Minireview Article

FISHERIES AS COMMON-POOL RESOURCES, ITS MANAGEMENT AND IMPACT ON FISHING ECOSYSTEM IN INDONESIA: A MINI-REVIEW

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ABSTRACT

Fisheries as a common-pool resource (CPR) provides the classic case of open access dilemma. Competition for yields is often fierce, and the absence of controls over access could lead to conflicts. In fisheries management, quality, diversity, and availability of fishery resources should be maintained in sufficient quantities 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 CPR, its indicators, and its implication for the local fishing ecosystem.

Keywords: CPUE; CPR; Ecosystem; Fisheries; Governance; Management

1. INTRODUCTION

The structure of property rights has long been considered one of the most important factors affecting economic development and efficiency. For common-pool resources (CPR), where yields are partially excludable and competition is fierce, the absence of controls over access often leads to conflicts. Fisheries provide the classic case of open access dilemma[1][2], where market failures arise, in part, because agents are unable to prevent rent dissipation [3]. A growing body of research has emphasized the capacity of local organizations to manage CPR through collective action. There is often an implied dichotomy between local organizations and a hierarchical, centralized state, though these glosses over the fact that many common-pool resource systems are most often jointly managed [4]. Another alternative is to implement the "privatization of the commons"[5] or the creation of individual private property rights for common-pool resources though in comes down to each country's economic ideologies.

In fisheries management, quality, diversity and availability of fishery resources should be maintained in sufficient quantities for present and future generations; as to sustains the Commons [6][7]. 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[8,9]. Depending on the fishing activities conducted, large or small-scale, consensus on managing the resource often carries varying design and implementation. There are several basic principles in approaching fisheries management, including but not limited to, by assessing:

a) The impact of fisheries is limited to the marginal of ecosystem toleration;
b) The protection of ecological interaction between resources and its environment;
c) The compatibility of management tools for all kind of fish;
d) The cautiousness in decision making process, and

e) The assurance of balancing human needs and ecosystem.

Conservation goals are achieved through diverse efforts, including spatial management to regulate extractive uses of natural resources [10]. Indonesia has subdivided their fishing grounds into several fisheries management areas (FMAs).

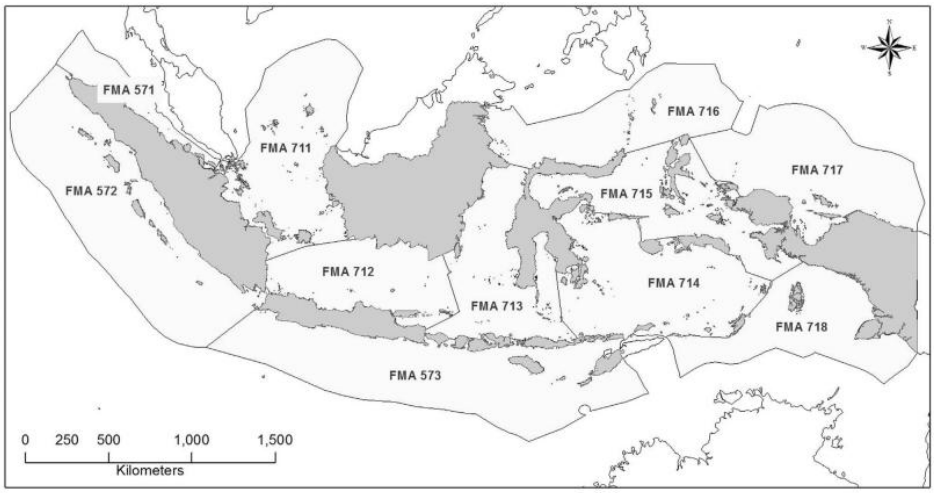

Fig. 1. Indonesian FMAs[11]

Several area-based and species-based fisheries management have been planned and developed. 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 a variable, pointer, or index to measure the current condition of a selected component as a guide to achieve control-based management. There are mainly three aspects of fisheries on ecosystems: gear impact on habitats, mortality because of bycatches of other marine organisms, and indirect trophic impact because of the altered abundance of targeted and bycatch species. Therefore, it is needed to identify the relevant indicators and references points marking a target, limit or threshold to gauge fisheries activities impact on environmental scale [12][13].

