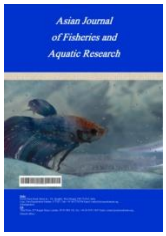

Asian Journal of Fisheries and Aquatic Research

18(1): 30-36, 2022; Article no.AJFAR.88524
ISSN: 2582-3760

Fisheries as Common-Pool Resources, Its Management and Impact on Fishing Ecosystem in Indonesia: A Mini-Review

Gifarri Azanna Yudawan [a*], Ajya Khayrruraja [a], Azahra Islamiati [a] and Achmad Rizal [a]

[a] *Department of Fisheries, Faculty of Fisheries and Marine Sciences, Padjadjaran University, Bandung, Indonesia.*

Authors' contributions

This work was carried out in collaboration among all authors. All authors read and approved the final manuscript.

Article Information

DOI: 10.9734/AJFAR/2022/v18i130430

Open Peer Review History:
This journal follows the Advanced Open Peer Review policy. Identity of the Reviewers, Editor(s) and additional Reviewers, peer review comments, different versions of the manuscript, comments of the editors, etc are available here: https://www.sdiarticle5.com/review-history/88524

Mini-review Article

Received 15 April 2022
Accepted 27 June 2022
Published 29 June 2022

ABSTRACT

Fisheries as a common-pool resource (CPR) provides a classic case of open access dilemma: competition for yields is often fierce and the absence of access management could lead to conflicts. Availability, quality, and diversity of fishery resources in sufficient quantities are the foundation of fisheries management for present and future generations. Indonesia's governing body, or more broadly, the governance, should be the moving force in producing policy outcomes involving coordination of conservation efforts to regulate extractive uses of natural resources. This paper briefly reviews the Indonesian fisheries policy as a CPR, its indicators, and its implication for the local fishing ecosystem.

Keywords: CPUE; CPR; ecosystem; fisheries; governance; management.

1. INTRODUCTION

Property right's structure has been defined as one of the most important factors affecting efficiency of economic development. For common-pool resources (CPR), where yields are partially excludable and competition is fierce, the absence of controls over access could lead to

**Corresponding author: Email: gifarri19001@mail.unpad.ac.id;*

conflicts. Fisheries provides a classic case of open access dilemma [1], where market failures could arise because agents inabilities to prevent rent dissipation [2]. Most recent studies emphasized the capacity of local organizations to manage CPR through collective action. Though it glosses over the fact that many CPR systems are often jointly managed, there is thought to be an established dichotomy between local organizations and a hierarchical, centralized state [3]. Another alternative is to implement the "privatization of the commons" [4] or the creation of individual private property rights for common-pool resources though in comes down to each country's economic ideologies.

Quality, diversity and availability of fishery resources should be maintained in sufficient quantities; as to sustains the Commons [5,6]. The most often sought associated fisheries management goals includes the impact of fishing on the component of ecosystem and tries to courage other activities to protect the sustainability of catch and the ecosystem [7,8]. Depending on the conducted fishing activities, whether its scale small or large, debates over managing common resources often constitute varying design and implementation.

There are several basic principles in approaching fisheries management, including but not limited to:

a) Assessing fisheries impact to ecosystems and its marginal toleration;
b) Conserving ecological interaction between resources and its environment;
c) Governing suitable catch tools for all kind of fish;
d) Implementing and evaluation of decision, and
e) Assuring balance of human needs and ecosystem.

