Sustinere
Journal of Environment and Sustainability
Volume 8 Number 3 (2024) 333-345

Print ISSN: 2549-1245 Online ISSN: 2549-1253
Website: https://sustinerejes.com E-mail: sustinere.jes@uinsaid.ac.id

RESEARCH PAPER

Conservation program for freshwater stingrays in the Musi River, Palembang City, South Sumatra: Stakeholders analysis and priority programs

Sahaya Aulia Azzahra[1*], Pini Wijayanti[1], Nabila Nur Septiani[1], Lailatun Nikmah[2]
[1]*Department of Resources and Environmental Economics, IPB University, Indonesia*
[2]*Department of Economics, IPB University, Indonesia*

Article history:
Received 3 May 2024 | Accepted 30 October 2024 | Available online 30 December 2024

Abstract. Through the Minister of Maritime Affairs and Fisheries Decree (Kepmen KP) 01/2021, the Indonesian Government has granted full protection status for three freshwater stingray species found in the Musi River, Palembang City, South Sumatra. However, enforcement of regulations related to the full protection of these three species remains suboptimal. Therefore, the active involvement of stakeholders and implementation of practical conservation strategies are essential. This research aims to identify the interactions among stakeholders involved in managing freshwater stingrays and to develop priority conservation programs for these species in the Musi River, Palembang City, South Sumatra. The findings emphasize the key stakeholders in management of freshwater stingrays, including the Palembang City Fisheries Office, Fisheries Extension Officers in Palembang City, under the Research Institute for Fisheries Research and Fisheries Extension Palembang institution (BRPPUPP), Fishery Resources Surveillance and Monitoring (PSDKP) Batam Palembang Work Area, Coastal and Marine Resources Management Agency (BPSPL) Padang Palembang Work Area, and fishermen. The proposed priority conservation programs for freshwater stingrays include public awareness campaigns to promote the importance of full protection for these species, research on the biological characteristics and habitats of freshwater stingrays, and enhanced surveillance achieving through intensive monitoring by Community Surveillance Groups (Pokmaswas) and by increasing the number of personnel and fisheries surveillance fleets. Collaborative program development among stakeholders is critical to ensure the success of the freshwater stingray conservation initiatives in the Musi River.

Keywords: Analytic Hierarchy Process (AHP); illegal trading; MACTOR; species conservation; protected species

1. Introduction

Indonesia is a maritime country with the richest marine biodiversity in the world, hosting 20% of the world's 1,250 species diversity of elasmobranchs, or cartilaginous fish, such as sharks and rays (Jaya et al., 2022; Prasetyo et al., 2021; Dulvy et al., 2017). Specifically, Indonesian waters are home to at least 100 species of rays with high economic value (Fadhilah et al., 2019; Wijayanti

*Corresponding author. E-mail: shyau.azzahra@apps.ipb.ac.id
DOI: https://doi.org/10.22515/sustinere.jes.v8i3.402

et al., 2018). In addition to inhabiting marine waters, coasts, or estuaries, rays can also live in freshwater environments, such as rivers (Dulvy et al., 2017; Kinakesti & Wahyudewantoro, 2017).

Freshwater ray species in Indonesian rivers are generally classified within the Dasyatidae family, commonly known as longtail rays or stingrays (Kinakesti & Wahyudewantoro, 2017). For example, species such as *Himantura sp*. and *Taeniura lymma* have been recorded in the estuary of the Cibarangiang River, Pandeglang, Banten Province, *Fluvitrygon sp*. 'Musi I' and 'Musi II' are found in the Musi River, Palembang, South Sumatra Province (Muhammad et al., 2018; Kinakesti & Wahyudewantoro, 2017)).

Additionally, there are protected freshwater ray species, such as the leopard river ray (*Fluvitrygon oxyrhynchus*), the white-edged river ray (*Fluvitrygon signifier*), and the giant river ray (*Urogymnus polylepis*), all found in the Musi River, South Sumatra. Another notable species is the kai stingaree (*Urolophus kaianus*), which is endemic to the coastal areas of the Kei Islands, Maluku (KKP, 2021).

The Indonesian government has issued regulations for the fully protection of three freshwater ray species through the Ministerial Decree (Kepmen) of Marine Affairs and Fisheries No. 1/2021. However, these regulations have not yet been effective in controlling captures by small-scale fisherman. Field observations in the Musi River area, Palembang City, South Sumatra, reveal that the three protected freshwater ray species, categorized as "endangered" and listed under Appendix II for trade, are still being freely traded in traditional markets or online through marketplaces. In addition to Palembang, Ilham and Marasabessy (2021) reported that three critically endangered ray species, also with Appendix II of Convention on International Trade in Endangered Species of Wild Fauna and Flora (CITES) trading status, are still being traded by small-scale fishermen in Sorong City, West Papua Province.

Efforts to enforce protecting freshwater rays, such as public awareness campaigns, supervision, and the development of conservation strategies, require strong support from stakeholders in freshwater ray management. Active participation from various stakeholders is crucial for the sustainable management of freshwater ray resources (Karadeniz N. & Yenilmez Arpa, 2022). This is because stakeholder interactions are essential in generating modern small-scale fisheries management solutions that are socially acceptable (Baiju et al., 2022).

