

1 **A review of the legal framework for coral reef restoration in**
2 **Indonesia**

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28 **1. Introduction**

29 Located in the heart of the Coral Triangle, Indonesia is the center of global diversity for coral
30 reefs, with over 590 recorded species of hard corals which represent more than 95 percent of the total
31 number of species recorded throughout the Coral Triangle (Veron et al., 2009). Indonesia hosts the
32 greatest tropical coral reef extent within the Coral Triangle, covering around 40,000 km² (Allen Coral
33 Atlas, 2022; Burke et al., 2012). Furthermore, nearly 25% of Indonesia's 270 million population lives
34 within 30 km of a coral reef, comprising the world's largest human population closely connected to
35 coral reefs (Burke et al., 2012; Sing Wong et al., 2022). The dense coastal population significantly
36 contributes to the jeopardy faced by Indonesian reefs, of which more than 95% are under threat from
37 local factors, primarily due to overfishing and destructive fishing (Burke et al., 2012). Additionally,
38 some of the reefs have suffered repeated bleaching events since the 2016 El Niño Southern Oscillation
39 (ENSO) heatwave (Ampou et al., 2017; Bachtiar & Hadi, 2019; Eakin et al., 2019). As a result, many
40 of Indonesia's reefs are severely damaged (Kennedy et al., 2020; Putra et al., 2015; Razak et al., 2021;
41 Salinas-de-León et al., 2013); the 2019 'Status of Indonesian Coral Reefs' report surveyed 1,153 sites
42 across the country and found only 6.4% in an excellent state (>75% healthy hard coral), with the
43 majority (71.2%) classified as being in a poor or fair condition (<50% healthy hard coral) (Hadi et al.,
44 2020). Despite the majority of reefs being classified in lower categories in these assessments, some
45 reefs in the region remain in a relatively good state and display remarkable biodiversity (Limmon et al.,
46 2023; Purwanto et al., 2021). Thus, a key strategy for the conservation of Indonesian coral reefs lies in
47 improved management and addressing harmful local impacts, particularly in those areas still featuring
48 reefs in a relatively good state (Amkieltiela et al., 2022; Ceccarelli et al., 2022; White et al., 2021).
49 However, given the severity of degradation in some areas and the looming additional impacts of climate
50 change, there is increasing recognition that active restoration interventions may be needed in addition
51 to improved management to support the recovery and persistence of coral reefs (Hughes et al., 2017;
52 Knowlton et al., 2021).

53 In response to widespread reef degradation, a range of active reef restoration projects are
54 increasingly being implemented in Indonesian waters (Fox et al., 2019; Williams et al., 2019). A recent
55 review reported that 533 reef restoration projects have been initiated across Indonesia in the last 30

56 years, together comprising over 170,000 units of artificial reef and coral nurseries, and nearly 1 million
57 outplanted fragments of hard coral (Razak et al., 2022). This sheer number of projects and outplanted
58 coral fragments means that more restoration activity has been documented in Indonesia than in any
59 other country globally (Boström-Einarsson et al., 2020). However, high numbers of installed artificial
60 structures and outplanted fragments do not necessarily indicate successful restoration outcomes. Indeed,
61 poorly-designed projects that are placed in sub-optimal locations or lack appropriate methods for
62 outplanting and maintenance run the risk of damaging the reef without contributing to the active
63 regeneration of coral populations (Ferse, 2010; Ferse et al., 2013; Razak et al., 2022).

64 The management and exploitation of marine resources in Indonesia is governed by an extensive
65 and complex regulatory framework (Dirhamsyah, 2006), which has been the subject of critique for
66 decades (Dutton, 2005; Sahri et al., 2020; Syarif, 2009). This general pattern of a complex marine policy
67 structure is also borne out with regard to reef restoration; the deployment of artificial reefs or other
68 restoration methods falls under multiple government regulations and is controlled by multiple
69 government authorities. Three ministries, along with their associated regional offices, all have
70 responsibility for initiating, organising and implementing reef restoration projects in Indonesia - the
71 Ministry of Marine Affairs and Fisheries (MMAF), the Ministry of Environment and Forestry (MoEF)¹,
72 and the Coordinating Ministry for Maritime and Investment Affairs. Further, there are seventeen
73 policies and regulations related to coral reef restoration, with five of these introduced in 2020 and 2021
74 alone. As such, it is difficult to assess and understand the regulations and permit requirements pertaining
75 to reef restoration activities in Indonesia. To exacerbate this complexity, the legal framework is also
76 changing rapidly, with the relevant regulatory bodies releasing multiple revisions and updates to
77 regulations and permit requirements in recent years (Razak et al. 2022).

78 A high degree of decentralisation within Indonesia's complex regulatory framework
79 encourages an unusually high diversity of participation in coastal restoration activities, but its lack of a
80 synchronised approach can hamper efforts to establish common methods, standardise objectives for
81 holistic reef recovery, specify measurable target outcomes, and implement consistent ecological

¹ The Ministry of Environment and Forestry (MoEF) was created in 2014 to combine the previous Ministry of Environment (MoE) and Ministry of Forestry (MoF).

82 monitoring and long-term appraisal (Razak et al., 2022). This lack of standardised implementation and
83 institutional arrangements has doubtlessly contributed to some of Indonesia's current problems with
84 reef restoration effectiveness, in a similar way to how regulatory inefficiency has led to ineffectiveness
85 in the country's marine management (Dirhamsyah, 2006). This study aims to (a) provide an overview
86 of the regulatory landscape related to coral reef restoration in Indonesia, revealing gaps, overlaps and
87 shortcomings in the current national laws and regulations on coral reef restoration practice, and (b)
88 provide recommendations for overcoming some of these complex issues. In turn, applying the
89 recommendations from this study is likely to increase the efficiency of Indonesia's coral reef restoration
90 policy, and thus would allow for more effective reef restoration strategies and implementation across
91 the country.

92

93 **2. Materials and methods**

94 In this study, an extensive narrative review of Indonesia's national and ministerial legal policy
95 documents was carried out, identifying all regulations pertaining to coral reef or coastal ecosystem
96 restoration or rehabilitation. This approach was then used to develop a comprehensive outline of the
97 regulatory landscape relating to reef restoration in Indonesia. The review analyses the content of each
98 individual regulation, summarising core aspects and identifying its distinct features. In particular, this
99 study focuses on the regulatory implications in relation to planning, permitting systems, funding, and
100 monitoring programs. Implications relating to maintenance, enforcement and compliance are also
101 discussed here as they are likely to increase in significance as reef restoration becomes more common
102 in the future.

103

104 *2.1. Approach to Document Retrieval*

105 Our initial approach to identifying regulations concerning the restoration of coral reefs in
106 Indonesia consisted of identifying relevant documents by using the online search engines 'Google' and
107 'Google Scholar.' This decision was prompted by their extensive capability to search in languages
108 beyond English, including Bahasa Indonesia. Our search for legal documents followed a structured
109 process involving the combination of word pairs from two distinct categories, as outlined in Table 1.

110 One category described the legal framework, while the other pertained to specific aspects of coral reef
 111 restoration.

112 After identifying the names of the relevant regulations, we procured review materials from two
 113 legislative databases: *peraturan.go.id* (an online platform managed by the Directorate General of
 114 Legislation of the Indonesian Ministry of Law and Human Rights) and *jdih.kkp.go.id* (a legal
 115 documentation and information network of the MMAF). Legal documents in Bahasa Indonesia were
 116 accessible through these online portals. Several of the authors (TBR, SCAF, CAGA), proficient in both
 117 Indonesian and English, read and translated the documents when required. However, it is important to
 118 acknowledge that despite our efforts to conduct a systematic search, challenges related to the
 119 reproducibility of this method persist. To amend this, all regulations associated with reef restoration in
 120 Indonesia have been appended as supplementary materials within this paper (Supplementary Material).

121
 122 **Table 1** Multiple purposive searches were carried out for legal policy documents, with each one
 123 combining at least one term describing a legal framework (left-hand column) and one term describing
 124 an aspect of coral reef restoration (right-hand column).

Legal policy framework search term	Coral reef restoration search term
<i>Undang-undang</i> (Law)	<i>Terumbu karang</i> (coral reef)
<i>Peraturan Pemerintah</i> (Government Regulation)	<i>Pesisir</i> (coastal)
<i>Peraturan Presiden</i> (Presidential Regulation)	<i>Pulau-pulau kecil</i> (small islands)
<i>Peraturan Menteri</i> (Ministerial Regulation)	<i>Rehabilitasi</i> (rehabilitation)
<i>Keputusan Menteri</i> (Ministerial Decree)	<i>Restorasi</i> (restoration)
	<i>Pemulihan</i> (recovery)
	<i>Transplantasi</i> (transplantation)

126
 127 **2.2 Terminology**

128 Three related terms referring to restoration efforts are used in Indonesia’s laws and regulations
 129 namely restoration (*restorasi*), rehabilitation (*rehabilitasi*), and recovery (*pemulihan*). The three terms

130 are used interchangeably across Indonesian regulations, but they do not follow the internationally
131 accepted definitions set by the Society for Ecological Restoration (SER) (McDonald et al., 2016;
132 Society for Ecological Restoration International Science & Policy Working Group, 2004). According
133 to the SER, ‘restoration’ refers to the “*process of assisting the recovery of an ecosystem that has been*
134 *degraded, damaged or destroyed*”. ‘Rehabilitation’ “*emphasi[s]es the reparation of ecosystem*
135 *processes, productivity and services*” and differs from restoration in that it does not aim to re-establish
136 species composition and community structure. ‘Recovery’ is “*the process by which an ecosystem*
137 *regains its composition, structure and functionality*”, which can be assisted by restoration. For
138 simplicity, in this paper we use the term “restoration” when we refer to all three aspects; when referring
139 to specific regulations we use the exact translation of each of these terms
140 (restoration/rehabilitation/recovery) as written in the respective regulation. In most cases, what is
141 described in the regulations would most appropriately be termed ‘rehabilitation’ according to the SER
142 definition.