2.1 CATCH PER UNIT OF EFFORT (CPUE) AS INDICATOR

The Catch per Unit of Effort (CPUE) has been a standard test among biologists 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 [14]. 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 [15]. 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[16];
b. the proportion of the size of the catch[17]; and
c. the proportion of the use of discard (catches wasted)[18].

For example, a simple fishery model in which the realized catch can be defined as:

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

In which:
C = Catch
f = effort
q = catchability coefficient
B = stock biomass1

Catch can be measured in numbers of fish caught or in the yield by weight. Effort can be measured in for example size of the fleet, or time spent at sea fishing with a particular gear. Using (1) the catch per unit of fishing effort (CPUE) in its basic form can be defined as the total catch divided by the total fishing effort in a given period, or in formula 2.

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

In which:
U = Catch per unit effort

Indonesian fisheries management is often determined by its maximum sustainable yield (MSY) following the concept of Schaefer model [19] (ex: [20]), which is based on an analysis of annual catch and effort data. As long as the correlation of catch and effort is negative, Schaefer curve can be used to estimate the MSY (Maximum Sustainable Yield) and estimate fishing stocks and economic efficiency.

2.2 FISE-SIZE SELECTIVITY AS INDICATOR

Size is an important parameter governing biological and ecological processes in marine ecosystem[21]. 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[22–24] which larger ones will prey the smaller depend on the 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[16,23]. Comprehensive information about size-selectivity of common commercial fishing gears is crucial to fisheries management to maximize yield and protects juvenile fish[25]. 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 common property resource, is closely related to governance issues. It spans regulation related to socio-economic, political, and bureaucratic systems. Governance can be defined as the involvement of a wide range of institutions and actors in the production of policy outcomes involving coordination through networks and partnerships. Governance 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.

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

As said previously, fisheries as 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 cross-scale dynamics and feedback, self-organization, 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[28].

Indonesian government has declared the intention to establish an extensive marine protected area (MPA) network to sustains its open-access regime[29]. 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 expansion of the country's marine conservation network presents a real opportunity for the recovery of overexploited resources. However, from the perspective of local needs for food security, there needs to be a governance system that can allow local fishers to capture the spill-over benefits created by protected areas. Without proper fisheries management in the surrounding waters, the socio-economic benefits for local fishers may not be realized. Without such management in the surrounding waters, the MPA itself may not yield benefits.

4. FISHERIES AS A CPR AND ITS IMPACT

Open access system often leads to excessive use of marine resources, such as over-fishing [30][31]. In Indonesia, in addition to the problem of meeting the needs of marine resources, various environmental problems such as damage to coastal ecosystems[32,33] (coral reefs, mangrove forests, and estuaries), the aforementioned over-fishing; often associated with unregulated and illegal fishing [34], as well as pollution[35]. 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 [36], such as rising sea water temperatures, sea level rise, ocean acidification, increased extreme climate events[37], 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[38]:

- Exposure: the probability of a hazard (also: disturbance or stress) occurring;
- 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 [39]. This report was written to describe the situation of marine ecosystems in 2009, yet it is still relevant today as continued unsustainable and destructive[24][25] fishing activities has been proven time and time again to harm the ecosystem severely. The need of 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) specifying fishing method or gear; (ii) specifying fishing and aquaculture activities; (iii) preventing activities such as pollution and destructive fishing of the resource and its ecosystems; and (iv) rehabilitation of the resources and its habitat.

A report by the 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.

5. CONCLUDING REMARKS

Fisheries as natural common-pool resource raises a complex issue. 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.