Although previous researchers have developed biodiversity conservation strategies, specific conservation strategies for freshwater rays in the Musi River have not yet been formulated and implemented in Indonesia. Furthermore, research on stakeholders and conservation strategies for freshwater rays in the Musi River is remains limited. According to pre-survey interviews with representatives of the Palembang City Fisheries Service, the lack of data and research on freshwater rays presents a significant challenge to managing these species sustainably.

The sustainability of freshwater rays in the Musi River is closely tied to stakeholder interactions and the implementation of effective conservation strategies. Identifying the stakeholders involved in freshwater ray management is crucial, as they play a key role in determining the success of sustainability efforts. Additionally, data on priority conservation programs for freshwater ray is essential for the government to formulate sustainable management strategies.

The general objective of this research is to develop sustainable conservation strategies for freshwater rays. This objective can be achieved by addressing two specific objectives: identifying stakeholder interactions in the management of freshwater rays in the Musi River, Palembang City, South Sumatra, and formulating priority conservation programs for freshwater rays in the Musi River, Palembang City, South Sumatra.

2. Material and method

The study's first objective was achieved by collecting primary data on stakeholders involved in managing freshwater rays and analyzing their levels of influence through in-depth interviews. The second objective was addressed through focus group discussions (FGDs) and surveys using

questionnaires to obtain primary on priority conservation programs for freshwater rays. Secondary data from books, accredited scientific articles, the Central Statistics Bureau (BPS), and other relevant and credible databases were also utilized to design the study and support findings. Stakeholders were selected using the expert sampling method, with the population grouped into three sample categories based on their expertise in the study's areas: government, academia, and practitioners in conservation or environmental fields.

2.1. Matrix of alliance, conflicts, tactics objective, and recommendations

In identifying stakeholder interactions in the management of freshwater rays in the Musi River, Palembang, South Sumatra, the study employed the Matrix of Alliance, Conflicts, Tactics Objective, and Recommendations (MACTOR) method, supported by MACTOR version 5.3.0. The MACTOR method aids in identifying similarities and differences among stakeholders in achieving shared objectives. Mapping stakeholder positions in natural resource management contexts is particularly challenging due to the involvement of numerous institutions with varying interests, necessitating a quantification process to illustrate the stakeholder relationships. The MACTOR analysis begins with the identification of stakeholders involved in achieving the desired objective - in this case, sustainable freshwater ray conservation. In the second step, the influence or strength of one actor (A) in influencing another actor (B), is assessed and represented by scores ranging from 0 to 4. Once the influence scores of each stakeholder are obtained, the third step involves analyzing these scores using mathematical algorithms to construct a Matrix of Direct Influence or MDI matrices.

After obtaining the results, the final step in the MACTOR analysis is to determine the level of influence and interdependence among stakeholders. These findings can be presented in a matrix containing four quadrants of stakeholder positions as outlined by Godet (1991) (see Figure 1 and Table 2).

Table 1. Scores of influence levels among stakeholders (Fauzi, 2019)

Score	Level of influence	Description
0	No influence	Actor (A) does not influence other actors (B)
1	Operational procedures	Actor (A) influences the operational procedures of other actors (B)
2	Projects	Actor (A) influences the projects of other actors (B)
3	Missions	Actor (A) influences the missions of other actors (B)
4	Existences	Actor (A) influences the existence of other actors (B)

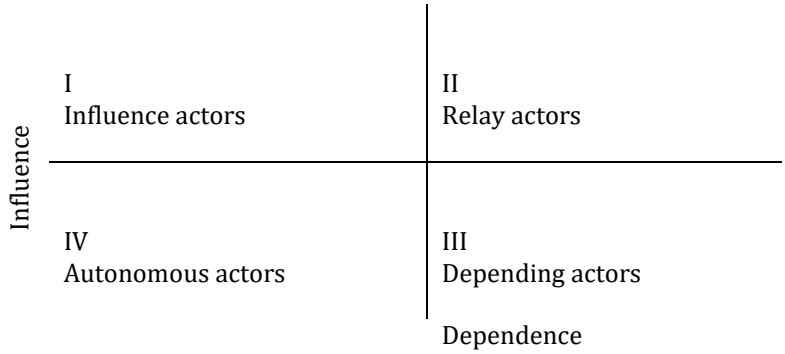

Figure 1. Matrix of interaction among stakeholders (Godet, 1991)

Table 2. Explanation of matrix of interactions among stakeholders (Godet, 1991)

Score	Level of Influence	Description
I	Influence actors	1. Strong influence and low dependency 2. Actors capable of shaking depending on actors
II	Relay actors	1. Strong influence but high dependency 2. Crucial actors as key players
III	Depending actors	1. Weak influence and high dependency 2. Actors influenced by influence actors and relay actors
IV	Autonomous actors	1. Weak influence and low dependency 2. Actors unable to influence or be influenced by other actors

Table 3. The scale of importance levels among elements (Falatehan, 2016)

Scale	Importance Level	Description
1	Equal importance	Element (A) is equally essential as element (B)
3	Moderate importance	Element (A) is slightly more critical than element (B)
5	Strong importance	Element (A) is equally essential as element (B)
7	Very strong importance	Element (A) is highly important compared to element (B)
9	Extreme importance	Element (A) is significantly more important than element (B)

2.2. Analytical Hierarchy Process

This research employs the Analytical Hierarchy Process (AHP) supported by SuperDecisions version 2.10.0 to formulate priority conservation programs for freshwater rays in the Musi River, Palembang, South Sumatra. The AHP method is a decision-making approach that incorporates multiple criteria, making it suitable for multi-criteria decision-making (Falatehan, 2016). Establishing priority programs in the natural resource management is particularly challenging due to the involvement of numerous institutions with diverse interests, necessitating a systematic quantification process to determine these priorities (Saaty, 1990).