To achieve these goals, diverse actions are needed. Spatial management, for example, is used to regulate natural resources exploitation by most countries [9]. Indonesian Government has subdivided their fishing grounds into several fisheries management areas (FMAs) pictured below:

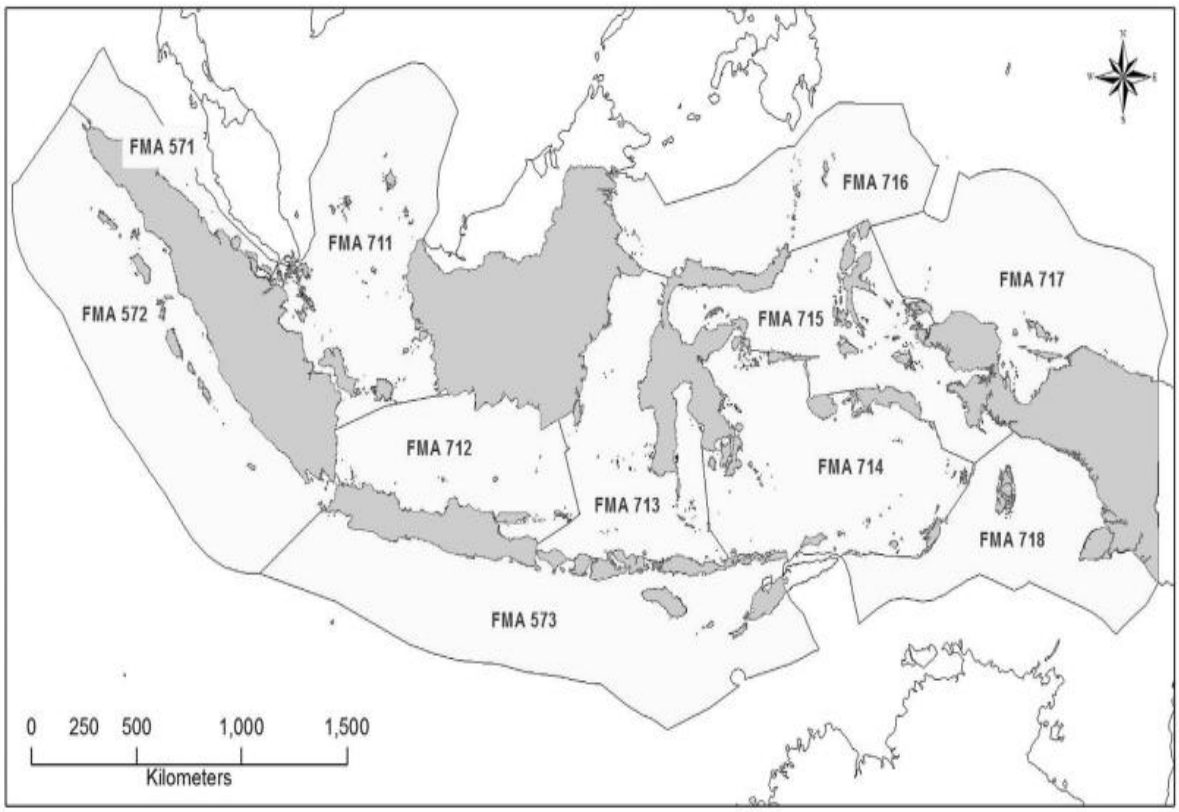

Fig. 1. Indonesian FMAs [10]

A number of species-based and area-based fisheries management have been planned, developed, and implemented in Indonesia in a continued effort to sustains its fisheries sector. This paper provides a quick review and insight on Indonesian policy on fisheries as CPR, its indicators, and its implication on local fishing ecosystem.

2. FISHING INDICATORS

Indicators is an index to measure a current condition of a selected component as a guide to achieve control-based management. There are mainly three aspects of fisheries that directly relates to a fishing ecosystem: first, gear impact on habitats; second, mortality caused by bycatches; and third, indirect trophic impact because of the altered abundance of targeted and bycatch species. Therefore, identifying relevant indicators and references is an critical aspect to gauge fisheries activities impact on environmental scale [11,12].

2.1 Catch per Unit of Effort (CPUE) as Indicator

The Catch per Unit of Effort (CPUE) has been standardized among biologists as a test to determine developments in fish stocks. It is also used in economic-focused studies to estimate the efficiency of a fishing operation. Fishing gear productivity is defined as catches with a unit weight per catching effort, where the catching effort here can be either a fishing gear or a trip [13]. High productivity is of course the main objective of capture, though ecosystem aspects is the other significant concern as high catch most often means more fish stocks is depleted [14]. It is known through assessment of the level selectivity-based environmental friendliness is derived from three indicators namely:

a. The proportion of the main catches on the by catch [15];
b. The proportion of the size of the catch [16]; and
c. The proportion of the use of discard (catches wasted) [17].