143

144 **3. Results**

145 Indonesia’s first artificial reefs were deployed in the 1970s, but legal regulations governing this
146 activity were not developed until a decade later (Fig. 1). Coral reef restoration activity began to expand
147 considerably in the wake of the national Coral Reef Rehabilitation and Management Project
148 (COREMAP) launched in 1998 (IUCN - The World Conservation Union, 2002). The regulatory
149 framework for environmental restoration began with more general regulations issued by MoF and MoE
150 in the 1990s, and subsequently became more specific to the marine environment in the 2000s upon the
151 establishment of MMAF in 1999 (Fig. 1, Table 2).

152 Eighteen laws and regulations were identified that relate to coral reef restoration in Indonesia
153 (Supplementary Material). Some regulations contain only minimal mention of restoration, while others
154 are entire laws dedicated to ecosystem restoration including coral reefs. Fifteen of the regulations
155 mention requirements that are specific to marine spatial use, while the remaining three refer in more
156 general terms to all types of environmental rehabilitation. In summarising these regulations, we
157 identified nine specific components of reef restoration activity within fifteen regulations; planning,

158 consultation and approval, responsibility, permitting, funding, location, methodology, post-installation
159 activities (monitoring, evaluation and maintenance), and sanctions for non-compliance (Fig. 2, Table
160 2).

161 Three regulations, i.e., Presidential Regulation No. 121/2012, MoF Ministerial Regulation No.
162 P.48/Menhut-II/2014 and MMAF Ministerial Regulation No. 26/2021, are the most comprehensive in
163 regulating the restoration of coastal ecosystems, including coral reefs. Two of these regulations (Pres.
164 Reg. 121/2012 and MMAF Reg. 26/2021) are almost word-for-word identical. We created flowcharts
165 for these three regulations for easy understanding of the most comprehensive restoration guidelines that
166 have been set by the Indonesian government (Figs. 3 and 4).

167 **Table 2.** Indonesian legal policy framework for planning, implementation, and monitoring and evaluation of reef restoration projects. Regulations in each
 168 section are listed by the earliest year of issuance. The summary of each regulation uses the exact terms (restoration/rehabilitation/recovery) used in the original
 169 (indicated by italics; see section 3.1).

170

Authority/issue of concern	Regulation	Article (verse)	Summary of the regulation
<i>I. Restoration planning</i>			
Planning documents/guidelines	MoE ² Decree No. 4/2001	6, 8	Governor/Regent/Mayor is required to prepare a mitigation program for damaged coral reefs – including prevention, treatment and <i>recovery</i> programs. The minister in charge of environmental management is required to establish a national policy for the mitigation of damaged coral reefs.
	MoF ² Regulation No. P.48/Menhut-II/2014	13-14	Planning for ecosystem <i>recovery</i> should include the following steps: a) preparation and b) drafting of action plans. Step a) includes definition of the desired final condition and the <i>recovery</i> priority scale, community involvement and sustainability, strategic and action plans. Step b) includes objectives and target outcomes, status and function of the proposed <i>recovery</i> area, ecosystem condition, typology, location and area size, referenced ecosystem for <i>recovery</i> , desired final condition, <i>recovery</i> scale and types of activity, area map, funding source and project schedule/timeline. These plans are prepared by a working unit, assessed by the head of the management unit, and approved by the Technical Director on behalf of the General Director.
	Presidential Regulation No. 63/2015	9-10	MMAF's <i>General Director of Marine Spatial Management</i> formulates and implements <i>rehabilitation</i> policy, standard procedures and criteria, technical guidance and supervision, evaluation and reporting of a <i>rehabilitation</i> program
	Government Regulation No. 27/2021	44	The national government delegates a minister to prepare guidelines (norms, standard procedures, criteria) for <i>rehabilitation</i> and enhancement of fisheries resources and their environments.
	MMAF Regulation No. 26/2021	48 (3-5)	Planning documents for the <i>rehabilitation</i> of fisheries resources and their environment are prepared by the national government, governor, or regent/mayor, in consultation with local stakeholders (Article 48 (3)); or can also be prepared by individual citizens who gain direct or indirect benefits from fisheries resources and their environment, in consultation with the national government, governor, regent/mayor, and other ministry in charge of the environment and forestry (Article 48 (4-5)).
	Government Regulation No. 22/2021	418	<i>Rehabilitation</i> can be done through the following stages: identification of the location, cause, and level of damage; choosing a <i>rehabilitation</i> method; drafting a <i>rehabilitation</i> implementation plan; drafting an implementation report of the environmental damage <i>rehabilitation</i> for the minister, governor or regent/mayor according to their authority.

² Although MoE and MoF are no longer in existence and have been transformed into a joint MoEF (see Footnote 1), regulations issued by MoE/MoF remain valid as long as they have not been revoked.

	Government Regulation No. 22/2021	419	<i>Restoration</i> can be done through the following stages: identification of the location, cause, and level of damage; choosing a <i>restoration</i> method; drafting a <i>restoration</i> implementation plan; drafting an implementation report of the environmental damage <i>restoration</i> for the minister, governor or regent/mayor according to their authority.
Technical requirements	Government Regulation No. 27/2021	15	Technical requirements for building and construction projects in the sea (<i>artificial reefs</i> in Article 9.2g)
Feasibility study	Presidential Regulation No. 121/2012 MMAF Regulation No. 26/2021	5-9 45-48	<i>Rehabilitation</i> planning should include identification of cause and level of destruction (through field assessment, data collection and analyses), and formulation of <i>rehabilitation</i> plans.
	MoF Regulation No. P.48/Menhut-II/2014	6, 8, 11-12	Ecosystem <i>recovery</i> should be based on the management plan (set by the management unit) and results from a feasibility study conducted by the management unit or evaluation team.
2. Consultation and approval			
Hydrography and oceanography agencies	Government Regulation No. 27/2021	30	Placement of construction projects in the sea should refer to the Indonesian Sea Map, and include informing the agencies in charge of hydrography and oceanography.
Regional working unit	Presidential Regulation No. 121/2012	9 (2-3)	<i>Rehabilitation</i> plans should be consulted with the Regional Working Unit in charge of marine and fisheries affairs at the <i>rehabilitation</i> location, as well as with other related ministries.
National and local governments and local stakeholders	MMAF Regulation No. 26/2021	48 (3-5)	Planning documents for <i>rehabilitation</i> of fisheries resources and their environment are prepared by the national government, governor, or regent/mayor with consultation with local stakeholders, or can also be prepared by individual citizens who gain direct or indirect benefits from fisheries resources and their environment with consultation with the national government, governor, regent/mayor, and other ministry in charge of environment and forestry.
3. Responsibility for implementation			
National and local governments, local community, individual citizens	Government Regulation No. 60/2007	3	Conservation of fisheries resources and their ecosystems is the responsibility of the national and local government, and community – including conservation of coral reef ecosystems (Article 5.2c), and <i>rehabilitation</i> of habitat and fish populations (Article 6.1b).
	Law No. 27/2007 (Law No. 1/2014) Presidential Regulation No. 121/2012	33 2 (1)	<i>Rehabilitation</i> is led by the national government, local government, and/or individual citizens who directly or indirectly utilise/gain benefit from coastal areas and small islands.
	Presidential Regulation No. 121/2012	12	<i>Rehabilitation</i> can be done through cooperation between the national and local government, individual or community in human resources, funding, data and information, science and technology, training and counselling, tools and infrastructure, and/or other necessary sectors.
	Law No. 32/2014	22 (1-2a)	The national and local government are responsible for protecting, conserving, <i>rehabilitating</i> , using and enriching coastal and small island resources and their ecological systems.
	MMAF Regulation No. 26/2021	42 (1)	<i>Rehabilitation</i> of fisheries resources and their environment is conducted by the national government, governor, regent/major, and everyone within the Indonesian Fisheries Management Area (<i>WPPNRI</i>).
	MMAF Regulation No. 26/2021	66 (1-2)	<i>Rehabilitation</i> can be done through cooperation between the national government, governor, regent/major, and individual citizens, in terms of human resources, funding, data and information, science and technology, training and counselling, and/or tools and infrastructure.
Management unit, permit holder	MoF Regulation No. P.48/Menhut-II/2014	15 (1-2)	Ecosystem <i>recovery</i> is led by the management unit and/or could be led by the permit holder following a permit issuance from the minister. <i>Recovery</i> effort should involve the local

