Perspective on management strategic for sustainable development of coral reef fisheries at Ternate Island through ecosystem-based management approach

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Abstract. The coral reef fisheries activity at the coastal area of Ternate Island may impact the coral reefs' resources and ecosystems in this region. Management and utilization of the coral reef fishery resources that are not accompanied by an understanding of the structure and function of each component of the ecosystem can increase disturbance to the ecosystem, and adversely affect the structural components of the coral reef ecosystem in the coastal area of Ternate Island. Management and utilization of the coral reef fishery resources that are not accompanied by an understanding of the structure and function of each component of the ecosystem can increase the amount of disturbance to the ecosystem, and adversely affect the structural components of the coral reef ecosystem in the coastal area of Ternate Island. The lack of information and understanding of the ecosystem structure and function makes harvest controls impractical in fisheries management. Spatial management, such as MPAs, community marine tenure, and comprehensive marine zoning, within restrictions on destructive and inefficient fishing gear, may lead to reversing the decline in coral reef fisheries and the associated ecosystem. The urgent need to reform coral reef management focuses on the interconnected system as linked social-ecological systems.

1. Introduction
Coastal and marine ecosystems are complex ecosystems as an adaptive system consisting of groups of living-organisms that are interconnected with their habitats [1]. Fisheries management with a single-species approach is an approach that is considered as a traditional approach in fisheries management that is partial [2, 3]. Therefore, the concept of ecosystem-based fisheries management has received attention in sustainable fisheries management [3, 4, 5, 6]. An ecosystem-based approach considers the impacts that occur on ecosystems due to fisheries activities and the impact of ecosystems on fisheries resources.

The understanding of ecosystem dynamics is essential to know the structure and function of the communities that compose the ecosystem [7]. Various assessment methods for ecosystem conditions have been developed to assess the relationship scale between species or groups of species and calculate the relative importance of each component in maintaining the sustainability of an ecological
These approaches allow us to study the ecosystem parts that related to the energy flow that occurs in a trophic network, the direction, and magnitude of the biomass production, as well as the effects that received by each component before any external disturbance (e.g., the effect of fishing activities). These interactions can be presented and interpreted in a natural resource management context [9].

Fisheries management assessment always linked with several issues about the uncertainties data sources for the management. This uncertainty mostly related to the bias from the fisheries resource assessment model that been use to evaluate the target species within minimum data. This condition becomes worst with the presence of unreported catches [10, 11], which lead to uncertainties assessment for the dynamic of stock size and the fishing effort [12]. Therefore, data and information management related to the fisheries resource management must consider the available data, especially in poor data management related to the status and condition of the resources [13].

Coral reef fishing activities in the coastal area of Ternate Island have an impact on the resources and ecosystems of coral reefs in this region, where most of the target fish tend to caught in a relatively smaller size than the maximum size that can be achieved by each target fish species [14]. The size of the first time caught (LC) is also smaller than the size of the first time mature gonad (Lm) of fish, where this condition indicates overfishing in the recruitment group (recruitment overfishing) [15, 16]. As a result, the recruitment process for new individuals from each target fish species is very small and impacts the structure of fish resource populations in coral reef ecosystems in the coastal areas of Ternate Island.

The results of research conducted by Rumagia [16] stated that most of the functional groups of coral reef ecosystems in the coastal areas of Ternate Island are at trophic levels II and III. It means that the coral reef fishery activities in the coastal area of Ternate Island have targeted fish groups at a low trophic level, thus indicating the phenomenon of fishing down the marine food web, which in turn will also have an influence on the structure and dynamics of coral reefs ecosystem resources in this region. This study also shows that the structure of coral reef ecosystems in the coastal area of Ternate Island is classified as a developing stage with low maturity and stability of the ecosystem, making the ecosystem vulnerable to a disturbance that enters into it. Management and utilization of the coral reef fishery resources that are not accompanied by an understanding of the structure and function of each component of the ecosystem can increase the amount of disturbance to the ecosystem, and adversely affect the structural components of the coral reef ecosystem in the coastal area of Ternate Island. Therefore, the stability of Ternate Island's coastal ecosystem is essential for the sustainability of the resources.

