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Dynamics and Conflict Potential on Fish Resource Utilization in the Sawu Sea National Park: A Case Study in Rote Ndao Regency, East Nusa Tenggara

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ABSTRACT

The Sawu Sea National Park (SSNP) is a critical marine conservation area that supports the sustainability of fish resources and the livelihoods of coastal communities in Rote Ndao Regency; however, there are indications of various socio-ecological dynamics in the use of fisheries resources. The objectives of this study are identify the spatial patterns and actors involved in fish resource utilization within the TSF sub-zone in Rote Ndao Regency, assess the ecological and social impacts of fishing activities, and formulate adaptive and participatory policy recommendations to support sustainable small-scale fisheries in marine conservation areas. A mixed-methods approach was applied, including a quantitative survey, in-depth interviews, field observations, and GIS-based spatial analysis. The findings reveal the presence of external fishers utilizing modern fishing gear within the TSF sub-zone, leading to increased exploitation pressure and rising conflict potential. Declines in CPUE, fish size, and the disappearance of particular species are early signs of overfishing. Overlapping fishing grounds among fleets exacerbate social tensions and threaten ecological sustainability. Strategic recommendations include enhanced monitoring, evidence-based adaptive zoning, participatory conflict resolution, habitat restoration, and incentives for eco-friendly fisheries. This study underscores the importance of participatory and collaborative governance approaches to sustain fish resources in conservation areas.

Keywords: small-scale fisheries, SSNP, adaptive zoning, fisher conflicts, sustainability

INTRODUCTION

Indonesia, as the world's largest archipelagic state, harbours exceptional marine biodiversity, making it a priority area for global marine biodiversity conservation efforts (KKP 2020; Salayan *et al*., 2024). Among Eastern Indonesia's critical marine conservation zones is the Sawu Sea National Park (SSNP), spanning 3.35 million hectares and encompassing vital habitats, including coral reefs, seagrass beds, and tropical pelagic waters. Beyond its ecological role, SSNP is a socio-economic pillar for coastal communities that predominantly rely on small-scale fisheries (Paulus *et al*., 2023).

Rote Ndao Regency is a strategic area within SSNP, where traditional fishing practices dominate coastal residents' livelihoods (Paulus *et al*., 2023; Turisno *et al*., 2024; Rahmadhan *et al*., 2024). Local fishers primarily use low-tech gear such as gillnets, handlines, bottom longlines, and lampara nets. According to SSNP's zoning plan, a significant portion of Rote Ndao's waters is designated as the Traditional Sustainable Fisheries (TSF) sub-zone, which is intended to ensure resource sustainability and safeguard local fishers' access rights.

However, utilization of this sub-zone is not exclusive to local communities. Fishers from outside the region—including those from Kupang City, Kupang Regency, Alor, and even other provinces such as West Nusa Tenggara and South Sulawesi—also exploit the area. These external actors employ more advanced fishing technologies, such as purse seines and diving compressors, which exert greater exploitation pressure and trigger horizontal conflicts with local fishers.

Warning signs such as declining catch per unit effort (CPUE), reduced fish sizes, and overfishing of high-value species like snapper (*Lutjanus* spp.) and grouper (*Epinephelus* spp.) have raised serious sustainability concerns (Suebpala, 2018). The overlap in fishing grounds between local and external fleets, coupled with weak compliance with conservation zoning regulations, undermines the effectiveness of current fisheries management systems (Castrejón *et al*., 2024; Oyanedel, 2021).

Previous studies have primarily focused on fish stock assessments and general conservation management but have yet to explore the specific socio-ecological dynamics in Rote Ndao, particularly concerning fisher migration, gear distribution, and potential user conflicts. Therefore, this study offers a location-based analysis to understand better the dynamics of fish resource use within the TSF sub-zone of SSNP.

The objectives of this study are to (1) identify the spatial patterns and actors involved in fish resource utilization within the TSF sub-zone in Rote Ndao Regency, (2) assess the ecological and social impacts of fishing activities, and (3) formulate adaptive and participatory policy recommendations to support sustainable small-scale fisheries in marine conservation areas.