			community in order to increase socio-economic status and to ensure the sustainability of ecosystem <i>recovery</i> .
	MoF Regulation No. P.48/Menhut-II/2014	49 (1-3)	Ecosystem <i>recovery</i> is led by the management unit, in cooperation with other stakeholders, or if within an MPA's <i>rehabilitation</i> zone can be led by a business entity with a minister's permit.
Permit holder, liable person (business and non-business)	Government Regulation No. 19/1999	16 (1)	Any person or person in charge of a business and/or an activity causing marine pollution and/or destruction is responsible for <i>recovering</i> the damage.
	Law No. 27/2007 (Law No. 1/2014)	21 (4d)	Permit holders of a business right in the coastal waters are responsible for <i>rehabilitating</i> damage of natural resources caused in their locations.
	Law No. 27/2007 (Law No. 1/2014)	66 (1-2)	Any person and/or person in charge of an activity causing destruction to coastal areas and small islands must pay compensation to the nation and/or do <i>rehabilitation</i> and/or <i>recovery</i> .
	Law No. 32/2009	54 (1-2)	Any person polluting and/or damaging the natural environment has to <i>recover</i> the environmental function through <i>rehabilitation</i> (54.2c) and <i>restoration</i> (54.2d).
	Law No. 32/2009	55 (3), 82 (2)	The minister, governor, or regent/major can appoint a third party to do the <i>recovery</i> effort using the guaranteed funds deposited by the permit holder (Article 55(1-2)).
	Law No. 32/2009	82 (1)	The minister, governor, or regent/major has the right to force the person in charge of a business and/or an activity to do <i>recovery</i> for pollution and/or damage they have caused.
	Law No. 32/2009	87 (1)	A person in charge of a business and/or an activity causing environmental pollution and/or damage must pay compensation and/or undertake appropriate actions.
	MMAF Regulation No. 28/2021	137e	A permit holder (business and non-business) has to protect the sustainability of marine ecosystems and perform <i>rehabilitation</i> if natural resources have been damaged.
	Government Regulation No. 27/2021	38 (1)	If the government's mandatory monitoring and evaluation of marine structures found any damage has occurred to marine ecosystems, the initiator of the construction activity must do <i>rehabilitation</i> .
Volunteer (individual or community)	Presidential Regulation No. 121/2012	15 (1)	Community or individual citizens can take part in the implementation and maintenance of <i>rehabilitation</i> voluntarily.
	MMAF Regulation No. 26/2021	67 (1)	Any person can take part in the <i>rehabilitation</i> of fisheries resources and their environment.
4. Permit requirements and responsible authority issuing permit			
National and local governments	Law No. 27/2007 (Law No. 1/2014) Law No. 32/2014	16 (1) 47 (1)	Any person permanently using marine space (parts of coastal waters and small islands) within Indonesian waters and jurisdiction area must obtain a location permit.
	Law No. 27/2007 (Law No. 1/2014)	20 (1-2)	The national and local government are responsible for the issuance of a location permit and a utilisation permit for the local and traditional communities who use space and resources in the coastal waters and small islands for their livelihoods/daily needs.
	Law No. 27/2007 (Law No. 1/2014)	21 (1), 22	No permits are needed for customary law communities using marine space and coastal and small island resources within the area of customary law authority recognised by the Indonesian laws.
Minister of Environment and Forestry	MoF Regulation No. P.48/Menhut-II/2014	15 (1)	Ecosystem <i>recovery</i> is led by the management unit and/or could be led by the permit holder following a permit issuance from the Minister of Environment and Forestry.
Minister of Marine Affairs and Fisheries	MMAF Regulation No. 28/2021	113, 114, 116	Any person undertaking permanent use of marine space (i.e., continuous for a minimum of 30 days) on the coastal waters, waters areas, and/or jurisdiction areas is required to have a KKPRP permit (<i>Kesesuaian Kegiatan Pemanfaatan Ruang Laut</i> or suitability of usage of marine space) from the Minister of Marine Affairs and Fisheries. Marine space includes surface, water column, and seabed. A KKPRP is the basic permit requirement for both business and/or non-

			business activities, and the issuance of a KKPRL permit for areas relevant to defence and security should get the approval/consideration from the Ministry of Defence.
	Government Regulation No. 27/2021	12	Initiators who are planning to build and/or install a building and construction in the sea have to apply for a KKPRL permit from the Minister of Marine Affairs and Fisheries.
5. Funding and government budgets for restoration			
National and local governments, local community, individual citizens	Law No. 32/2009	42, 43 (2)	The national and local government must develop and implement environmental economic instruments including a) guaranteed funds for <i>recovery</i> ; b) mitigation funds for pollution, destruction, <i>recovery</i> ; c) trust funds for conservation of natural environments.
	Law No. 32/2009	46	The national and local government must allocate a budget for the <i>recovery</i> of natural environments that have been polluted or damaged (including coral reefs as per Article 21.3b).
	Presidential Regulation No. 121/2012	12 (1, 2b)	<i>Rehabilitation</i> can be done through cooperation between the national and local government, individual or community – including sharing the <i>rehabilitation</i> costs.
	MMAF Regulation No. 26/2021	66 (1, 2b)	<i>Rehabilitation</i> of fisheries resources and their environment can be done through cooperation between the national government, governor, regent/major, and individual citizens – including sharing the <i>rehabilitation</i> costs.
State budget, regional budget, other legal & unrestricted source	MoE Decree No. 4/2001	13	State budget (<i>ABPN</i>) and or other funding set by the law is used for reef health monitoring and management of damaged coral reefs. Regional budget (<i>APBD</i>) is used by local governments for a regular 5-yearly reef health inventory; preserving reefs in good condition; preparing a mitigation program for damaged reefs; yearly survey/evaluation of reef condition.
	Presidential Regulation No. 121/2012 MMAF Regulation No. 26/2021	16 68	Funding for <i>rehabilitation</i> can be sourced from the state budget (<i>APBN</i>), regional budget (<i>APBD</i>), and/or other sources that are legal and unrestricted.
Permit holder, liable person (business and non-business)	Government Regulation No. 19/1999	17 (5)	Costs for mitigation of marine pollution and/or destruction, and marine quality <i>recovery</i> caused by an emergency situation should be paid by the person responsible for the damage.
	Government Regulation No. 19/1999	24 (1)	A person or persons in charge of a business and/or an activity causing marine pollution and/or destruction have to pay for the countermeasure and <i>recovery</i> costs.
	Law No. 27/2007 (Law No. 1/2014)	66 (3)	Any person causing damage is responsible for paying for the <i>rehabilitation</i> costs for coastal areas and small islands to the nation.
	Law No. 32/2009	55 (1-2)	A holder of an environmental permit must deposit a guaranteed fund which can then be used by the minister, governor, or regent/major to <i>recover</i> environmental function.
	Law No. 32/2009	87 (1)	Any person in charge of a business and/or an activity causing environmental pollution and/or damage must pay compensation and/or undertake appropriate actions.
6. Criteria for restoration location			
Designated safety area	Law No. 32/2014	32 (2-4)	The operational area of marine construction/installation activity should not exceed a designated safety area, otherwise a permit from the responsible authority is required. Marine construction/installation activity should also consider the conservation of coastal and small island resources.
Nature reserve and sanctuary	MoF Regulation No. P.48/Menhut-II/2014	all	This law stipulates guidelines for marine ecosystem <i>recovery</i> within nature reserves (<i>Kawasan Pelestarian Alam</i>) and sanctuaries (<i>Kawasan Suaka Alam</i>).
Recommendation from a feasibility study	MoF Regulation No. P.48/Menhut-II/2014	16	Areas for ecosystem <i>recovery</i> should be selected based on results from a feasibility study, and according to criteria regarding the extent of ecosystem damage.
Extent of damage	Presidential Regulation No. 121/2012	3	<i>Rehabilitation</i> is decided based on criteria for the extent of damage to ecosystems or populations, i.e. the level of physical, chemical and/or biological damage.