REFERENCES

[1] Gordon HS. The economic theory of a common-property resource: the fishery. Class. Pap. Nat. Resour. Econ., Springer; 1954, p. 178–203.
[2] Salafsky N, Margoluis R, Redford K. Adaptive management. A Tool Conserv Pract DC Biodivers Support Program 2001.
[3] Homans FR, Wilen JE. Markets and rent dissipation in regulated open access fisheries. J Environ Econ Manage 2005;49:381–404.
[4] Hess C, Ostrom E. Ideas, artifacts, and facilities: information as a common-pool resource. Law Contemp Probl 2003;66:111–45.

[5] Brooks MA, Heijdra BJ. Rent-seeking and the privatization of the commons. Eur J Polit Econ 1990;6:41–59.
[6] Ostrom E. The challenge of common-pool resources. Environ Sci Policy Sustain Dev 2008;50:8–21.
[7] 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.
[8] 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.
[9] 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.
[10] Douvere F. The importance of marine spatial planning in advancing ecosystem-based sea use management. Mar Policy 2008;32:762–71.
[11] 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.
[12] Moldan B, Janoušková S, Hák T. How to understand and measure environmental sustainability: Indicators and targets. Ecol Indic 2012;17:4–13.
[13] Kusumartono FXH, Rizal A. An integrated assessment of vulnerability to water scarcity measurement in small islands of Indonesia. World News Nat Sci 2019;24.
[14] Maunder MN, Punt AE. Standardizing catch and effort data: a review of recent approaches. Fish Res 2004;70:141–59.
[15] 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.
[16] 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.
[17] 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.
[18] Solomon OO, Ahmed OO. Fishing with light: Ecological consequences for coastal habitats. Int J Fish Aquat Stud 2016;4:474–83.
[19] Schaefer MB. Some aspects of the dynamics of populations important to the management of the commercial marine fisheries 1954.
[20] 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.
[21] 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.
[22] Stein RA. Selective predation, optimal foraging, and the predator-prey interaction between fish and crayfish. Ecology 1977;58:1237–53.
[23] Thiebaux ML, Dickie LM. Structure of the body-size spectrum of the biomass in aquatic ecosystems: a consequence of allometry in predator–prey interactions. Can J Fish Aquat Sci 1993;50:1308–17.
[24] Kerr SR, Dickie LM. The biomass spectrum: a predator-prey theory of aquatic production. Columbia University Press; 2001.
[25] Carvalho PG, Humphries A. Gear restrictions create conservation and fisheries trade-offs for management. Fish Fish 2022;23:183–94.
[26] De Moor T. From common pastures to global commons: A historical perspective on

interdisciplinary approaches to commons. Natures Sci Sociétés 2011;19:422–31.
[27] 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.
[28] Fabinyi M, Barclay K. Fisheries Governance. Asia-Pacific Fish. Livelihoods, Springer; 2022, p. 65–90.
[29] 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.
[30] Arthur RI. Small-scale fisheries management and the problem of open access. Mar Policy 2020;115:103867.
[31] 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.
[32] 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.
[33] 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.
[34] Muawanah U, Pomeroy RS, Marlessy C. Revisiting fish wars: conflict and collaboration over fisheries in Indonesia. Coast Manag 2012;40:279–88.
[35] 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.
[36] 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.
[37] 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.
[38] Weißhuhn P, Müller F, Wiggering H. Ecosystem vulnerability review: proposal of an interdisciplinary ecosystem assessment approach. Environ Manage 2018;61:904–15.
[39] Lee M, Diop S. Millennium ecosystem assessment. An Assess Assessments Find Gr Expert Purs to UNGA Resolut 60/30 2009;1:361.
[40] Pet-Soede L, Erdmann M. An overview and comparison of destructive fishing practices in Indonesia. SPC Live Reef Fish Inf Bull 1998;4:28–36.
[41] Bailey M, Sumaila UR. Destructive fishing and fisheries enforcement in eastern Indonesia. Mar Ecol Prog Ser 2015;530:195–211.