MATERIAL AND METHOD

This study employed a mixed-methods approach to analyze the dynamics of fish resource utilization within the Traditional Sustainable Fisheries (TSF) sub-zone of the Sawu Sea National Park (SSNP), focusing on the Rote Ndao Regency (Lindkvist *et al*., 2022; Thurstan *et al*., 2020). An exploratory case study design was adopted to comprehensively capture the spatial, ecological, and socio-economic dimensions of small-scale fisheries (Ahedo *et al*. 2021; Ullah *et al*., 2023).

Time and Study Area

This research is based on results from 2017 research and is updated with data collected in 2023. The research was conducted along the coastal region of Rote Ndao Regency within SSNP. Site selection was based on the intensity of fishing activities and the representativeness of different local conditions. The selected villages included: a) Oelua, located in northwest Rote Island, representing areas with high fishing activity; b) Oeseli, located in the southwest, with moderate fishing intensity; and c) Sotimori, situated in the northeast, representing low-intensity fishing zones (Figure 1).

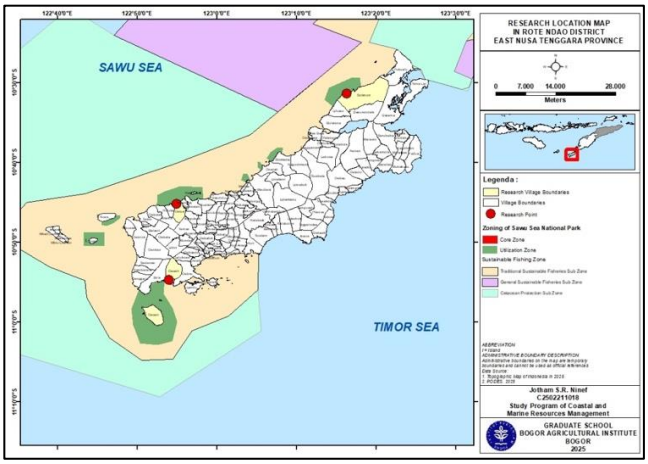

Figure 1. The location for data collecting in Rote Ndao Regency

Data Collection

Data collection involved both quantitative and qualitative methods:

- Quantitative surveys were conducted among fishers using structured questionnaires. A stratified random sampling approach was applied based on fishing gear type and fishers' origin.
- In-depth interviews were conducted with local and non-local fishers, SSNP managers, and community leaders to gather perceptions regarding resource utilization dynamics and conflict issues.
- Field observations were used to document fishing activities, types of gear used, and the condition of fish habitats and ecosystems.
- Secondary data were obtained from official Ministry of Marine Affairs and Fisheries documents, SSNP annual reports, and relevant scientific literature.

Data Analysis

An integrated analysis combined quantitative and qualitative dimensions:

- Survey data were analyzed using the Catch per Unit Effort (CPUE) indicator to evaluate fishing efficiency and exploitation pressure on fish stocks.
- Interview data were analyzed thematically to reveal patterns of social interaction, actor conflicts, and governance effectiveness.
- Spatial data from the GPS coordinates of fishing activities were processed in ArcGIS. The resulting maps illustrated fleet mobility, spatial use concentration, and operational overlaps between fishing groups.

RESULT AND DISCUSSION

Dynamics of Fish Resource Utilization

The Traditional Sustainable Fisheries (TSF) subzone within the Sawu Sea National Park (SSNP) was designated to secure local fishers' access and promote the sustainable use of marine resources. However, in practice, this subzone reveals complex utilization dynamics involving diverse external actors and significant shifts in spatial fishing patterns.

Four primary categories of fishers were identified in the TSF sub-zone (Figure 2):

a) Local fishers from coastal villages in Rote Ndao, located in the TSF zone,
b) Fishers from other sub-districts within Rote Ndao located outside the TSF zone,
c) Fishers from neighboring regions such as Alor, Kupang City, and Kupang Regency,
d) Fishers from other provinces, including West Nusa Tenggara and South Sulawesi.