The initial step in conducting an AHP analysis is to hierarchically structure the elements required to achieve the desired objective - in this case, sustainable freshwater ray conservation (Falatehan, 2016). The second step involves assessing the relative importance of one element (A) compared to another (B), using a scale of 1–9 (Saaty, 1990) (see Table 3). Once the importance scales for each element are determined, the third step entails analyzing these scales using mathematical vectors in the form of the Matrix of Pairwise Comparison (MPC) (Falatehan, 2016).

After completing the analysis, the final step in the AHP process is to identify the most important programs that require prioritization. These findings can be presented in a table summarizing the elements and their assessment results (Saaty, 1990).

3. Result

3.1. Interactions among stakeholders in freshwater ray management in the Musi River

Data on stakeholders involved in the management of freshwater rays in the Musi River, Palembang, South Sumatra, were gathered through literature studies, expert recommendations, and pre-survey focus group discussions (FGDs). The pre-survey FGDs were conducted with local government institutions including the Palembang City Fisheries Service, Research Institute for Fisheries Research and Fisheries Extension (BRPPUPP) Palembang, Fishery Resources Surveillance and Monitoring (PSDKP) Batam Palembang working area, and Coastal and Marine Resources Management Agency (BPSPL) Padang Palembang working area. These discussions with the four stakeholders provided recommendations for identifying additional stakeholders, as outlined in Table 4.

Interactions among stakeholders in freshwater ray management are represented indicated by scores in the Matrix of Direct Influence (MDI), which reflects the influence and dependence among stakeholders. The scoring process was not based on questionnaire responses but on verbal discussions with stakeholders. Therefore, research bias may arise in translating the outcomes of these narrative discussions into scores for MDI input. The scores indicating interactions among stakeholders use a scale of 0–4 (see Figure 2), as follows: no influence (score 0); operating procedures (score 1); projects (score 2); missions (score 3); and existences (score 4) (Fauzi, 2019).

For instance, the interaction between fishermen (Nlyn) and village intermediary traders (Lrng) has a score of 4 (existences), indicating that the existence or presence of village intermediary traders is influenced by fishermen. Village intermediary traders are stakeholders who purchase fish supplies from fishermen to resell to consumers. Thus, fishermen influence the presence of village intermediary traders. Another example is the interaction between researchers and academics (Research) with fishermen (Nlyn), which shows a score of 1 (operating procedures), meaning that researchers and academics influence the operational procedures of fishermen. Researchers and academics are stakeholders involved in research and education in

Table 4. Stakeholders in freshwater ray management in the Musi River

Code	Stakeholders	Symbol
A1	Fishermen	Nlyn
A2	Village intermediaries' traders (Lorong)	Lrng
A3	Distributor	Dstr
A4	Palembang City Fisheries Service	Dskn
A5	Research Institute for Fisheries Research and Fisheries Extension (BRPPUPP) Palembang	Pnylh
A6	Fishery Resources Surveillance and Monitoring (PSDKP) Batam Palembang Working Area	Psdkp
A7	Coastal and Marine Resources Management Agency (BPSPL) Padang Palembang Working Area	Bpspl
A8	Directorate of Conservation and Marine Biodiversity, Ministry of Maritime Affairs and Fisheries (Directorate of KKHL KKP)	Kkhl_kkp
A9	Academics/researchers	Riset
A10	Conservation Non-Government Officials (NGOs)	Ngo
A11	Media in Environmental Investigation	Media

MDI	Nlyn	Lrng	Dstr	Dinas	Pnylh	Psdkp	Bpspl	Kkhl_KKP	Riset	NGO	Media
Nlyn	0	4	4	3	3	3	3	2	1	1	1
Lrng	4	0	0	2	2	2	2	1	1	1	1
Dstr	4	0	0	2	2	2	2	1	1	1	1
Dinas	4	3	3	0	3	3	3	1	2	2	2
Pnylh	3	3	3	3	0	3	2	1	1	1	1
Psdkp	3	3	4	3	3	0	2	1	1	1	1
Bpspl	3	3	3	3	3	3	0	1	1	1	1
Kkhl_KKP	3	3	3	3	3	3	4	0	2	3	1
Riset	1	1	1	2	2	2	3	2	0	3	1
NGO	3	2	2	2	2	2	2	2	3	0	2
Media	0	0	0	0	0	0	0	1	3	3	0

© LIPSOR-EPITA-MACTOR

Figure 2. Results of scores on the level of influence among stakeholders

fisheries, so their findings will affect the operational procedures fishermen use to catch fish. The analysis results, showing each actor's interaction, are summarized in Table 5.

3.2. Program prioritization for freshwater ray conservation in Musi River

The prioritization program for conserving freshwater rays consists of three strategic alternatives: protection of freshwater rays, conservation of freshwater rays, and enforcement of regulations related to freshwater rays, along with 11 programs (see Table 6). These three strategic alternatives have undergone two revisions and adjustments from initially drafted strategies before field observations and surveys were conducted. The first modification was based on pre-survey FGDs with local government institutions: Department of Fisheries of Palembang City; BRPPUPP Palembang; PSDKP Batam working area Palembang; and BPSPL Padang working area Palembang. Subsequent changes were made based on FGD results with 12 freshwater ray managers of three groups: government, academia, and environmental practitioners (see Table 4).