Ecosystem-based management for sustainable fisheries in the coastal area of Ternate Island is needed to reduce the problems that can be caused by the existence of the coral reef fisheries activities in this region, as well as the impact of development in the coastal area of Ternate Island for regional development needs, on the existence of coral reef ecosystems and fisheries resources. The choice of management strategy undertaken is expected to have a positive impact on the existence of the coral reef fishery resources and their ecosystems, as well as to provide opportunities for the development of fisheries businesses carried out by communities in the coastal areas of Ternate Island in meeting the socio-economic needs of the community.

2. Strategies option for sustainable management of coral reef fisheries
Ecosystem-based management always considers the interconnectedness and interdependent nature of the components of ecosystems and emphasizes the importance of ecosystems' structure and function that provide a variety of environmental services [17]. Francis et al. [18] define: "An ecosystem is a system of organisms that are determined geographically, including humans, the environment, and the processes that control their dynamics. The ecosystem approach to management is adaptive management, which can be done geographically, taking into consideration an understanding of the ecosystem and its uncertainties, and trying to balance the various objectives and interests of social factors".
An ecosystem approach always involves several integrated ecological, economic, and social goals. According to Folke et al. [19], one thing to note is that ecosystems are a complex adaptive system, where uncertainties and unexpected things must also be taken into account in their management. Likewise, the human side, which is part of the socio-ecological system with the characteristics of complex adaptive systems, such as the diversity of human behavior and institutions managing ecosystems, local interactions between management actors, and selective management processes, shape social structure and dynamics in ecosystem management. Therefore, it is imperative to regulate social dimensions and social contexts to produce adaptive governance in ecosystem management, including participatory processes, collective action activities, and learning processes [19].

Rumagia et al. [20] stated that coral reef fisheries sustainability at the coastal area of Ternate Island tended to increase between 2012 until 2017 (Table 1). The maximum value for coral reef fisheries at Ternate Island coast range between 0 – 0.17, while the minimum threshold value tended to change between 2012 to 2017 where it decrease in 2015 then increase again in 2016 until 2017. The result of this research also shows that coral reef fisheries sustainability at the North Maluku Province also tends to increase between 2012 and 2016, but decreased in 2017 for the maximum threshold with the index value range from 0 to 1.09. Meanwhile, the national demersal fisheries shows that there is a change in the index value, where the maximum threshold tends to be increase in the period 2012 to 2015, then decline in the next years, with the index value ranging from 0 to 2.84 [20].

Based on the information previously explained, there are several choices of management strategy (Table 2 and Figure 1) that can be carried out in the management of the coral reef fisheries activities in the coastal area of Ternate Island, including 1) Input control, which is control of fishing efforts; 2) Output control, which is control of the total catch; 3) Technical measures, related to the management application; and 4) Access rights.

**Table 1.** Maximum and minimum value of sustainability window (SuWi) index for coral reef fisheries activities in the coastal area of Ternate Island, North Maluku Province, and national demersal fisheries in the period 2012 to 2017.

| SuWi  | 2012 | 2013 | 2014 | 2015 | 2016 | 2017 | Max  | Min  |
|-------|------|------|------|------|------|------|------|------|
| SWCRF<sub>max</sub> | 0.00 | 0.06 | 0.09 | 0.12 | 0.15 | 0.17 | 0.00 | 0.17 |
| SWCRF<sub>min</sub> | 0.00 | 0.01 | 0.07 | 0.01 | 0.05 | 0.09 | 0.00 | 0.09 |
| SWCRFPv<sub>max</sub> | 0.00 | 0.00 | 0.26 | 0.71 | 1.09 | 0.59 | 0.00 | 1.09 |
| SWCRFPv<sub>min</sub> | 0.00 | 0.02 | 0.00 | 0.27 | 0.47 | 0.47 | 0.00 | 0.47 |
| SWNDF<sub>max</sub> | 0.00 | 0.67 | 0.92 | 2.84 | 1.88 | 1.70 | 0.00 | 2.84 |
| SWNDF<sub>min</sub> | 0.00 | 0.22 | 0.62 | 0.56 | 1.35 | 1.33 | 0.00 | 1.35 |