A simple fishery model in which the catch can be defined as:

$$C = f\ q\ B \quad (1)$$

In which:

C = Catch
f = effort
q = catchability coefficient
B = stock biomass

Catch can be defined as numbers of fish caught or in the yield by weight. Effort is defined as time spent at sea fishing with a particular gear. Therefore, the catch per unit of fishing effort (CPUE) in its basic form is defined as the total catch divided by the total fishing effort in a given period, or:

$$CPUE = C/f \quad (2)$$

In which:

CPUE = Catch per unit effort

Fisheries management in Indonesia is often determined statistically by calculating a MSY (Maximum Sustainable Yield) of its surrounding water following the concept of Schaefer model [18] (ex: [19]), based on a data analysis of annual catch (C) and effort (f). If the correlation of catch and effort is negative, Schaefer curve can be used as a reference point to estimate the MSY and estimate fishing stocks in Indonesian water. An accompanying surplus model, MEY (Maximum Economic Yield) is often used to determine the economic efficiency to decide profitability of fishing stocks exploitation.

2.2 Size Selectivity as Indicator

Size is an important parameter governing biological and ecological processes in marine ecosystem [20]. Ecological interest for all types of communities also uses size distribution as an important topic related to information on community metabolism. Size of organisms is the main parameters for predator-prey interaction [21], in which the larger ones will prey the smaller fish depending on its mouth opening.

$$\text{Main Catch Proportion (\%)} = \frac{Amount\ of\ Main\ Catching}{Catch\ Total} \times 100\%$$

$$\text{By-catch Proportion (\%)} = \frac{Amount\ of\ By-catching}{Catch\ Total} \times 100\%$$

There are several methods for using fish size parameter in fisheries management purposes, such as size-selectivity and biomass-size spectrum [22,23]. Comprehensive information about size-selectivity of common commercial

fishing gears is crucial to fisheries management to maximize yield and protect juvenile fish [24]. Fishing gears may be used as tools to monitor length distribution of the stock catches.

3. GOVERNANCE AND ITS ACTORS

The debate about the importance of regulating natural resources, including the sea as a CPR is related to governance issues. It spans regulation related to socio-economic, political, and bureaucratic systems. Governance is defined as the involvement of a wide range of institutions and actors in the production of policy outcomes involving coordination through networks and partnerships. It refers to formal and informal rules, as well as traditions that apply in society. Governance is a force that "…steers human behavior through combinations of civil society, state, and market incentives to achieve strategic objectives".

CPR as a whole system is extremely complex. One of the easier to illustrate governance model is specifying an actor and their roles in maintaining the system. Table 1 illustrate fisheries actors and their role in maintaining CPR [25,26].

As stated previously, fisheries as a natural common-pool resource makes it difficult to prevent other parties from entering the territory of a waters (standard exceptions) and there is high competition in utilizing the same natural resources (high subtract-ability) [16,17]. Its utilization tends to be open access which results in a decrease in total production. Several management models have been developed for the management of resource use so that it is economically and ecologically sustainable. The existence of a complex system like CPR raises attention to the properties of social and ecological systems that are not included in top-down decision making, such as self-organization, cross-scale dynamics and feedback, multiple domains of attraction, as well as exposure to external influences, uncertainties, and changes in social and ecological systems that affect the resilience of these system. An integrated, more systematic assessment is needed to regulate, accounting for country-specific governance indicators [27].