External fishers typically use larger vessels and modern fishing gear such as *lampara* nets, trolling lines, bottom long lines, and diving compressors. In contrast, local fishers rely on traditional gear such as gillnets and handlines (He *et al*., 2021; Idris *et al*., 2022).

Fishing mobility patterns indicate that administrative boundaries do not constrain fishing activities (Dubik *et al.*, 2019; Havice, 2018). External fleets operate intensively across broader areas, including zones beyond conservation limits, resulting in unevenly distributed spatial pressure (Havice, 2018).

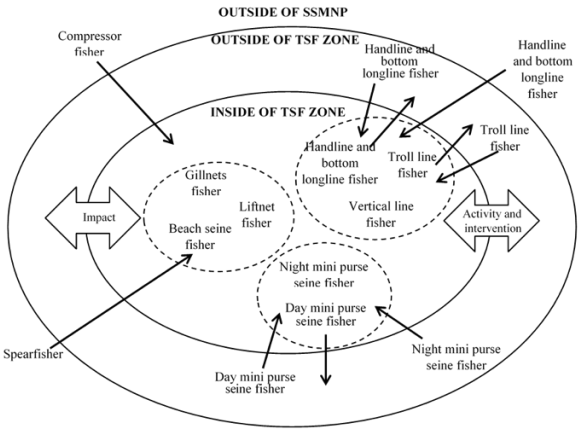

Figure 2. Dynamics of fish resource utilization in the TSF sub-zone of SSNP in Rote Ndao Regency

As shown in Figure 2, there is a clear overlap between the fishing grounds of local and non-local fishers, leading to spatial conflicts and increased pressure on marine ecosystems. Local fishers tend to fish within 1–2 nautical miles of the coast, while external fleets may reach areas around northern Timor Island and even near the Indonesia–Australia border. External actors' use of modern gear allows for higher catch volumes and accelerates the decline of fish stocks.

Figure 3 illustrates disparities in spatial reach and resource access. The presence of external fleets with higher fishing intensity has led to increased ecosystem stress. Indicators such as declining CPUE, reduced fish sizes, and the disappearance of high-value species (e.g., *Lutjanus* spp. and *Epinephelus* spp.) signal severe overfishing (Castagnino *et al*., 2023; Ulman *et al*., 2020). Weak compliance with zoning regulations and inadequate spatial monitoring further exacerbate the situation (Mwaura & Odera, 2021).

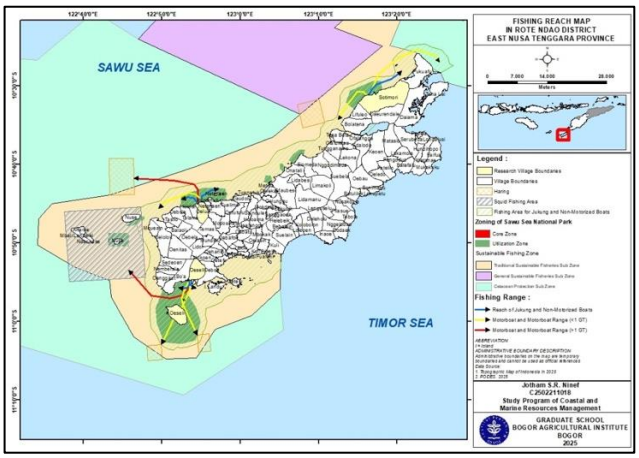

Figure 3. Spatial reach of small-scale fisheries in Rote Ndao Regency

These dynamics underscore the need for adaptive management approaches incorporating spatial data and local participation (Divsalar *et al*., 2024). Zoning systems must be redesigned based on actual usage patterns rather than static formal maps. Participatory approaches are essential to ensure zoning serves as an administrative tool and a responsive mechanism to real-time socio-ecological dynamics (Gourguet *et al*., 2021; Nugroho & Uehara, 2023).