Once the structural hierarchy model was developed, pairwise comparison assessment matrices were prepared based on stakeholders' responses to the freshwater ray conservation priority program questionnaire. The questionnaire was distributed online to 12 stakeholders from March 29 to April 19, 2023. Eight stakeholders completed the assessment of the freshwater ray conservation priority program, including five from the government sector (Fisheries Extension Officer of Palembang City, BRPPUPP Palembang, PSDKP Batam working area Palembang, BPSPL Padang working area Palembang, and Directorate of KKHL KKP, two from the academic sector (IPB and Sriwijaya University), and one environmental investigative media practitioner. The stakeholders' assessments of the freshwater ray conservation priority program were structured into pairwise comparison assessment matrices, as shown in Appendix 1. The values used as input for the pairwise comparison matrix are the geometric mean values derived from all stakeholder assessments.

In general, the priority programs to support freshwater stingray conservation that should be implemented first are outlined in Table 6. To achieve the benefits of sustainable fisheries conservation and utilization, the priority should be placed on ceasing excessive, illegal, and harmful fishing activities with an enforcement strategy related to freshwater stingrays being the most critical. To accomplish this, the prioritized conservation programs include community outreach regarding the full protection of freshwater stingrays, research on their biological characteristics and habitats, intensive monitoring through the role of Fisheries Community Monitoring Groups (Pokmaswas), and increasing the number of personnel and fisheries surveillance fleets. Implementing priority programs for freshwater stingray conservation requires collaboration from various stakeholders.

In implementing community outreach programs for the full protection of freshwater stingrays, the role of government agencies such as the Palembang City Fisheries Service, Fisheries Extension Officers of Palembang City under BRPPUPP Palembang, and BPSPL Padang in the Palembang work area is essential for program success. However, academics can also contribute by implementing these programs through community service activities or collaborating with local community members through Pokmaswas. The involvement of researchers and scholars is crucial for conducting research on the biological characteristics and habitat of freshwater stingrays. Additionally, PSDKP Batam in the Palembang work area and Fisheries Extension Officers of Palem-

Table 5. Results of analysis on interactions among freshwater ray managers stakeholders

Quadrant	Stakeholder positions	Stakeholders
I	Influence actors	Kkhl_KKP; NGO; Riset
II	Key actors	Dskn; Pnylh; Psdkp; Bpspl; Nlyn
III	Depending actors	Lrng; Dstr
IV	Autonomous actors	Media

bang City under BRPPUPP Palembang are expected to provide more intensive guidance to Pokmaswas, ensuring that these community groups can fulfill their functions effectively. The national government, particularly the Directorate General of Marine and Fisheries Resources Supervision (DPSDKP) of the Ministry of Marine Affairs and Fisheries, can assist by adding personnel and fisheries surveillance fleets, as the Marine and Fisheries Resources Supervisory Unit (Satwas SDKP) operates at the regional level.

Table 6. Priorities in freshwater stingray conservation in the Musi River

Level	Element	Analysis outcome	Priority choices	Key actors
I	Benefit			
	Preserving and utilizing fisheries resources sustainably	-	-	-
II	Output			
	1. Stopping excessive, illegal, and damaging fishing (2A)	0.72	1	-
	2. Recovering fish stocks adequately in the shortest possible time (2B)	0.28	2	-
III	Strategic Alternatives A			
	1. Protection of freshwater rays (3A)	0.34	2	-
	2. Preservation of freshwater rays (3B)	0.23	3	
	3. Enforcement of regulations related to freshwater rays (3C)	0.44	1	-
	Strategic Alternatives B			-
	1. Protection of freshwater rays (3A)	0.32	2	-
	2. Preservation of freshwater rays (3B)	0.25	3	
	3. Enforcement of regulations related to freshwater rays (3C)	0.42	1	-
IV	Program A			-
	1. Socialization to the community regarding full protection of freshwater rays (4A-1)	0.63	1	Fisheries Service, Fisheries Extension Officers and BPSPL
	2. Release of accidentally caught freshwater rays (bycatch) (4A-2)	0.12	3	
	3. Establishment of areas and development of freshwater ray conservation action plans (4A-3)	0.23	2	
	Program B			
	1. Inventory of freshwater ray stocks (4B-1)	0.25	2	Academics/ researcher
	2. Population enhancement through freshwater ray aquaculture (4B-2)	0.25	3	
	3. Research on biological characteristics and habitat of freshwater rays (4B-3)	0.35	1	
	4. Genetic data storage of freshwater rays for germplasm conservation (4B-4)	0.15	4	
	Program C			
	1. Limited utilization to parties holding Fish Species Utilization Permit (SIPJI) (4C-1)	0.16	4	
	2. Increase in personnel and fishing surveillance fleet (4C-2)	0.29	2	
	3. Intensive monitoring through Community Surveillance Groups (Pokmaswas) (4C-3)	0.29	1	DPSDKP KKP RI
	4. Imposition of sanctions on parties involved in illegal freshwater ray trade (4C-4)	0.27	3	PSDKP and Fisheries Extension Officers