	MoF Regulation No. P.48/Menhut-II/2014	25	Damaged marine ecosystems areas need <i>rehabilitation</i> if a) cover of hard coral or seagrass is less than 75% or of mangrove less than 50%, b) indicator species are rare, c) there have been changes in salinity, substrate sediment, clarity or tidal range, or d) changes in coastal seascape exceed 30%.
	MoF Regulation No. P.48/Menhut-II/2014	26	Heavily damaged marine ecosystem areas need <i>restoration</i> if a) coverage of hard coral or seagrass is less than 50% or of mangrove less than 30%, b) indicator species are endangered, c) there have been changes in salinity, sediment, clarity or tidal range, and/or d) changes in coastal seascape exceed 60%.
	MMAF Regulation No. 26/2021	43	<i>Rehabilitation</i> of fisheries resources and their environments is decided based on damage and/or population criteria including physical, chemical and biological damage.
Rehabilitation zone	MoF Regulation No. P.48/Menhut-II/2014	14 (8)	Based on the approved ecosystem <i>recovery</i> plan, the General Director of MoF should designate a <i>recovery</i> location as the <i>rehabilitation</i> zone/block, and decide on which method to use (natural mechanisms, <i>rehabilitation</i> or <i>restoration</i> method).
7. Methodology for restoration			
Rehabilitation and restoration	Law No. 32/2009 Government Regulation No. 22/2021	54 (2) 415 (1)	<i>Recovery</i> of environmental functions (including for coral reefs) can be done through the following stages: termination and elimination of the pollution sources, remediation, <i>rehabilitation</i> , <i>restoration</i> , and other methods following the latest development in science and technology.
	MMAF Regulation No. PER 30/MEN/2010	15c, 26e	Absolute protection (protection and conservation in 26e) of fish habitat and populations in the core zone (utilisation zone in 26e) can be supported by ecosystem <i>recovery</i> and <i>rehabilitation</i> actions.
	MoF Regulation No. P.48/Menhut-II/2014	7, 44-48	Ecosystem <i>recovery</i> can be achieved through natural mechanisms, <i>rehabilitation</i> and/or <i>restoration</i> .
	MMAF Regulation No. 26/2021	50	Coral reef <i>rehabilitation</i> can be achieved through the enrichment of natural resources, habitat improvement, and/or other environmental-friendly activities.
Artificial reefs and coral transplantation	MoE Decree No. 4/2001	Attachment II	The 2nd attachment of this law regulates several aspects of coral reef <i>recovery</i> , i.e. community engagement and development, and community surveillance in mitigation and management programs (part C). <i>Recovery</i> of damaged coral reefs can be supported by active <i>rehabilitation</i> in order to increase coral populations, reduce the abundance of harmful fleshy algae, and increase reef fish populations (part D2). Increasing coral populations can be achieved through increasing coral recruits by providing recruitment tiles, increasing migration through coral transplantation, and reducing coral mortality by preventing physical damage, coral disease and competition with other biota (part D2a).
	Law No. 31/2004 (Law No. 45/2009)	7 (1p) - clarification	Installation of artificial reefs as one of the methods for <i>rehabilitation</i> and enhancement of fisheries resources.
	Presidential Regulation No. 121/2012	10 (2b, 4d-e)	<i>Rehabilitation</i> can be done through habitat improvement including transplantation and/or artificial habitat.
	MoF Regulation No. P.48/Menhut-II/2014	45c, 46 (3)	<i>Rehabilitation</i> can be done by improving the substrate for corals (i.e. enriching/expanding/rearranging substrate for coral growth that naturally occurs in the location).
	MoF Regulation No. P.48/Menhut-II/2014	47c, 48 (3)	<i>Restoration</i> can be done by improving the substrate and coral transplantation (i.e. adding/developing artificial substrate and coral transplantation by using coral donors that naturally grow or have previously grown in that location).

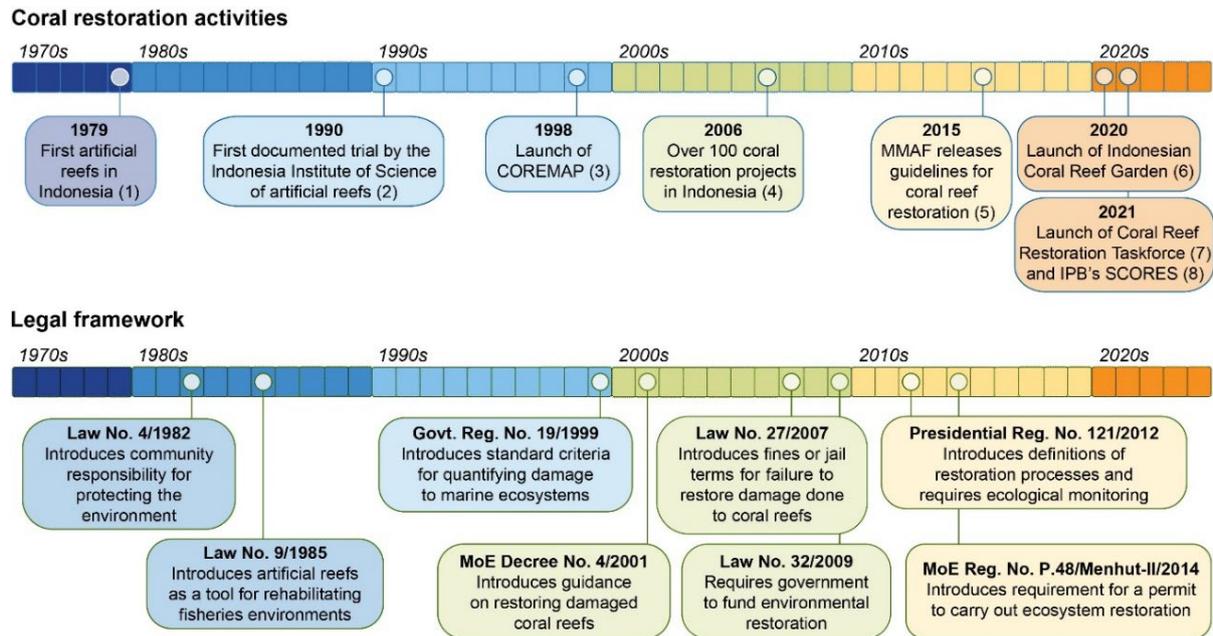
	Government Regulation No. 27/2021	34 (1)	Repurposing of out-of-use marine constructions and installations from the oil and gas industry into artificial reefs for research or marine tourism (<i>rigs to reefs</i> program).
	MMAF Regulation No. 26/2021	51 (1)	Enrichment of coral reef resources can be done by transplantation and/or artificial habitat following the latest development in science and technology.
	MMAF Regulation No. 26/2021	51 (2-3)	Transplantation is planting/attaching coral fragments to a substrate medium (e.g. concrete, structured frame, steel pole, dead corals). Coral fragments should be collected from the vicinity of the <i>rehabilitation</i> location, not from a conservation area. Collected fragments must not exceed 10% of the existing population, and must be taken from a mature mother colony.
	MMAF Regulation No. 26/2021	51 (4), 52 (5)	Artificial habitat can be made from artificial reefs and/or fish shelter using concrete, biorock, bioreef and other environmental-friendly materials following the latest science/technology.
	MMAF Regulation No. 26/2021	53	Coral species used in <i>rehabilitation</i> should come from a similar genetic pool to those growing in the <i>rehabilitation</i> location; local material should be used in constructing transplantation racks, artificial reefs, and fish shelters; technology for transplantation and artificial reefs should consider biological seasons, hydro-oceanographic patterns and ecosystem carrying capacity.
8. Post-installation: monitoring, evaluation and maintenance			
Maintenance	Presidential Regulation No. 121/2012	5c, 11d	Maintenance of a <i>rehabilitation</i> program can be done by maintaining the conditions of the <i>rehabilitated</i> ecosystem and/or protecting the population from natural/anthropogenic impacts.
Monitoring and evaluation	MoE Decree No. 4/2001	7	Within the mitigation program for damaged coral reefs, the Governor/Regent/Major must carry out monitoring and evaluation of coral reef conditions once a year.
	Presidential Regulation No. 121/2012	14	Monitoring and evaluation of a <i>rehabilitation</i> program is 1) conducted by the MMAF, other ministers in charge of the protection and management of the natural environment, governor, regent/major according to their authority; 2) conducted both during the implementation and maintenance phases; 3) covering the area, cover, and density of constituent components of the ecosystem; water quality; survival rate; and/or growth rate; 4) performed once every six months.
	MoF Regulation No. P.48/Menhut-II/2014	52	To ensure the success of ecosystem <i>recovery</i> , it is obligatory for management units to perform monitoring and evaluation.
	MoF Regulation No. P.48/Menhut-II/2014	53	The general director, governor or regent/major according to their authority should form a team led by the director of the conservation area to perform periodic evaluation and maintenance of ecosystem <i>recovery</i> programs.
	Presidential Regulation No. 63/2015	10e	The MMAF's General Director of Marine Spatial Management is responsible for conducting evaluation and reporting on <i>rehabilitation</i> programs in coastal areas and small islands.
	MMAF Regulation No. 26/2021	75	Monitoring and evaluation of <i>rehabilitation</i> and enrichment of fisheries resources and their environment is conducted by the national government, governor, regent/major according to their authority, once every six months.
9. Sanction for non-compliance			
Noncompliance with restoration responsibility	Law No. 27/2007 (Law No. 1/2014)	74 (1)	Those who fail to fulfil their rehabilitation obligation face a maximum jail term of six months or a fine of IDR 300,000,000 (approx. USD 20,200).
Noncompliance with need for permit for marine space use	Law No. 32/2009	109	Any person doing business and/or activity without an environmental permit faces a maximum jail term of six years or a fine between IDR 1,000,000,000 and IDR 3,000,000,000 (approx. USD 67,200 - USD 201,620).