Fisheries Utilization Networks and Governance Challenges

The fish resource utilization network in Rote Ndao Regency reflects a complex socio-economic and spatial configuration involving diverse actors and overlapping access to fishing grounds. This complexity illustrates interregional socio-economic linkages and a contested access and market control structure.

Three main categories of actors were identified:

a) Local fishers generally use traditional fishing gear, such as gillnets, handlines, *lampara* nets, and lift nets.
b) Fishers from other parts of Rote Ndao and neighboring regencies, such as Kupang, operating outside the TSF sub-zone;
c) Fishers from outside SSNP, including those from West Nusa Tenggara, South Sulawesi, and Alor, often use diving compressors, spears, and handlines.

Each group has differential access to fishing grounds and marketing chains, indicating a structural inequality in utilization. Local fishers sell their catch within Rote Ndao or transport it to Kupang by sea. In contrast, non-local fishers frequently export their catch directly to their home regions or process it in Rote Ndao before sending it as dried products to external markets.

The figure 4 illustrates a multipolar structure involving actors, fishing zones, and marketing flows. This network reveals economic and logistical flows that transcend administrative boundaries. Actors outside the region—equipped with capital, advanced fleets, and broader market access—enjoy greater benefits. Conversely, local fishers face logistical and technological limitations, making them economically vulnerable (Stacey *et al.*, 2021).

This pattern echoes trends across Southeast Asia, where integration with national and regional markets has enabled external actors to dominate local value chains. Small-scale fisheries thus face competition not only in ecological terms but also in the political-economic domain.

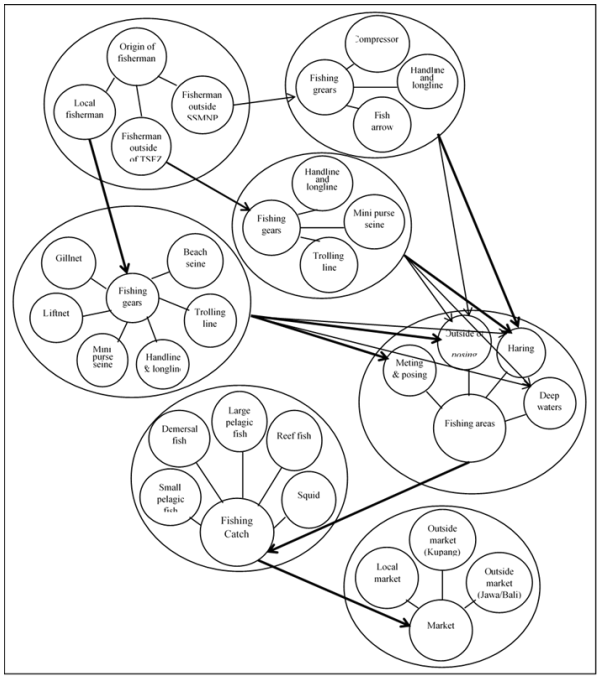

Figure 4. Fish resource utilization network in Rote Ndao Regency

The recommendation address to these inequalities, fisheries governance must extend beyond ecological zoning to incorporate economic justice. Recommended strategies include strengthening local fisher cooperatives, improving market access through infrastructure, increasing transparency in supply chains and pricing, and regulating inter-regional trade using functional zoning frameworks. (Lowitt *et al*. 2020) states that integrating small-scale fishers into community-based distribution systems can enhance income, marketing efficiency, and sustainability.

Conflict Potential in Fish Resource Utilization

The multi-actor use of the TSF sub-zone has given rise to several conflicts rooted in unequal access, technological disparities, and differing perceptions of resource rights. These conflicts threaten social cohesion and undermine the effectiveness of conservation and resource governance (Tuda *et al.*, 2019; Warren & Steenbergen, 2021).

Observations and interviews revealed three major conflict types:

a) Horizontal conflicts between local and external fishers (Chuenpagdee & Jentoft, 2018)
b) Conflicts between fishing gear technologies—traditional versus modern (Hu *et al*., 2021).

c) Conflicts between resource users and conservation managers regarding zoning legitimacy and access rights (Muhl & Sowman, 2020).

