewed as improving the functionality of MPA operations while maintaining clarity in roles.

MMAF Regulation No. 31/2020 (Article 35, verses 1–3) limits staffing to government employees, excluding community representatives, NGOs, or other relevant stakeholders from participating as MPA staff. This regulatory constraint has potentially resulted in a significant gap in fulfilling specific roles. Fortunately, NGOs such as the Coral Triangle Center (CTC), Konservasi Indonesia (KI), Yayasan Konservasi Alam Nusantara (YKAN), Wildlife Conservation Society (WCS), and other international and local NGOs have actively contributed to filling some of these gaps by supporting biophysical, socio-economic, and surveillance monitoring [53], as well as offering training, technical support, and funding. While this support is invaluable, it reinforces the importance of institutionalized partnerships and collaborative frameworks [54].

Regarding staff competencies, our study emphasizes that many existing competencies are overly broad and insufficiently detailed (Table S3). This may be due to the lack of tailored training programs designed to address the complexities of MPA management. While broad competency frameworks capture general skills, more targeted competencies are needed to address the operational realities of each MPA. Training should be linked to ecological and social conditions, including locally collected and culturally contextualized data [39]. While further research is needed to understand the causal links between MPA effectiveness and staff competencies, our study represents an important first attempt to identify role-specific competencies for MPA staff in Indonesia.

4.2. Challenges and solutions in ensuring sufficient staffing for MPA management

Our study reveals uneven distribution in MPA staff across Indonesian provinces, with national MPAs typically having more staff than provincial MPAs (Fig. 4). This discrepancy may be attributed to stronger institutional support in some MPAs, where stricter monitoring and control measures are in place [32]. Conversely, many provincial MPAs, such as those in West Nusa Tenggara and South Sulawesi, suffer from inconsistent institutional support, including limited funding and staff shortages [3,29], despite their significant contribution to Indonesia's MPA expansion efforts [42].

Overall, most Indonesian MPAs face human resources challenges, with some lacking sufficient staff members to conduct surveillance or monitoring activities [13,22,35,38,20]. When compared to global staffing benchmarks, i.e., an average of 27 staff or up to 165 staff members per 100,000 hectares in Southeast Asia [28]. The 236 staff managing over 16 million hectares across 36 studied MPAs illustrate a striking deficit. Notably, many of these staff are also responsible for managing other MPAs within their provincial jurisdiction, which are not included in our analysis. This shortfall directly threatens the essential management functions of MPAs, including enforcement and monitoring, with potentially severe consequences for ecological outcomes [25,30,36]. Gill et al. [17] reported that MPAs with adequate staffing have

almost three times better ecological conditions than those without.

Our findings highlight significant gaps when evaluating the current staffing across sampled MPAs. Analysis reveals that nearly two-thirds of the MPAs studied do not meet the minimum Level I requirement of 8 staff. Furthermore, only two provinces (East Nusa Tenggara and Riau Islands) reach the Level IV threshold of 20 staff per MPA (Fig. 5). This substantial disparity between recommended and actual staffing underscores a systematic limitation that threatens management effectiveness and conservation outcomes. While the proposed benchmarks offer a valuable guideline, MPA managers and policymakers should not apply them rigidly. Instead, we recommend an adaptive approach: clearly identify core staff roles and responsibilities, then conduct periodic assessments to evaluate whether staff numbers, functions, and competencies are adequate for evolving needs. Such an iterative, evidence-based process is critical in translating policy commitments into effective, on-the-ground MPA management.

Our analysis reveals a significant positive correlation between MPA staff numbers and cumulative stressor levels (Figure S1), suggesting that areas experiencing higher human and environmental pressures tend to be allocated more staff. This pattern implies that management efforts are at least partially responsive to external threats, with staffing decisions reflecting the need for greater oversight and intervention in regions facing intensified stress. However, our analysis shows no significant correlation between staff numbers and MPA size (Fig. 4) or between staff numbers and ecological attributes such as coral, mangrove, and seagrass cover (Figure S1), indicating that spatial and environmental factors have not been systematically considered in determining staff allocations. While larger MPAs often pose greater management challenges and require more staff, a detailed assessment of this relationship was beyond the scope of this study. Importantly, increasing staff numbers alone, whether to meet the minimum Level I benchmark (8 staff) or the optimal Level IV benchmark (20 staff), does not guarantee improved performance. However, insufficient staffing and the necessary competencies are clear barriers to even basic levels of effective MPA management.