	Law No. 32/2014	47 (3)	Any person permanently using marine space within Indonesian waters not according to the issued permit faces administrative sanctions including a warning letter, temporary termination of their activity, closure of the location, revocation or cancellation of licence, and/or administrative fine.
	Law No. 32/2014	49	Any person permanently using marine space without a location permit faces a maximum jail term of six years or a fine of IDR 20,000,000,000 (approx. USD 1,350,000).
	MMAF Regulation No. 28/2021	239	Any person permanently using marine space without a location permit will not be given a KKPRL permit and faces administrative sanctions as stipulated by the law.
Damaging coral reefs through negligence ³	Law No. 27/2007 (Law No. 1/2014)	73 (2)	Any person who causes damage to coral reefs through negligence faces a jail term between one and three years or a fine of IDR 1,000,000,000 (approx. USD 67,200).
	Law No. 32/2009	99	Any person who due to their negligence causes damage to the environment (including coral reefs, Article 21 (3b)) beyond the limits of what the environment can tolerate to continue its functioning faces a jail term between one and three years and a fine between IDR 1,000,000,000 and IDR 3,000,000,000 (approx. USD 67,200 - USD 201,620).
	Law No. 32/2014	47 (3)	Any person permanently using marine space within Indonesian waters and jurisdiction areas but not according to the permit issued faces administrative sanction including warning letter, temporary termination of their activity, closure of the location, licence revocation, licence cancelation, and/or administrative fine.
Failure to report the installation of a structure in the sea	MMAF Regulation No. 28/2021	184c	Any person who fails to report the installation and/or placement of a structure in the seas to the MMAF minister or the governor, according to their respective authorities, faces administrative sanctions.

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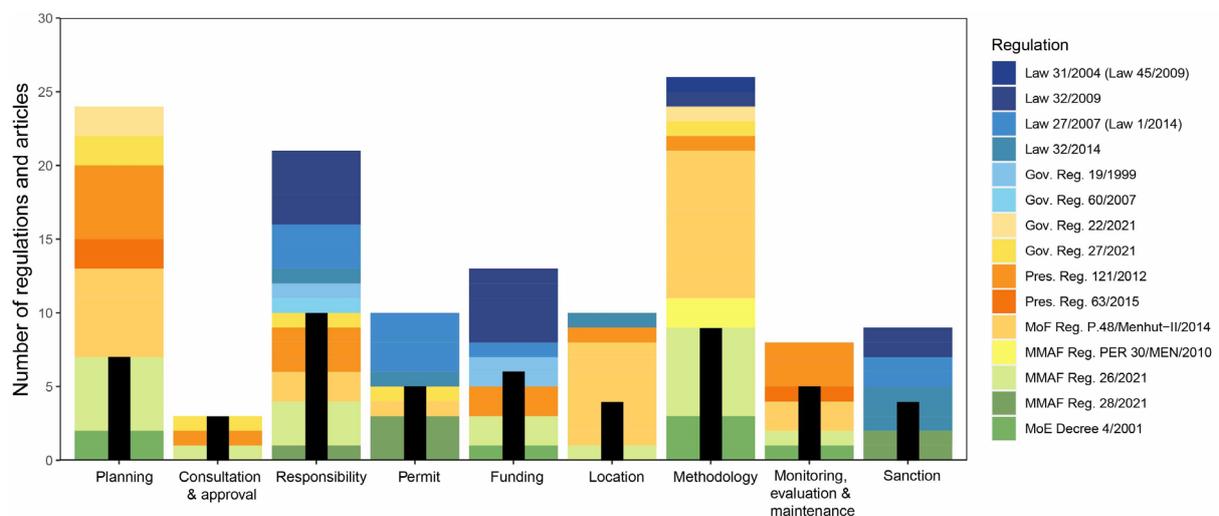
³ Negligence might be considered to apply in cases where artificial reef structures are not placed correctly, thus causing damage to coral reefs

173 Fig. 1. Development of activities and legal framework pertaining to coral reef restoration in Indonesia
 174 since the 1970s.
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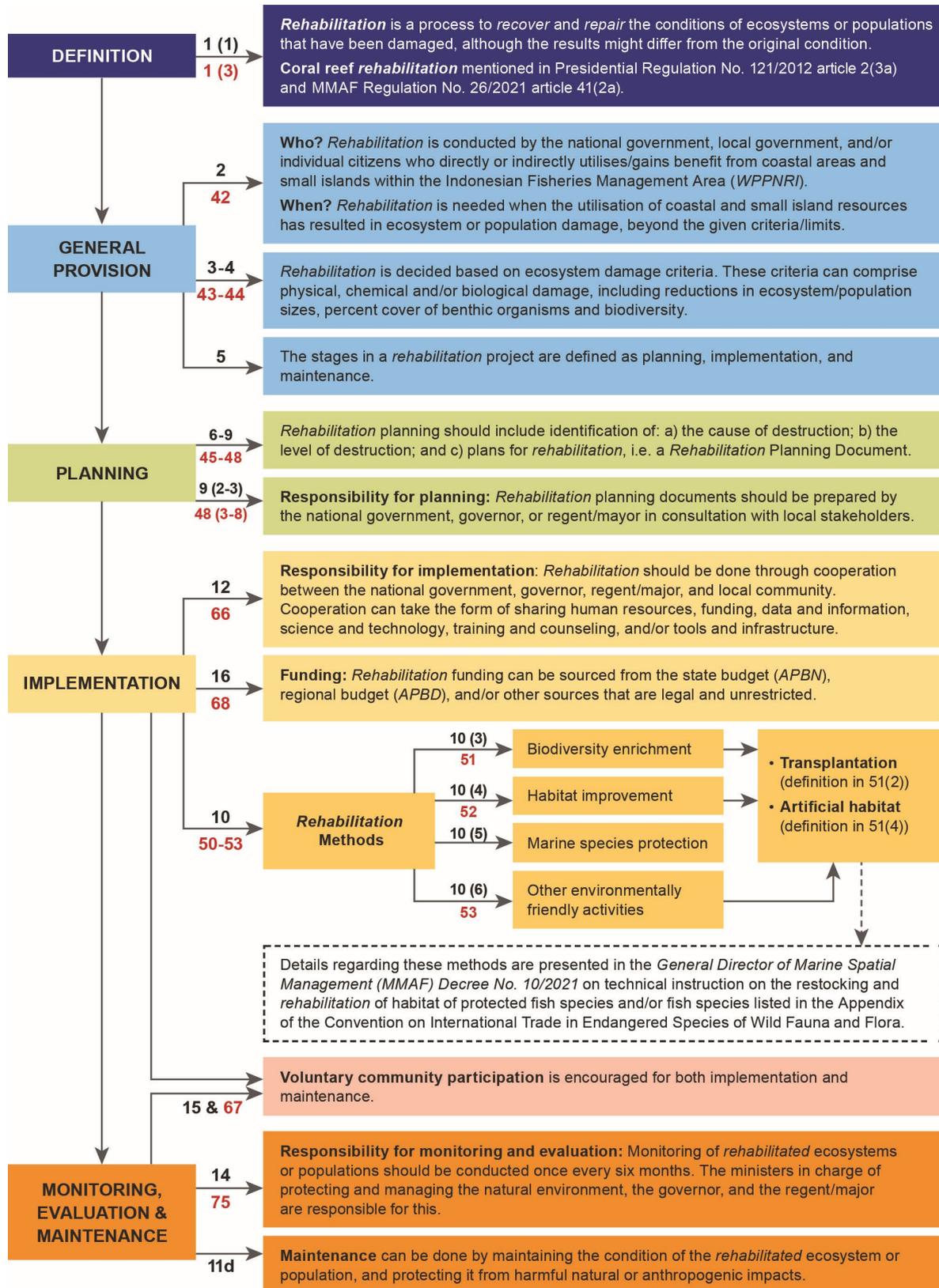
176 Note: (1) Sukarno (1988); (2) Yahmanto and Budiyanto (1992), (3) IUCN - The World Conservation Union
 177 (2002); (4) Razak et al. (2022); (5) Dermawan (2015); (6) [https://maritim.go.id/detail/luncurkan-pen-icrg-](https://maritim.go.id/detail/luncurkan-pen-icrg-menko-luhut-bantu-perekonomian-bali-akibat)
 178 [menko-luhut-bantu-perekonomian-bali-akibat](https://maritim.go.id/detail/luncurkan-pen-icrg-menko-luhut-bantu-perekonomian-bali-akibat); (7) <https://www.coraltrianglecenter.org/coral-restoration/>;
 179 (8) School of Coral Reef Restoration (SCORES) is a working group and knowledge-sharing platform initiated and
 180 hosted by the Department of Marine Science and Technology, IPB University, Indonesia
 181 (https://indonesianreefrestorations.org/).
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 186 Fig. 2. The nine primary components of reef restoration activity in Indonesia are outlined
 187 across different regulations (black bars), with individual articles specified within each
 188 regulation (colored bars).
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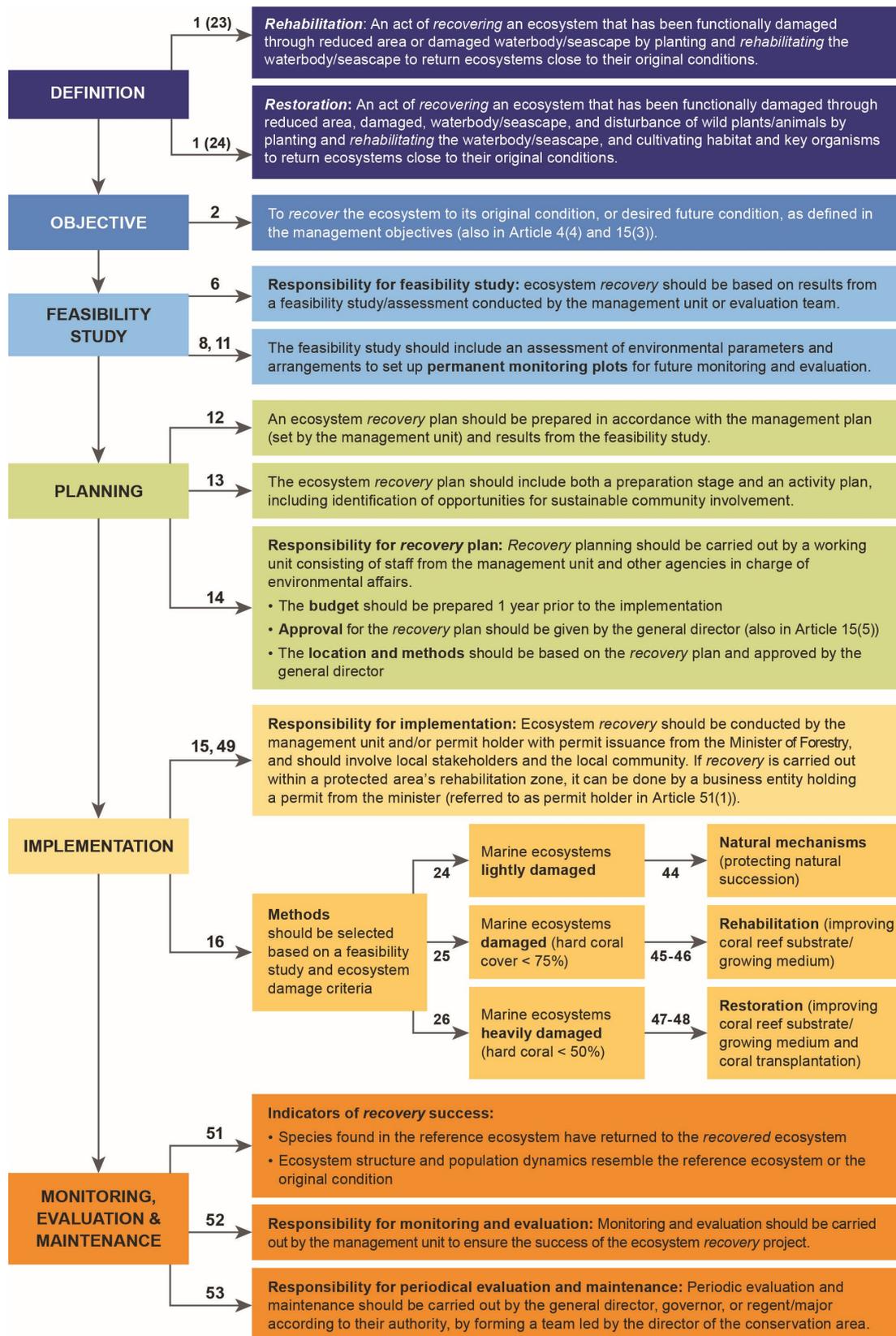