Technological inequality is a major driver. External fishers bring advanced gear, such as purse seines and diving compressors, while locals rely on simple, low-reach tools. This disparity fuels perceptions of spatial injustice, often escalating into open confrontation.

Figure 5 highlights overlapping fleet operations in critical areas such as *meeting* and *posing*, which are primary fishing hotspots. Discrepancies in perceived resource rights further exacerbate tensions. Some external fishers claim historical usage of the area before zoning enforcement, asserting legitimacy. In contrast, local communities perceive their presence as threatening traditional fishing space and sustainability.

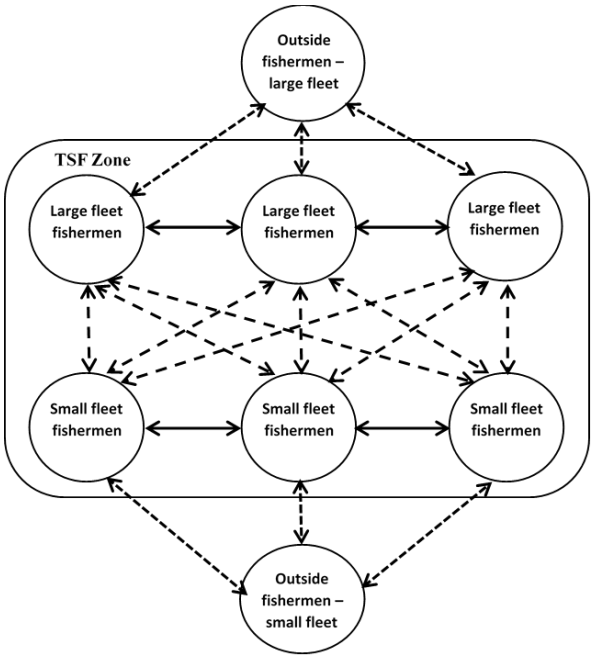

Figure 5. Conflict potential among fishers in the TSF sub-zone based on actor type and fleet

Similar patterns have been observed in the Banda Sea and Lembeh Strait, where limited community participation in conservation zoning triggered resistance. These tensions are exacerbated by weak trust in management authorities and a lack of formal, inclusive mechanisms for conflict resolution.

Ecological conflicts are also prevalent. Destructive fishing methods, such as diving compressors and bottom trawls, damage key habitats, including coral reefs and seagrass beds—critical spawning areas. Such degradation directly reduces catch yields for local fishers and worsens their economic conditions.

Recent studies indicate that habitat loss due to spatial conflict can reduce fishery productivity by up to 40% within a decade. Similar ecological disputes have been reported in marine protected areas in the Philippines and Tanzania.

Currently, conflict resolution in SSNP is informal and ad hoc. No formal, cross-community mechanism exists to address the diverging interests. Dialogue platforms involving local and external fishers and conservation authorities have yet to be systematically established. Conflict resolution thus remains dependent on personal networks or informal leaders.

This institutional vacuum risks escalating conflicts as resource pressures grow. Successful marine conservation governance depends on building institutional legitimacy and facilitating conflict mediation. Best practices from other conservation areas show that community-based mediation and participatory spatial planning can reduce conflict and improve compliance.

CONCLUSION

1. The utilization of fisheries resources in the Traditional Sustainable Fisheries (TSF) subzone of the SSMNP exhibits complex socio-spatial dynamics involving local fishermen within the TSF subzone, fishermen from outside the TSF subzone, and fishermen from outside the SSMNP.
2. Fishing activities result in unequal access, increased exploitation intensity, and weak monitoring, contributing to excessive pressure on fish stocks and critical habitats.
3. Sustainable small-scale fisheries management must integrate ecological zoning with considerations of spatial and social equity involving communities, data-based monitoring, and institutional strengthening.