Indonesian government has declared the intention to establish a more expansive marine protected area (MPA) network to sustains its open-access regime [28]. The number of marine reserves covers almost 16 million hectares in 2013, and is projected to be able to cover 20 million hectares by 2020. The extension of its marine conservation network provides an opportunity to recover from overexploited fisheries resources. However, there still the need to create a governance system that enables Indonesian local fishers to capture the spill-over benefits created by protected areas. Without a proper fisheries management, exhausting fisheries sector as a CPR may not yield a profitable result, let alone sustainable.

Table 1. Fisheries actors and their roles in maintaining CPR

Actors	Roles
Local Fishermen	The Local fishermen have duties and authorities in costal fisheries users, and participating in monitoring and enforcement the rules
Local Government	Local Government has duties and authorities in making formal regulation, dividing the coastal area, technical assistance, coordinating with other local governments, and continuous monitoring
National Government	National Government has duties and authorities in providing funds and supporting technical assistance, and monitoring the implementation of policies
University/Schools	Learning institution has duties and authorities in guidance and academical training
Local Communities	The locals have duties and authorities in examining and reporting fisheries activities in coastal area

4. FISHERIES AS A CPR AND ITS IMPACT

Open access system often leads to excessive use of marine resources, such as over-fishing [29,30]. In Indonesia, in addition to the problem of meeting the needs of marine resources, various environmental problems such as damage to coastal ecosystems [31,32] (coral reefs, mangrove forests, and estuaries), the aforementioned over-fishing; often associated with unregulated and illegal fishing [33], as well as pollution [34]. The over-exploitation of fish stocks that threatens the Indonesian fisheries sector represents one facet of governance failure in this industry. Nonetheless this is a critical issue for the future and such concerns need to be formally addressed.

Other external challenges that also need attention are global climate change and its impacts [35], such as rising water levels, rising ocean temperatures, acidification, increased extreme climate events [36], and so on. Globally, damage to the marine environment due to unsustainable use of marine resources is increasingly widespread due to its inherent vulnerabilities. “Vulnerability” in this context can be described by its three constituting elements as follows [37]:

- Exposure: the probability occurrence of a hazard;
- Sensitivity: the measure of susceptibility of the hazard;
- Adaptive capacity: the ability to cope with the hazard and its consequences.

In relation to this trend, the results of the Millennium Ecosystem Assessment on the condition of marine ecosystems in the last 25 years conclude that most of the environmental services originating from coastal and marine ecosystems are in a damaged condition and are used unsustainably, thus experiencing a faster quality decline compared to other ecosystems [38]. This report was written to describe the situation of marine ecosystems in 2009, yet it is still relevant today as continued unsustainable and destructive [39] fishing activities has been proven time and time again to harm the ecosystem severely. Implementing an ecosystem-based management in the fisheries sector is important to avoid a substantial decrease in the quality of marine biodiversity and the negative consequences that will arise as a result of this decline in quality on coastal countries. These includes the need to: (i) specify method or gear of fishing activities; (ii) specify aquaculture and catching activities; (iii) prevent destructive activities that could affect the ecosystem; and (iv) rehabilitate natural resources and its ecosystems.

A report by International Program on the State of the Oceans warns that there is a systematic decline in the health of marine ecosystems due to various stressor that results in habitat loss due to coastal development, influx of species. invasive aliens into a marine ecosystem, as well as climate change; and that without significant changes in policies of per using fisheries as a CPR, the harming of the fishing ecosystem will cause consequences that will be felt not only locally, but also by communities around the world [40].

5. CONCLUSION

Fisheries as a natural common-pool resource raises a complex issue because of its open-access nature, especially regarding its impact to a country’s marine ecosystem. An integrated, more systematic assessment accounting for country-specific governance indicators per using resulting data such as CPUE could be used as a way for the governing body to regulate better. If regulations and management are not carried out, fisheries sector will experience losses in the open-access regime. Ideally, the highest profit is accompanied with efficient fishing efforts. Fisheries management aids in determining the number of allowable catches and regulating the size of fish that can be caught so that resources are preserved to be used in the future as a sustainable benefit. Establishing an expansive marine protected area (MPA) and fisheries management area (FMA) network is a small step in a long process needed to be taken to avoid decrease in natural resources and sustains the open-access regime of fisheries as a CPR.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