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192 Fig. 3. Flowchart of restoration* stages for coral reef ecosystems mentioned in Presidential Regulation
 193 No. 121/2012 (article (verse) number in *black*) and MMAF Regulation No. 26/2021 (*red*). *The exact
 194 terminology used in both regulations is *rehabilitation*.



196 Fig. 4. Flowchart of restoration* stages for coral reef ecosystems outlined in MoF Ministerial
 197 Regulation No. P.48/Menhut-II/2014 with the corresponding article (verse) numbers indicated. *The
 198 exact terminology used in this regulation is *recovery*.



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4. Discussion

General findings

There are currently eighteen regulations in place for coral reef restoration in Indonesia with fifteen covering the nine main components in reef restoration activity discussed in detail in this study. Five of these regulations were issued in 2021 alone, including two presidential regulations and three by MMAF. Additionally, between 2010 and 2020, seven other regulations were enacted, coinciding with the period during which 73% of the 533 reef restoration projects were executed (Razak et al., 2022). The high number of regulations issued suggests that the Indonesian government recognises the pressing need to regulate restoration practices, particularly in light of the recent surge in interest and activity in coastal ecosystem restoration.

The Indonesian regulations are relatively comprehensive and largely cover a broad range of aspects for reef restoration, from definition to monitoring and evaluation, with particular emphasis on three regulations: Pres. Reg. 121/2012, MoF Reg. P.48/Menhut-II/2014, and MMAF Reg. 26/2021. Two regulations (i.e., Pres. Reg. 121/2012 and MMAF Reg. 26/2021) are highly similar, as they use almost identical language, and both establish requirements for restoring reefs in a broad sense. On the other hand, MoF Reg. P.48/Menhut-II/2014 is exclusively intended for reef restoration within marine reserves or protected areas that fall under the MoEF's jurisdiction. As reef restoration requires addressing the root causes of degradation in order to be successful, and thus should be accompanied by adequate management efforts such marine managed areas (e.g., MPAs or OECMs), this exclusive focus further accentuates the fragmentation of the Indonesian marine policy landscape (see below). The Coordinating Ministry for Maritime and Investment Affairs became the third ministry to carry out a coral reef restoration program in Indonesia, including the largest effort ever mobilized in the country, known as the 'Indonesian Coral Reef Garden'⁴. This initiative involved the planting of nearly 96,000 units of artificial reefs and coral nurseries, covering an area of 74.3 hectares across five locations in Bali between October 2020 and January 2021 (Prasetyo, 2021). However, this newly formed ministry has not yet established any regulations at the ministerial level.

⁴ <https://maritim.go.id/detail/kemenko-marves-pastikan-program-restorasi-terumbu-karang-terbesar>

227 Although these regulations are comprehensive and mostly comply with international standards
228 and principles, there are some inconsistencies with international terminology and some discrepancies
229 in the assignment of roles and responsibilities. The terms restoration (*restorasi*), rehabilitation
230 (*rehabilitasi*), and recovery (*pemulihan*) are often used interchangeably in Indonesian regulations.
231 While this may not pose any issues for certain aspects of restoration, it can be problematic for
232 methodology, and monitoring, evaluation, and maintenance (Table 2 sections 7 and 8) since they require
233 clarification according to the specific actions taken (whether it is recovery, rehabilitation, or
234 restoration). For example, whether the goal is to re-establish species present at a site before degradation,
235 or rather to focus on ecosystem processes and functions, might determine the methods used to carry out
236 restoration or the metrics used to monitor progress and evaluate outcomes.

237

238 *Agencies responsible for restoration*

239 The Indonesian regulatory system is complex and entails the participation of several
240 government agencies, including both central and local ones. The system also features a significant
241 degree of fragmentation and duplication, with decision-making authority spread across multiple
242 jurisdictions. While the numerous regulations issued at different levels may cause confusion for permit-
243 issuing ministries, it is evident that higher-level and recent regulations, such as presidential and
244 government regulations, mostly assign responsibility to MMAF. In contrast, MoEF regulations,
245 including the older versions of MoE and MoF, still refer to their respective ministers for restoration
246 efforts within their jurisdictional areas.

247 The dichotomy between MMAF and MoEF has been a subject of debate and an issue in marine
248 ecosystems management in Indonesia (Lazuardi et al., 2020). Currently, there are seven marine national
249 parks and 23 marine conservation/protection areas falling under the jurisdiction of MoEF⁵, largely as a
250 legacy of the first protected areas in Indonesia being established under the MoF at a time when there
251 was no ministry dedicated to marine affairs. However, newer marine managed areas are established
252 mostly under MMAF⁶. To avoid similar fragmentation and overlap in the regulatory landscape, we

⁵ <http://sidakokkhl.kkp.go.id/sidako/status-pengelolaan-kawasan-konservasi/tipe/KLHK>

⁶ <http://sidakokkhl.kkp.go.id/sidako/status-pengelolaan-kawasan-konservasi/tipe/KKPN>

253 suggest that marine restoration efforts should be under the jurisdiction of a single ministry. According
254 to the discussions held during the IPB University’s School of Coral Reef Restorations (SCORES)⁷
255 webinars, the most pressing concern for restoration practitioners in Indonesia is the uncertainty
256 surrounding permit applications. Our findings indicate that although there are several regulations in
257 place, only five of them are related to permits (Table 2 section 4), and among these, MoF Reg.
258 P.48/Menhut-II/2014 is the only one that explicitly requires a permit for restoration activity. The other
259 regulations pertain to the permanent use of marine space, which involves the installation of artificial
260 structures for restoration purposes.