4. Discussions

4.1. Interactions among stakeholders in freshwater ray management in the Musi River

Based on the analysis results (see Table 5), the Directorate of Conservation and Marine Biodiversity, Ministry of Maritime Affairs and Fisheries (Dir. KKHL KKP), environmental NGOs, and researchers and academics are stakeholders found in Quadrant I or classified as influence actors. These stakeholders have dominant influence and low dependence (Wijayanto et al., 2022). The Directorate of Conservation and Marine Biodiversity, Ministry of Maritime Affairs and Fisheries is a government institution authorized to plan and formulate national policies related to conservation of 20 types of fish through Ministerial Regulation (Permen)-KP Number 1 of 2021 concerning Protected Fish Species. Environmental NGOs play a crucial role in developing this policy, providing recommendations on which fish species (including freshwater rays) need to be conserved. This is supported by FGD results, which state that the formulation of policies for the full protection of 20 fish species, including freshwater rays, is based on expert judgments from environmental NGO activists. Additionally, previous research conducted by researchers and academics significantly contributes to the formulation of these policies. Therefore, stakeholders in Quadrant I can also be referred to as context setters (Kusumawardhani et al., 2023).

Stakeholders falling into Quadrant II (Relay actors) include the Palembang City Fisheries Service, BRPPUPP Palembang (which acts as Fisheries Extension Officer for Palembang City), PSDKP Batam working area Palembang, BPSPL Padang working area Palembang, and fishermen. Quadrant II stakeholders can be termed relay actors with high influence and dependence (Wijayanto et al., 2022). Fishermen wield substantial influence in managing freshwater rays, as they are professionals engaged in fishing activities in the Musi River area. However, other stakeholders, such as the Department of Fisheries and Fisheries Extension Officers, also influence fishermen. Meanwhile, the Palembang City Fisheries Service holds significant sway in managing freshwater rays as a local government authority responsible for fisheries, but it is greatly influenced by higher-level institutions such as the Provincial Fisheries Departments and the Ministry of Maritime Affairs and Fisheries (KKP). Similarly, BRPPUPP, PSDKP, and BPSPL, tasked with extension, supervision, and resource management at the regional level, are heavily influenced by higher-level structural institutions like the KKP. Therefore, stakeholders in Quadrant II can be considered key players due to their pivotal roles, which, if mismanaged, could pose risks to the success of freshwater ray management (Kusumawardhani et al., 2023).

Quadrant III, depending on the actors, encompasses village intermediaries, traders, and ornamental fish distributors. These stakeholders do not wield a dominant influence in freshwater ray management, as they lack authority akin to governmental agencies (Wijayanto et al., 2022). Stakeholders in this quadrant receive significant influence from Quadrants I and II stakeholders and bear the brunt of top-down policies in freshwater ray management. Hence, they can be referred to as subjects (Kusumawardhani et al., 2023).

Based on the results of the analysis, stakeholders in Quadrant IV are environmental investigative media. Quadrant IV stakeholders are autonomous actors with low influence and dependence (Wijayanto et al., 2022). Environmental investigative media are non-governmental institutions that do not influence or have authority in freshwater ray management. They operate independently and serve to disseminate issues and research findings related to freshwater rays to the public through easily understandable media. Thus, they can be supportive stakeholders in freshwater ray conservation. Therefore, stakeholders in Quadrant IV can be referred to as crowds (Kusumawardhani et al., 2023).

4.2. Program prioritization for freshwater ray conservation in Musi River

Based on the pairwise comparison assessment matrix analysis of outputs to benefits, stopping excessive, illegal, and damaging fishing (Output 2A) is identified as a key expected output in freshwater ray conservation. The analysis results indicate that the weight of this outputs

assessment is higher than that of other outputs, such as recovering fish stocks adequately in the shortest possible time (Output 2B, see Figure 3).

According to FGD results with practitioners, halting freshwater ray fishing through full protection regulations is a feasible measure to prevent the extinction of wild freshwater ray populations. This is particularly important given the limited research on breeding procedures and methods to enhance freshwater ray populations. Academic stakeholders have similarly highlighted that freshwater rays are long-lived species with a very lengthy reproductive cycles, making rapid restoration of their population challenging. Consequently, halting excessive, illegal, and damaging fishing is a priority output in freshwater ray conservation, as it is both cost-effectiveness (requiring the lowest conservation costs) and enforceability compared to other measures (Squires, 2012).

In the subsequent stage, the analysis of alternative strategies for achieving outputs suggests that stopping excessive, illegal, and damaging fishing (2A) is closely associated with prioritizing the enforcement of regulations related to freshwater rays (3C) in conservation efforts. This conclusion is supported by the assessment score of this strategy, which is the highest compared to the other two alternatives: protection of freshwater rays (3A) and preservation of freshwater stingrays (3B) (see Figure 4).