Beyond staff quantity, adequate enforcement, monitoring, and stakeholder engagement are essential to enhance MPA performance [11]. Although site-specific management plans theoretically guide staffing and budgetary needs, many plans in Indonesia remain overly generic. They often fail to prioritize key stressors within the management plans [10] or define necessary competencies. Addressing staff shortages must, therefore, be part of a broader strategy. First, improving management capacity can be facilitated through collaborative efforts with local communities and government partners such as NGOs, the private sector, and research institutions. For example, at the time of our study (2018–2020), West Papua had only two staff members to manage six MPAs spanning over two million hectares (Fig. 4A). Despite being understaffed (Fig. 5), Raja Ampat MPA in West Papua achieved optimal effectiveness due to strong collaborations with NGOs [32]. This example highlights that while staffing benchmarks are valuable, cross-sectoral collaborations are essential for supplementing human resources and technical expertise. Second, recognizing that each MPA has unique ecological characteristics, socioeconomic contexts, and management complexities makes standardizing staffing targets difficult to apply uniformly. Nevertheless, our proposed benchmarks (Table 1, Fig. 5) offer a pragmatic reference based on management functions, which can support planning and resource allocation when adapted to site-specific needs.

5. Conclusion and recommendations

Over the past few decades, Indonesia has made substantial progress in expanding its Marine Protected Area (MPA) network to meet global biodiversity targets. However, this expansion has not been matched by sufficient investment in staff capacity, which remains a critical barrier to effective MPA implementation. Our study underscores the need to move beyond fulfilling staffing numbers and toward a structured, competency-based human resource approach.

Despite limitations in site-level data, our nationwide scoping provides a valuable overview of current MPA staffing conditions, identifying areas of strength and critical gaps across organizational structures, staff numbers, and competencies. This information is essential for initiating informed dialogues on effective resource allocation and guiding targeted management actions. Given the standardized governance system applied to Indonesian MPAs, establishing a national staff capacity standard aligned with legal mandates and certification frameworks is necessary and achievable.

To strengthen MPA governance in Indonesia and potentially serve as a model for other nations striving to meet their commitments under SDG 14 and the global “30 by 30” target, we propose four key recommendations: (1) formalize and clarify organizational structures, roles, and responsibilities to minimize functional overlap and enhance operational coherence within MPA management units; (2) ensure adequate staffing levels matched with role-specific competencies, through coordinated partnerships with district governments, NGOs, and other relevant stakeholders. This is important as district-level authorities are uniquely positioned due to their proximity to communities and strong social ties with stakeholders, making them indispensable to locally responsive MPA management; (3) tailor staffing strategies to local contexts, including ecological characteristics (e.g., coral, seagrass, and mangrove cover), MPA size, geographical location, socioeconomic context (e.g., intensity of stressors or stressors level, socioeconomic status), and institutional complexity; and (4) institutionalize regular monitoring and evaluation of staff capacity to guide adaptive management, track progress, and identify persistent or emerging challenges.

CRediT authorship contribution statement

Agustin Capriati: conceptualization, data curation, formal analysis, funding acquisition, investigation, visualization, writing – original draft, writing – review and editing, **Hesti Widodo:** conceptualization, funding acquisition, investigation, validation, writing - review and editing, **Ingrid A. van de Leemput:** conceptualization, methodology, supervision, writing – review and editing, **Amehr Hakim:** resources, validation, data curation, writing - review and editing, **Estradivari:** validation, writing – review and editing, **Silvianita Timotius:** data curation, validation, writing – review and editing, **I Nyoman Suardana:** data curation, validation, writing – review and editing, **Amkieltiela:** validation, writing – review and editing, **Muhammad Zainuri:** validation, writing – review and editing, **Suradi W. Saputra:** validation, writing - review and editing, **Sutrisno Anggoro:** validation, writing - review and editing and **Leontine E. Becking:** conceptualization, supervision, funding acquisition, validation, writing – review and editing.

Declaration of Competing Interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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Appendix A. Supporting information

Supplementary data associated with this article can be found in the online version at doi:10.1016/j.marpol.2025.106885.

Data availability

Data will be made available on request.

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