REFERENCES

1. Salafsky N, Margoluis R, Redford K. Adaptive management. A Tool Conserv Pract DC Biodivers Support Program; 2001.
2. Homans FR, Wilen JE. Markets and rent dissipation in regulated open access

fisheries. J Environ Econ Manage. 2005; 49:381–404.
3. Hess C, Ostrom E. Ideas, artifacts, and facilities: information as a common-pool resource. Law Contemp Probl. 2003;66: 111–45.
4. Carothers C, Chambers C. Fisheries privatization and the remaking of fishery systems. Environ Soc. 2012;3:39–59.
5. Ostrom E. The challenge of common-pool resources. Environ Sci Policy Sustain Dev. 2008;50:8–21.
6. Rizal A, Herawati H, Zidni I, Apriliani IM, Ismail MR. The role of marine sector optimization strategy in the stabilisation of Indonesian economy. World Sci News. 2018;102:146–57.
7. Virapongse A, Endress BA, Gilmore MP, Horn C, Romulo C. Ecology, livelihoods, and management of the Mauritia flexuosa palm in South America. Glob Ecol Conserv. 2017;10:70–92.
8. Anna Z, Suryana AAH, Maulina I, Rizal A, Hindayani P. Biological parameters of fish stock estimation in Cirata Reservoir (West Java, Indonesia): A comparative analysis of bio-economic models. Biodiversitas J Biol Divers. 2017;18:1468–74.
9. Douvere F. The importance of marine spatial planning in advancing ecosystem-based sea use management. Mar Policy. 2008;32:762–71.
10. Muawanah U, Yusuf G, Adrianto L, Kalther J, Pomeroy R, Abdullah H, et al. Review of national laws and regulation in Indonesia in relation to an ecosystem approach to fisheries management. Mar Policy. 2018; 91:150–60.
11. Moldan B, Janoušková S, Hák T. How to understand and measure environmental sustainability: Indicators and targets. Ecol Indic. 2012;17:4–13.
12. Kusumartono FXH, Rizal A. An integrated assessment of vulnerability to water scarcity measurement in small islands of Indonesia. World News Nat Sci. 2019;24.
13. Maunder MN, Punt AE. Standardizing catch and effort data: a review of recent approaches. Fish Res. 2004;70:141–59.
14. Hauge KH, Cleeland B, Wilson DC. Fisheries depletion and collapse. IRGC Rep “Risk Gov Deficits An Anal Illus Most Common Deficits Risk Governance” Int Risk Gov Counc Chemin Balexert. 2009;9:21.
15. Apriliani IM, Rizal A, Hamdani H, Denika A. Catch of Skipjack Tuna (*Euthynnus* sp.) in National Fisheries Port Pengambengan, Bali, Indonesia. World Sci News. 2019; 120:144–53.
16. Dewanti LP, Rahmahningrum SF, Rizal A, Khan A, Rostika R. Length catch and growth analysis of hairtail fish (*Trichiurus* spp.) in southern off West Java Sea (Case study: Pangandaran fishing base). Int J Fish Aquat Res. 2019; 4:13–6.
17. Solomon OO, Ahmed OO. Fishing with light: Ecological consequences for coastal habitats. Int J Fish Aquat Stud. 2016;4: 474–83.
18. Schaefer MB. Some aspects of the dynamics of populations important to the management of the commercial marine fisheries; 1954.
19. Rizal A, Apriliani IM. Assessment the impact of fiscal and monetary policy on West Java Province of Indonesia: a Computable General Equilibrium analysis. World Sci News. 2020;150:162–81.
20. Ahmad F, Dewanti LP, Arnenda GL, Rizal A. Length-weight relationship and catch size of bigeye tuna (*Thunnus obesus*) landed in Benoa, Bali, Indonesia. World News Nat Sci. 2019;23:34–42.
21. Hunsicker ME, Ciannelli L, Bailey KM, Buckel JA, Wilson White J, Link JS, et al. Functional responses and scaling in predator–prey interactions of marine fishes: contemporary issues and emerging concepts. Ecol Lett. 2011;14:1288–99.
22. Blanchard JL, Andersen KH, Scott F, Hintzen NT, Piet G, Jennings S. Evaluating targets and trade-offs among fisheries and conservation objectives using a multispecies size spectrum model. J Appl Ecol. 2014;51:612–22.
23. Sprules WG, Barth LE. Surfing the biomass size spectrum: some remarks on history, theory, and application. Can J Fish Aquat Sci. 2016;73:477–95.
24. Carvalho PG, Humphries A. Gear restrictions create conservation and fisheries trade-offs for management. Fish Fish. 2022;23:183–94.
25. De Moor T. From common pastures to global commons: A historical perspective on interdisciplinary approaches to commons. Natures Sci Sociétés. 2011;19: 422–31.
26. Ayunda N, Anna Z. Evaluasi awik-awik pengelolaan sumber daya perikanan pantai lombok timur. J Kebijak Sos Ekon Kelaut Dan Perikan. 2015;5:47–57.