To achieve the output of recovering fish stocks adequately in the shortest possible time (2B), the enforcement of regulations related to freshwater rays (3C) is prioritized over other strategies, such as the protection of freshwater rays (3A) and preservation of freshwater stingrays (3B) (see Figure 5). These findings align with the previous research emphasizing the importance enforceability as a key criterion for conservation activities, particularly the effective implement-

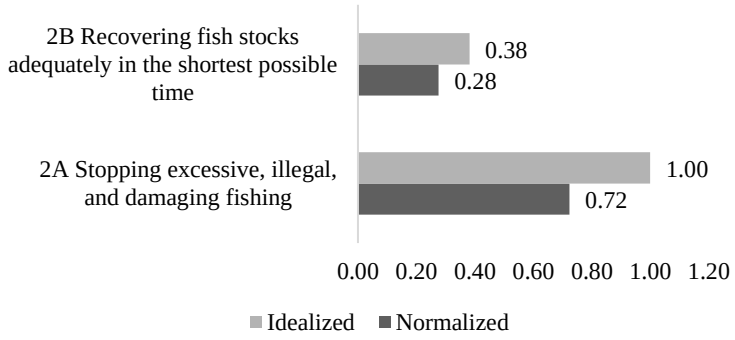

Figure 3. Priority outputs to achieve freshwater ray conservation benefits

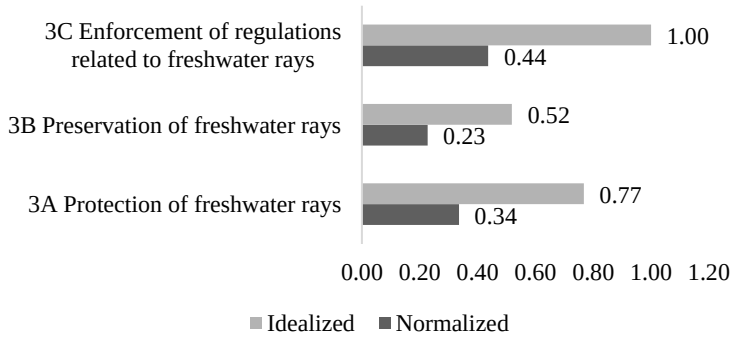

Figure 4. Priority alternative strategies to achieve output A

ation of conservation programs (Squires, 2012). The enforcement of regulations related to freshwater stingrays is the most feasible strategy to implement, as stakeholders at the national level have already formulated full protection regulations for these species.

In the final stage, the analysis of programs aimed at achievement alternative strategies for the protection of freshwater rays (3A) highlights socialization of full protection measures to the community (4A-1) as a priority in freshwater stingray conservation. This conclusion is supported by the assessment score of this program, which has the highest among the three freshwater stingray protection programs (see Figure 6). The other programs include the establishment of of conservation areas and the development of freshwater ray conservation action plans (4A-3) and the release of accidentally caught freshwater rays (bycatch) (4A-2).

These findings are supported by statements from government and academic representatives, who state that establishing conservation zones or drafting a national-level conservation action plan involves lengthy processes, complex bureaucratic procedures, and requires a comprehensive multidisciplinary scientific foundation. As a result, designating freshwater stingray conservation areas is less suitable in terms of cost-effectiveness and enforceability for short-term implementation (Squires, 2012). Similarly, releasing captured freshwater stingrays as bycatch poses challenges related to enforceability and moral considerations, such as the stigma or perceptions regarding surrounding conservation activities (Squires, 2012). According to FGDs with practitioners and government officials, these challenges arise because the captured fish, including freshwater stingrays caught as bycatch, often serve as vital source of livelihood for fishermen's families, coupled with weak supervision of protected fish species in the field.

The analysis of programs aimed at achievement alternative strategies for the preservation of freshwater stingrays (3B) identifies research on the biological characteristics and habitat of freshwater rays (4B-3) as a top priority. This program is ranked higher than other programs (see

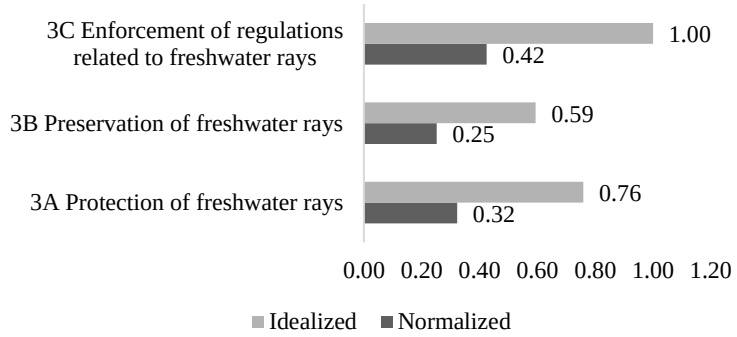

Figure 5. Priority alternative strategies to achieve output B

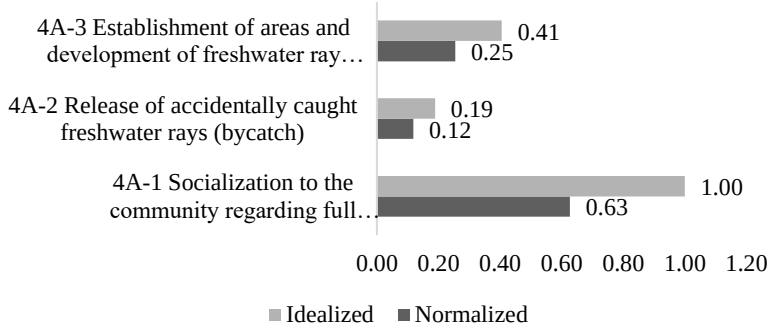

Figure 6. Priority programs to achieve alternative strategy A

Figure 7), such as population enhancement through freshwater ray aquaculture (4B-2), inventory of freshwater ray stocks (4B-1), and genetic data storage for germplasm conservation (4B-4). Discussions with academics suggest that this program could serve as an initial step for developing aquaculture techniques and determining the maximum allowable catch of freshwater stingrays, making it a more practical conservation approach than genetic data storage. From an enforceability perspective, this program represents a suitable and effective step in advancing freshwater stingray conservation efforts (Squires, 2012).