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REFERENCES

Ahedo V, Zurro D, Caro J, Galán JM. 2021. Let us go fishing: A quantitative analysis of subsistence choices with a special focus on mixed economies among small-scale societies. *PLoS One*. 16(8) e0254539. https://doi.org/10.1371/journal.pone.0254539

Castagnino F, Estévez RA, Caillaux M, Velez-Zuazo X, Gelcich S. 2023. Local ecological knowledge (LEK) suggests that overfishing and sequential depletion of Peruvian coastal groundfish are occurring. *Marine and Coastal Fisheries*. *15*(6): e210272. https://doi.org/10.1002/mcf2.10272

Castrejón M, Moity N, Charles A. 2024. The bumpy road to conservation: Challenges and opportunities in updating the Galapagos zoning system. *Marine Policy*: 163: 106146. https://doi.i org/10.1016/j.marpol.2024.106146

Chuenpagdee R, Jentoft S. 2018. Transforming the governance of small-scale fisheries. *Maritime studies.* 17(1): 101–115. http://dx.doi.org/10.1016/j.repbre.2021.03.003

Divsalar A, Mousavi SJ, Emami F. 2024. Exploring Adaptive Management Techniques in Coastal Resource Conservation. *Journal of Resource Management and Decision Engineering* 3(1), 11–18. https://doi.org/10.61838/kman.jrmde.3.1.3

Dubik BA, Clark EC, Young T, Zigler SBJ, Provost MM, Pinsky ML, Martin KS. 201). Governing fisheries in the face of change: Social responses to long-term geographic shifts in a US fishery. *Marine Policy*. 99: 243–251. https://doi.org/10.1016/j.marpol.2018.10.032

Gourguet S, Marzloff MP, Bacher C, Boudry P, Cugier P, Dambacher JM, ... , Thébaud O. 2021. Participatory qualitative modeling to assess the sustainability of a coastal socio-ecological system. *Frontiers in Ecology and Evolution*. 9: 635857. http://dx.doi.org/10.3389/fevo.2021.635857

Havice E. 2018. Unsettled sovereignty and the sea: Mobilities and more-than-territorial configurations of state power. *Annals of the American Association of Geographers.* 108(5), 1280–1297. https://doi.org/10.1080/24694452.2018.1446820

He P, Chopin F, Suuronen P, Ferro RS, Lansley J. 2021. Classification and illustrated definition of fishing gears. *FAO Fisheries and Aquaculture technical paper*. (672): I-94. https://doi.org/10.4060/cb4966en

Hu F, Zhong H, Wu C, Wang S, Guo Z, Tao M, ..., Liu S. 2021. Development of fisheries in China. *Reproduction and Breeding*, 1(1): 64–79. http://dx.doi.org/10.1016/j.repbre.2021.03.003

Idris U, Frank SAK, Muttaqin MZ. 2021. Traditional fishing technology of the fishermen's community in Papua. *ETNOSIA: Jurnal Etnografi Indonesia*. *6*(1): 125–135. https://doi.org/10.31947/etnosia.v6i1.13981

[KKP] Kementerian Kelautan dan Perikanan. 2020. *Laporan Tahunan Perikanan di Taman Nasional Perairan Laut Sawu*. Jakarta: Direktorat Jenderal Pengelolaan Ruang Laut. KKP RI Jakarta.

Lindkvist E, Pellowe KE, Alexander SM, Drury O'Neill E, Finkbeiner EM, Girón-Nava A, ..., Glaser M. 2022. Untangling social–ecological interactions: A methods portfolio approach to tackling contemporary sustainability challenges in fisheries. *Fish and Fisheries*. *23*(5): 1202–1220. https://doi.org/10.1111/faf.12678

Lowitt K, Levkoe CZ, Spring A, Turlo C, Williams PL, Bird S, ..., Simba M. 2020. Empowering small-scale, community-based fisheries through a food systems framework. *Marine Policy*. 120: 104150. https://doi.org/10.1016/j.marpol.2020.104150

Muhl EK, Sowman M. 2020. Rights, resources, rezoning, and the challenges of governance in South Africa's oldest marine protected area. *Conservation and Society*. *18*(4): 366–377. https://www.jstor.org/stable/26937303