261 When planning restoration projects, individuals or organisations must be aware of which
262 ministry’s jurisdiction the project location falls under. Reef restoration initiatives conducted within the
263 jurisdictional boundaries of MoEF must adhere to MoF Reg. P.48/Menhut-II/2014. In contrast,
264 restoration efforts outside of these areas may comply with other regulations, including the two more
265 comprehensive ones mentioned earlier, i.e., Pres. Reg. 121/2012 and MMAF Reg. 26/2021. Those
266 undertaking restoration efforts within the MoEF's jurisdiction should consult with and contact the local
267 office of the MOEF's marine national park, reserve, or sanctuary, submit their proposal, and apply for
268 a SIMAKSI permit (an example for SIMAKSI online application for Thousand Islands National Park)⁸.
269 For restoration projects in other areas, organisers should consult with and contact the regional office of
270 MMAF and apply for a KKPRL permit⁹. Besides institutional divisions, additional complexity arises
271 when combining reef restoration efforts with the establishment of managed areas such as MPAs. Here,
272 responsibility rests with different levels of government, including national for marine national parks
273 and provincial for community-based MPAs (for a discussion of the implications of shifts in
274 responsibilities for the latter, see Jompa et al. (2023)) This complexity underlines the need for a unified
275 approach at marine spatial planning in Indonesia that streamlines not only reef restoration but also its
276 systematic integration with marine management.

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⁷ <https://indonesianreefrestorations.org/>

⁸ <https://tnlkepulauanseribu.menlhk.go.id/simaksi/>

⁹ <https://bit.ly/BahanPKKPRLaut>

278 *Compliance with existing regulations*

279 Although there are legal foundations and best practice guidelines for reef restoration within
280 Indonesia's regulatory framework, the practical actions derived from these regulations remain uncertain.
281 Additionally, there are shortcomings in the implementation and enforcement of these regulations. For
282 example, despite the government's clear directive to monitor and conduct long-term evaluations of reef
283 restoration initiatives (Table 2 section 8), around 84% of such initiatives in Indonesia have resulted in
284 one-time installation of artificial reefs, without adequate assessment of their sustained impact or
285 progress (Razak et al., 2022). Similarly, in the case of post-installation maintenance, although Pres.
286 Reg. 121/2012 (Articles 5c and 11d) underlines the importance of maintaining restoration projects, only
287 11 out of 533 projects (2%) reported performing maintenance of their restoration plots (Razak et al.,
288 2022). Indeed, many one-off coral restoration projects have been abandoned, leaving behind discarded
289 and broken artificial structures that cause more harm to reefs than benefit (Munasik, 2008). This lack
290 of monitoring and maintenance is particularly concerning since these activities are critical to ensuring
291 the long-term success of reef restoration initiatives (Ceccarelli et al., 2018; Hein et al., 2017). To
292 compound the issue, there have been no public evaluations of these abandoned projects apart from the
293 one conducted by Munasik in 2008, and no actions have been taken against the individuals or groups
294 responsible for these unsuccessful projects. Contrastingly, there are several examples of successful
295 restoration projects in Indonesia where compliance with legal regulations and best practice guidelines
296 have resulted in successful outcomes (Lamont et al., 2022). The Mars Assisted Reef Restoration System
297 is one of the largest and best documented of these successful programmes, as an example of how
298 commitment to long-term monitoring and maintenance of restored reefs, in combination with effective
299 community engagement, can lead to successful restoration outcomes (Smith et al., 2021).

300 Under Law 27/2007 (amended by Law 1/2014), there are provisions for sanctions in relation to
301 reef damage. These sanctions, including fines or imprisonment, are outlined in Article 73 for individuals
302 or groups responsible for causing damage to coral reefs, Article 74 for their failure to restore the
303 damage, and Article 75 for not having the appropriate permit for the use of marine space. Currently,
304 inadequate or unsuccessful restoration efforts are not explicitly subject to any sanction provisions, and
305 it is thus unclear whether improperly conducted restoration efforts can lead to legal sanctions. It is

306 crucial to impose sanctions for damage arising from unsuccessful restoration efforts as a result of
307 negligent planning and non-compliance with government guidelines, such as using unsuitable materials,
308 abandoning projects, and incorrect placement causing harm to existing marine life (Table 2, section 9,
309 point 3 “*Damaging coral reefs through negligence*”). Restoration projects initiated without prior impact
310 assessments and expert guidance can lead to various threats to natural reefs. These potential risks
311 include the potential for physical damage to natural reefs if artificial reefs shift due to wave action
312 (Munasik, 2008); a risk of chemical leaching, e.g., as observed in the case of old tires in Osborne Reef,
313 Florida, USA (Reid et al., 2009); an upsurge in visitation to the restoration site, possibly transforming
314 it into a hub for eco-tourism (Hein et al., 2018); the likelihood of restored sites becoming hotspots for
315 fishing due to increased fish abundance around the artificial reefs (Saharuddin et al., 2012); and the
316 potential for artificial reefs to inadvertently facilitate the spread of invasive species (Schulze et al.,
317 2020). Additionally, establishing a clearly defined timeframe after implementation to assess the
318 effectiveness of restoration initiatives and determine appropriate consequences is imperative. The
319 implementation of such sanctions is anticipated to significantly reduce the occurrence of isolated
320 restoration practices in Indonesian waters.

321 One crucial factor with regards to compliance with any existing regulations is that restoration
322 practitioners are actually aware of the regulations that apply. The heterogeneous regulatory landscape
323 and multitude of responsible agencies suggests that it is very difficult for practitioners to be fully aware
324 of all applicable regulations even if they tried to comply. Besides streamlining of the regulatory
325 landscape, a dedicated awareness campaign and easily-accessible information on the applicable
326 regulations are suggested to improve awareness and compliance. In addition, as with marine
327 management, meaningful engagement and inclusion of local stakeholders in the implementation of reef
328 restoration efforts is important to achieve support and avoid further degradation of reefs from local
329 factors such as over- and destructive fishing (Giakoumi et al., 2018; Quigley et al., 2022).

330

331 *Maintenance, monitoring and evaluation*

332 The evaluation of restoration programs in Indonesia has traditionally focused on short-term,
333 measurable outcomes such as the quantity of deployed artificial units or transplanted coral fragments

334 and the size of the restored area. It is important to acknowledge that a high number of units and
335 fragments does not guarantee the success of a project (Hein et al., 2021). In addition, restoration projects
336 in Indonesia frequently express long-term goals, including an increase of coral cover, the enhancement
337 of fish populations, and the improvement of well-being for fishermen and coastal communities. These
338 objectives are commonly introduced at the beginning of the project but lack ongoing monitoring and
339 reporting, as well as concrete, quantitative targets. This is evident in the limited number of projects that
340 are subject to active monitoring (16%) and maintenance (2%), as well as the scarcity of progress reports
341 on restoration efforts (Razak et al., 2022).

342 The Indonesian regulations have outlined the obligation to conduct long-term monitoring,
343 evaluation, and maintenance (Table 2 section 8). This requirement is specified in Pres. Reg. 121/2012
344 (Article 14) and MMAF Reg. 26/2021 (Article 75). According to these regulations, monitoring should
345 occur every six months, but neither stipulate how long this regular monitoring should last. The
346 indicators that need to be monitored and evaluated as per the regulations include the area size, relative
347 cover and density of benthic ecosystem components, water quality, survival rate, and growth rate of
348 corals, as well as the community's awareness of the benefits of rehabilitation (social-ecological survey).
349 However, most of these indicators primarily focus on specific species or general metrics like coral
350 cover, rather than encompassing broader ecosystem processes or social-ecological indicators, for
351 example whether benefits have actually materialised.

352 Additionally, MoF Reg. P.48/Menhut-II/2014 stipulates that a permanent plot, comprising
353 0.01% of the total restored area, should be allocated for long-term evaluation (Article 8 verse 4).
354 Depending on the size of the restored area, this plot size may be very small. For instance, the average
355 size of reef restoration projects worldwide is 100 m² (Bayraktarov et al., 2019), which would only
356 require a monitoring plot of 0.01 m², which amounts to a single 10 cm × 10 cm square. Thus, in many
357 cases the mandated plot for monitoring is woefully inadequate. We propose that the percentage area to
358 be monitored should be inversely proportional to the size of the project, and that a minimum area for
359 monitoring should be stipulated. In other words, for smaller projects, it may be more practical to monitor
360 the entirety of the restored area than to monitor only a fraction of the site.

361 In addition to monitoring the restored areas, we would like to highlight the importance of
362 monitoring control plots, such as neighbouring natural reef habitats (Carr & Hixon, 1997; Goergen et
363 al., 2020). This practice is essential for establishing a reference point against which the progress of
364 restoration can be evaluated (Boakes et al., 2023; Williams et al., 2019). Furthermore, it serves as a
365 means to track changes in the conditions of natural reefs. By implementing this approach, we can
366 establish realistic targets for restoration based on the current state of the nearby natural reefs.

367 According to these regulations, as well as in Pres. Reg. 63/2015 (Article 10e) and MoE Decree
368 4/2001 (Article 7), the obligation to monitor and evaluate government restoration programmes rests
369 with the government. Unfortunately, the implementation of regular monitoring on restoration sites is
370 still very weak, and government agencies are often already stretched for resources and personnel. For
371 example, in a recent review, only 7 out of 205 coral restoration projects initiated by the government
372 have been monitored more than once (between 2 and 6 times) (from Table S2 in Razak et al. 2022). The
373 practical implications of this include not only a lack of comparability and accountability among
374 projects, but also potentially misleading conclusions regarding the success and feasibility of reef
375 restoration if the period of monitoring is not adequate (Ferse, 2010; Yap, 2003). The obligation to
376 conduct monitoring should thus rest with those conducting restoration activities, with demands for
377 reporting to responsible agencies such as MMAF, and should include standard monitoring duration to
378 improve comparability.