The program analysis for achieving the alternative strategy of enforcing regulations related to freshwater rays (3C) indicates that intensive monitoring through Community Surveillance Groups (Pokmaswas) (4C-3) and increasing personnel and the fishing surveillance fleet (4C-2) as prioritized programs. These efforts are prioritized over other programs (see Figure 8), such as the imposition of sanctions on parties involved in the illegal freshwater ray trade (4C-4) and the limited utilization of freshwater ray by SIPJI permit holders (4C-1). These findings align with previous conclusions emphasizing the cessation of freshwater stingray fishing and enforcement of full protection regulations as priority output and strategies in freshwater stingrays' conservation. Achieving these outputs and strategies can be effectively supported by enhancing surveillance through both top-down measures – such as increasing personnel and expanding the fisheries surveillance fleet - and bottom-up initiatives like forming Pokmaswas to conduct

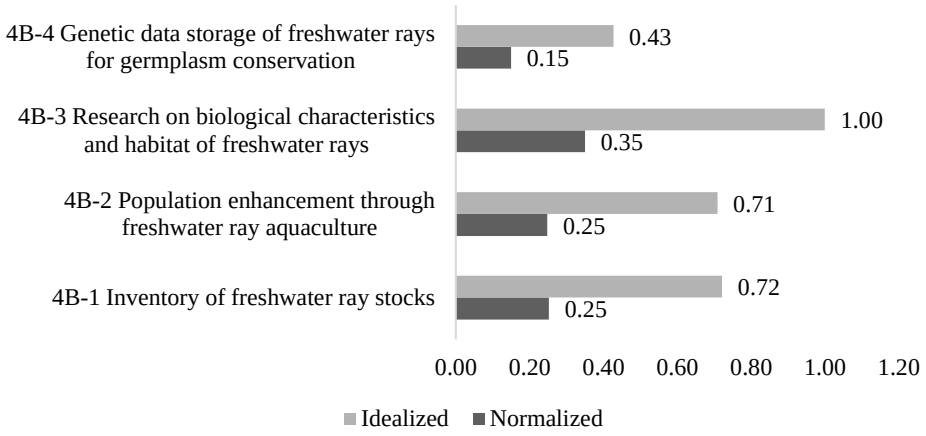

Figure 7. Priority programs to achieve alternative strategy B

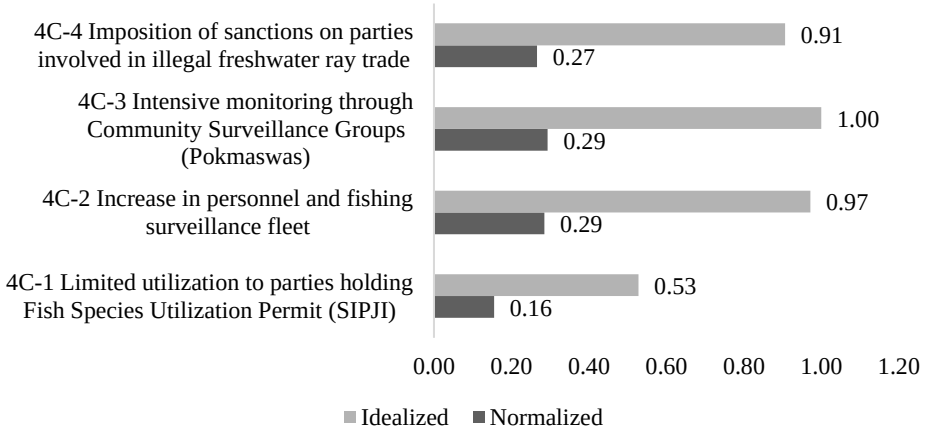

Figure 8. Priority programs to achieve alternative strategy C

intensive communities monitoring. Consequently, these two programs are practical enforceable step toward achieving the desired strategies and outputs in freshwater stingray conservation (Squires, 2012).

5. Conclusion

This research identifies key stakeholders involved in freshwater stingray management in the Musi River, including the Fisheries Service of Palembang City, Fisheries Extension Officers of Palembang City (under the BRPPUPP Palembang institution), PSDKP Batam in the Palembang Work Area, BPSPL Padang in the Palembang work area, and local fishermen. The proposed priority programs for freshwater stingray conservation include community outreach on the full protection of freshwater stingrays, research into their biological characteristics and habitat, and enhanced surveillance. Surveillance efforts should incorporate both bottom-up intensives, such as intensive monitoring by Fisheries Community Monitoring Groups (Pokmaswas), and top-down measures, including increasing personnel and expanding the fisheries surveillance fleet.

This study's key recommendation is to improve collaboration among stakeholders in managing freshwater stingrays. Stakeholders play vital roles in this process, and their lack of involvement or cooperation can pose significant risks. Additionally, the proposed conservation program for freshwater stingrays in the Musi River should be designed as a collaborative effort, enabling stakeholders to establish string linkages and optimize resource utilization to ensure the program's success.