27. Fabinyi M, Barclay K. Fisheries Governance. Asia-Pacific Fish. Livelihoods, Springer. 2022;65–90.
28. Adhuri DS, Rachmawati L, Sofyanto H, Hamilton-Hart N. Green market for small people: Markets and opportunities for upgrading in small-scale fisheries in Indonesia. Mar Policy. 2016;63:198–205.
29. Arthur RI. Small-scale fisheries management and the problem of open access. Mar Policy. 2020;115:103867.
30. Cabral RB, Halpern BS, Lester SE, White C, Gaines SD, Costello C. Designing MPAs for food security in open-access fisheries. Sci Rep. 2019;9:1–10.
31. Ferse SCA, Knittweis L, Krause G, Maddusila A, Glaser M. Livelihoods of ornamental coral fishermen in South Sulawesi/Indonesia: implications for management. Coast Manag. 2012;40:525–55.
32. Rizal A, Akbarsyah N, Kdyp P, Permana R, Andhikawati A. Molecular diversity of the bacterial community associated with Acropora digitifera (Dana, 1846) corals on Rancabuaya coastline, Garut District, Indonesia. World Sci News. 2020;144: 384–96.
33. Muawanah U, Pomeroy RS, Marlessy C. Revisiting fish wars: Conflict and collaboration over fisheries in Indonesia. Coast Manag. 2012;40:279–88.
34. Rizal A, Nurruhwati I. Analysis of the effect of city growth on The development of hinterland region In Cianjur Regency. World Sci News. 2019;115:260–8.
35. Rizal A, Anna Z. Climate change and its possible food security implications toward Indonesian marine and fisheries. World News Nat Sci. 2019;22:119–28.
36. Heryati H, Pranowo WS, Purba NP, Rizal A, Yuliadi LP. Java Sea Surface Temperature Variability during ENSO 1997–1998 and 2014–2015. Omni-Akuatika. 2018;14:96–107.
37. Weißhuhn P, Müller F, Wiggering H. Ecosystem vulnerability review: proposal of an interdisciplinary ecosystem assessment approach. Environ Manage. 2018;61:904–15.
38. Lee M, Diop S. Millennium ecosystem assessment. An Assess Assessments Find Gr Expert Purs to UNGA Resolut 60/30. 2009;1:361.
39. Bailey M, Sumaila UR. Destructive fishing and fisheries enforcement in eastern Indonesia. Mar Ecol Prog Ser. 2015;530: 195–211.
40. Merino G, Barange M, Blanchard JL, Harle J, Holmes R, Allen I, et al. Can marine fisheries and aquaculture meet fish demand from a growing human population in a changing climate? Glob Environ Chang. 2012;22:795–806.

Peer-review history:
The peer review history for this paper can be accessed here:
https://www.sdiarticle5.com/review-history/88524