Mwaura OK, Odera PA. 2021. Monitoring spatio-temporal compliance of urban development plans using GIS and remote sensing in Nairobi City County, Kenya. *Ghana Journal of Geography*. 13(3). https://dx.doi.org/10.4314/gjg.v13i3.4

Nugroho S, Uehara T. 2023. Systematic review of agent-based and system dynamics models for social-ecological system case studies. *Systems*. 11(11): 530. https://doi.org/10.3390/systems11110530

Oyanedel R. 2021. Tackling small-scale fisheries non-compliance [Dissertation]. University of Oxford.

Paulus CA, Fauzi A, Adar D. 2023. Analyzing Community Perception of Protected Areas to Mitigate Environmental Risks Using Qualitative Comparative Analysis Effectively: The Case of Savu Sea National Marine Park, East Nusa Tenggara, Indonesia. *Sustainability*. 15(23): 16498. https://doi.org/10.3390/su152316498

Ramadhan A, Oktavia P, Miftakhul H, Pramoda R, Apriliani T, Suardi I, ..., Eko NA. 2024. Integrating local knowledge for an inclusive blue economy: the opportunities and challenges of institutional bricolage. *Australian Journal of Maritime & Ocean Affairs*. 17(3): 448-467. https://doi.org/10.1080/18366503.2024.2350790

Salayan LM, Wulandari H, Huda MK. 2024. Peran ekosistem laut dalam konservasi keanekaragaman hayati di Indonesia. *Journal of Natural Sciences.* 5(3): 234-244. https://doi.org/10.34007/jonas.v5i3.717

Stacey N, Gibson E, Loneragan NR, Warren C, Wiryawan B, Adhuri DS, Steebergen DJ, Fitriana R. 2021. *Developing sustainable small-scale fisheries livelihoods in Indonesia: A review of current approaches and opportunities*. Marine Policy. 132:104654. https://doi.org/10.1016/j.marpol.2021.104654

Suebpala W. 2018. Ecological impacts of fishing gears in Ko Chang, Trat Province, Thailand. https://doi.org/10.58837/CHULA.THE.2018.230

Thurstan RH, Diggles BK, Gillies CL, Strong MK, Kerkhove R, Buckley SM, ..., McLeod I. 2020. Charting two centuries of transformation in a coastal social-ecological system: A mixed methods approach. *Global Environmental Change*. 61: 102058. http://dx.doi.org/10.1016/j.gloenvcha.2020.102058

Tuda AO, Kark S, Newton A. 2019. Exploring the prospects for adaptive governance in marine transboundary conservation in East Africa. *Marine Policy*. 104: 75-84. https://doi.org/10.1016/j.marpol.2019.02.051

Turisno BE, Mahmudah S, Dewi IGA. (2024). Zoning in Sabu Raijua Regency, East Nusa Tenggara Province, Indonesia, in Maintaining Coral Reef Ecosystem Conservation and Sustainable Coastal Management. *Contemp. Readings L. & Soc. Just.* 16: 1010.

Ullah H, Wahab MA, Rahman MJ, Al Mamun SN, Kumar U, Rahman MA, ..., Chishty SMSUH. 2023. Local ecological knowledge can support improved management of small-scale fisheries in the Bay of Bengal. *Frontiers in Marine Science*. 10: 974591. https://doi.org/10.3389/fmars.2023.974591

Ulman A, Zengin M, Demirel N, Pauly D. (2020). The lost fish of Turkey: A recent history of disappeared species and commercial fishery extinctions for the Turkish Marmara and Black Seas. *Frontiers in Marine Science*. 7: 650. https://doi.org/10.3389/fmars.2020.00650

Warren C, Steenbergen DJ. (2021). Fisheries decline, local livelihoods, and conflicted governance: An Indonesian case. *Ocean & Coastal Management*. 202: 105498. https://doi.org/10.1016/j.ocecoaman.2020.105498