Acknowledgment

The author expresses gratitude to the Yayasan Konservasi Indonesia for funding this research. Appreciation is also extended to the Fisheries Extension Officers of Palembang City, the fishermen near the Musi River in Palembang City, and all other parties who contributed to the completing of this research.

References

Baiju, K. K., Parappurathu, S., Abhilash, S., Ramachandran, C., Swathi Lekshmi, P. S., Padmajan, P., Padua, S., & Kaleekal, T. (2022). Achieving governance synergies through institutional interactions among non-state and state actors in small-scale marine fisheries in India. *Marine Policy*, *138*(February), 104990. https://doi.org/10.1016/j.marpol.2022.104990

Dulvy, N. K., Simpfendorfer, C. A., Davidson, L. N. K., Fordham, S. V., Bräutigam, A., Sant, G., & Welch, D. J. (2017). Challenges and Priorities in Shark and Ray Conservation. *Current Biology*, *27*(11), R565–R572. https://doi.org/10.1016/j.cub.2017.04.038

Fadhilah, A., Susetya, I. E., & Simeon, B. M. (2019). Elasmobranch catch composition of North Sumatera Fishers. *IOP Conference Series: Earth and Environmental Science*, *260*(1), 0–7. https://doi.org/10.1088/1755-1315/260/1/012109

Falatehan, A. F. (2016). *Analytical Hierarchy Process (AHP): Teknik Pengambilan Keputusan untuk Pembangunan Daerah.* Yogyakarta: Indomedia Pustaka.

Fauzi, A. (2019). *Teknik Analisis Keberlanjutan.* Jakarta: Gramedia Pustaka Utama.

Godet, M. (1991). Actors' moves and strategies: The mactor method. An air transport case study. *Futures*, *23*(6), 605–622. https://doi.org/10.1016/0016-3287(91)90082-D

Ilham, & Marasabessy, I. (2021). Identifikasi Jenis dan Status Konservasi Ikan Pari yang Diperdagangkan Keluar Kota Sorong pada Loka Pengelolaan Sumberdaya Pesisir dan Laut Sorong Identification. *Jurnal Riset Perikanan Dan Kelautan*, *3*(1), 290–302. https://ejournal.um-sorong.ac.id/index.php/jrpk/article/view/1273/697

Jaya, I., Satria, F., Wudianto, Nugroho, D., Sadiyah, L., Buchary, E. A., White, A. T., Franklin, E. C., Courtney, C. A., Green, G., & Green, S. J. (2022). "Are the working principles of fisheries management at work in Indonesia?" *Marine Policy*, *140*(March), 105047. https://doi.org/10.1016/j.marpol.2022.105047

Karadeniz N. and Yenilmez Arpa, N. 2022. *Guidelines for engaging stakeholders in managing protected areas*. Ankara. FAO and MAF. https://doi.org/10.4060/cb8347en.

KKP (2021). *Keputusan Menteri Kelautan dan Perikanan Nomor 1 Tahun 2021 tentang Jenis Ikan yang Dilindungi*. Jakarta: KKP RI.

Kinakesti, S. M., & Wahyudewantoro, G. (2017). Kajian Jenis Ikan Pari (Dasyatidae) Di Indonesia. *Fauna Indonesia*, *16*(2), 17–25.

Kusumawardhani, H. A., Susilowati, I., & Hadiyanto. (2023). Vulnerable yet Viable: Stakeholders' Role in Small-Scale Fishermen Governance towards Viable Life. *WSEAS Transactions on Environment and Development*, *19*, 207–217. https://doi.org/10.37394/232015.2023.19.18

Muhammad, I., Indra, Y., & Hilda, Z. (2018). The Role of Science in the Management of Biodiversity: A Case of Stingrays (Dasyatidae) Research to Provide Basic Data for Aquatic Fauna Conservation in South Sumatra. *E3S Web of Conferences*, *68*, 4–9. https://doi.org/10.1051/e3sconf/20186804010

Prasetyo, A. P., McDevitt, A. D., Murray, J. M., Barry, J., Agung, F., Muttaqin, E., & Mariani, S. (2021). Shark and ray trade in and out of Indonesia: Addressing knowledge gaps on the path to sustainability. *Marine Policy*, *133*(July), 104714. https://doi.org/10.1016/j.marpol.2021.104714

Saaty, T. L. (1990). How to make a decision: The analytic hierarchy process. *European Journal of Operational Research*, *48*(1), 9–26. https://doi.org/10.1016/0377-2217(90)90057-I

Squires, G. (2012). Urban and environmental economics: An introduction. In *Urban and Environmental Economics: An Introduction*. https://doi.org/10.4324/9780203825990

Wijayanti, F., Abrari, M. P., & Fitriana, N. (2018). Keanekaragaman Spesies dan Status Konservasi Ikan Pari di Tempat Pelelangan Ikan Muara Angke Jakarta Utara. *Jurnal Biodjati*, *3*(1), 23–35. https://doi.org/10.15575/biodjati.v3i1.1613

Wijayanto, Y., Fauzi, A., Rustiadi, E., & Syartinili. (2022). Development of Sustainable Urban Railway Service Model Using Micmac-Mactor: A Case Study in Jabodetabek Mega-Region Indonesia. *International Journal of Sustainable Development and Planning*, *17*(1), 135–146. https://doi.org/10.18280/ijsdp.170113