379

380 *Indicators for restoration success*

381 Rather than focusing solely on quantitative goals, the recovery and restoration of an ecosystem
382 are deemed successful when it possesses an adequate abundance of biotic and abiotic resources to
383 sustain its development independently, without the need for additional assistance or subsidies. At this
384 stage, the ecosystem is capable of maintaining its structural and functional integrity (Society for
385 Ecological Restoration International Science & Policy Working Group, 2004). On the other hand, the
386 Indonesian regulations establish ultimate restoration goals to ensure that the restored ecosystem closely
387 resembles its original or desired future state. Currently, the regulations refer to a "reference system" as
388 stated in MoF Reg. P.48/Menhut-II/2014 (Article 2 verse 1), aiming to restore ecosystem integrity to

389 its original or desired future condition. Other regulations like Pres. Reg. 121/2012 (Article 1 verse 1)
390 and MMAF Reg. 26/2021 (Article 1 verse 3) mention the recovery and repair of damaged ecosystems
391 or populations without specifying target indicators for measuring restoration efforts. Furthermore, while
392 coral restoration efforts can address a range of goals ranging from ecological and disturbance-driven
393 goals to research, socio-economic and climate change adaptation (Goergen et al., 2020; Hein et al.,
394 2020), the Indonesian regulations predominantly refer to ecological goals or restoration in response to
395 disturbance.

396 Despite efforts made by Indonesian regulations to ensure the achievement of these ultimate
397 goals, there is still a deficiency in the provision of specific and concrete indicators to measure restoration
398 effectiveness. The current indicators specified in the regulations primarily concentrate on general
399 metrics, and this approach can be problematic if it assumes an unrealistic "pristine" reference state
400 without considering the changing conditions in reefs. Future restoration guidelines in Indonesia should
401 therefore interpret what is written in the regulation into defining indicators that reflect key ecosystem
402 processes as targets, adopting a resilience-oriented and functional ecology-focused approach rather than
403 a static concept of restoration (Hein et al., 2020). Monitoring metrics could include a suite of standard
404 indicators to allow comparability together with goal-based indicators that are chosen to reflect the aims
405 of a particular restoration project (Goergen et al., 2020).

406

407 *Conclusion*

408 The increasing number of restoration projects, combined with insufficient adherence to current
409 regulations and a lack of documented evidence regarding their effectiveness, highlights the need for
410 proactive measures to raise public awareness about the government's rules and guidelines for reef
411 restoration. Such awareness-raising is crucial for ensuring that programs are understood, embraced, and
412 effectively implemented, particularly considering the absence of sanctions in Indonesian laws and
413 regulations for non-compliance with inadequate reef restoration programs.

414 The regulatory framework is likely to be critical in determining the feasibility and viability of
415 reef restoration programs in Indonesia. It plays a key role in influencing what, where and how to restore,
416 as well as who should be responsible for, engaged in, and benefit from restoration. The regulatory

417 framework can facilitate the necessary conditions for restoration initiatives, such as incorporating
418 scientific knowledge into restoration guidelines, organising community involvement in the process,
419 mobilising financial resources, and providing incentives to encourage action. In addition, regulations
420 can promote and assist the organisations and enterprises tasked with creating and executing restoration
421 strategies, as well as advancing knowledge and research in the field. However, the presence of complex
422 regulatory environments poses a risk of adverse impacts on restoration efforts, leading to confusion, a
423 lack of mechanisms for evaluating restoration success, and inadequate regulatory guidance. Also, to be
424 successful, restoration needs to be accompanied by measures reducing local stressors on reefs, pointing
425 to the need for better integration of reef restoration with marine management efforts. Addressing these
426 issues requires the establishment of similar arrangements across a broader range of government
427 agencies to address fragmentation and duplication. Collaboration among relevant jurisdictions is
428 essential. Moreover, the scientific community must acknowledge the need for additional information
429 and participate more actively in risk assessment and community engagement as part of the permitting
430 processes. Below, we provide eight suggestions based on our review of the policy framework to improve
431 reef restoration practice and its regulation in Indonesia.

432

433 5. Suggestions to improve restoration practice in Indonesia

- 434 ● **Eliminate threats.** The government must prioritise minimising or eliminating all threats and
435 destructive activities on coastal ecosystems before considering or granting permits for active
436 restoration plans in Indonesian waters. It is crucial to implement a proactive public awareness
437 program regarding the rules and regulations governing restoration efforts, while also
438 strengthening law enforcement, surveillance, and sustainable management practices. Reef
439 restoration efforts need to be systematically linked to improved marine management.
- 440 ● **Adopt mitigation hierarchy**¹⁰. The government can adopt the mitigation hierarchy that
441 provides a systematic framework for prioritising mitigation actions to address environmental
442 damage. It emphasises a sequence of steps, starting with avoidance of damage, followed by

¹⁰ <https://www.thebiodiversityconsultancy.com/our-work/our-expertise/strategy/mitigation-hierarchy/>

443 minimising damage, if necessary, then restoring after damage has occurred, and ultimately
444 offsetting damage in another location. Somehow a sequence of simplified mitigation steps has
445 been stipulated in Law 32/2009 (Article 54 verse 2) and Govt. Reg. 22/2021 (Article 415 verse
446 1). The suggestion is that effort should be prioritised in the above order and include damage
447 avoidance to begin with, rather than focussing on restoration or offsetting before protection or
448 minimising damage.

- 449 ● **Improve and update the national restoration guideline.** There are three existing guidelines:
450 *Tata laksana rehabilitasi terumbu karang* (Kementrian Lingkungan Hidup dan Kehutanan,
451 2019); *Pedoman rehabilitasi terumbu karang* (Dermawan, 2015); and MMAF General Director
452 Decree 10/2021 on technical instructions for a coral stock centre and rehabilitation with a
453 subsection on the establishment of coral stocks/nurseries (Supplementary Material). A new
454 updated guideline can be structured in line with the three most comprehensive Indonesian
455 regulations (Figs. 3 and 4), as well as adapt (with local context adjustment) the most recent
456 international manuals such as Shaver et al. (2020) for planning and design, and Goergen et al.
457 (2020) for monitoring of restoration projects.
- 458 ● **Agreement on terminologies.** One of the pressing issues that the national guideline should
459 clarify is inconsistencies in terminology used in different regulations. While most uses of
460 terminology (notably *rehabilitasi*) are not conflicting, there are some instances where they are
461 not internally coherent or not in line with the international definitions.
- 462 ● **Interagency collaboration.** The relevant government agencies need to collaborate in order to
463 streamline the permission process for restoration activities in Indonesian waters. This aligns
464 with the call for a restoration task force, which could be part of efforts to coordinate among the
465 different government agencies. Redundancies and overlapping jurisdictions need to be
466 addressed and, ultimately, a single agency be placed in charge of reef restoration in Indonesia.
- 467 ● **Adequate involvement of coastal communities.** Many restoration projects in Indonesia are
468 initiated by local communities, but these often lack structured support and guidance. A
469 feasibility study prior to restoration planning should assess the social acceptability of various
470 types of restoration interventions and their likely socio-economic outcomes. Marine

471 management tends to be more effective if there is sufficient/effective engagement of
472 stakeholders in design and implementation. Community engagement opportunities and
473 requirements should be streamlined for reef restoration projects. Legislation on marine
474 management contains a lot of provisions for community engagement/participation, which could
475 be used to inform restoration legislation (Baitoningsih, 2015). Importantly, this should entail
476 rights in addition to obligations, as well as support by the government in terms of resources and
477 knowledge. The wider goals of the restoration project should be adequately reflected in
478 monitoring and informed by social-ecological considerations (Hein et al., 2017).

- 479 ● **Maintenance and monitoring.** To ensure the effectiveness of restoration efforts in Indonesian
480 waters, it is crucial to thoroughly evaluate artificial reefs and human-made structures intended
481 for this purpose. Before granting permits, it is necessary to establish long-term maintenance
482 plans and monitoring programs to prevent abandonment and the accumulation of underwater
483 debris resulting from unsuccessful restoration projects. Review should be applied both for the
484 quality of the restoration plans and execution, as well as the financial plan to ensure adequate
485 resources are available for ongoing maintenance and monitoring.
- 486 ● **Establish a national reef restoration task force.** The task force would act as a scientific
487 authority to review, approve, supervise and advise the implementation and maintenance of
488 restoration projects, both existing and proposed. The task force should aim to ensure restoration
489 effectiveness through (1) facilitating collaboration between authorities, restoration practitioners
490 and communities, (2) raising awareness of regulations and best practice guidelines, (3)
491 streamlining and integrating reef restoration and marine management, (4) minimising overlap
492 and abandonment of projects, (5) advising on regulations and permit requirements, (6) working
493 closely with restoration working groups (such as SCORES at IPB University and Bali Reef
494 Rehabilitation Network led by the Coral Triangle Centre), (7) coordinating monitoring and data
495 collection, so that information on reef restoration projects is consolidated and made available
496 in a standardised way, and (8) interfacing with other national restoration task forces and
497 programmes at the international level, enhancing exchange of information and learning
498 opportunities.

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501 **References**

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