SWCRF = Sustainability window of coral reef fisheries at Ternate Island; SWCRFPv = Sustainability window of coral reef fisheries at North Maluku Province; SWNDF = Sustainability window of national demersal fisheries; Max = maximum; Min = minimum (Source: Rumagia et al. [20])

**Table 2.** Fisheries management tools for sustainable fisheries management in coral fisheries management in Ternate Island's coastal area using an ecosystem-based approach.

| Control measure | Description | Advantages | Disadvantages | Application in coral reef fisheries |
|-----------------|-------------|------------|---------------|-------------------------------------|
| Input controls/fishing effort controls | | | | |
| Fishing gears and fleets restriction | Limitation of gears size and efficiency | Facilitate the distribution of the number of catches for all fishermen | Raises in inefficiency of efforts and costs, rule enforcement | Limit the use of unselective and destructive fishing gear. |
| Nursery ground protection | Fishing restriction in resources nursery ground | Reduce recruitment overfishing | Race to fish, access restrictions to resources for the community | Zoning, MPA with collaborative management |
| User restrictions | Limits the number of fishers that involve in coral reef fisheries | Reducing fishing mortality | Raises the problem of allocation, does not reduce the total number of catches | Fishing permits, community marine tenure (CMT) |
2.1. Input controls: controlling fishing effort
The controlling of the fishing efforts for the coral reef fishery activities in the coastal area of Ternate Island was intended to be able to control and limit the size of fishing gears and fleets that can be used in the fishing activities. Through the application of this control, the selectivity of target fish catch can be done and limit the use of unselective and destructive fishing gear. The fishing efforts control can also be done by limiting the number of users of the coral reef fisheries resources, to reduce the rate of fish mortality due to unselective fishing, which can provide the minimum safe level for the target species in their life-cycle through recruitment processes. These controls can be achieved by...
implementing rules for the management and utilization of the coral reef fishery resources, such as the establishment of fishing license for the community by using appropriate fishing gears and fleets, and the application of local community fishing rights through community marine tenure (CMT).

2.2. Output controls: controlling total allowable catch (TAC)
Efforts for sustainable coral reef fisheries in the coastal area of Ternate Island using the ecosystem-based approach can also be made through the implementation of controls on the output generated from fishing activities, by restrictions on the total allowable catch (TAC) as well as the practice of individual catch quotas (Individual transferable quotas, ITQ) for non-commercial fishing.

The implementation of the TAC strategy and individual catch quotas can benefit from overfishing and allow everyone to utilize the coral reef fishery resources in the coastal area of Ternate Island. Also, through the implementation of this strategy, it is hoped that it can control fishing by local communities for their consumption and still meet the community’s consumption needs.

One of the consequences that must be considered in the implementation of this strategy is that competition in fishing activities (race to fish) will increase by the fishermen and other local communities, which can affect the existence of fisheries resources. Race to fish will impact the resources species, especially the key species that become the fishing target, such as species from the family of Carangidae and Lutjanidae, which is a group of key species that play a role in sustaining the dynamics of coral reef ecosystems on the coast of Ternate Island. Therefore, the application of this strategy must be accompanied by clear regulations and governance so that it can be controlled and meets the desired management objectives.

2.3. Implementation of technical measures (where, when, and how)
Technical measures that can be applied in the ecosystem-based approach for sustainable management of coral reef fisheries in the coastal area of Ternate Island can be done through the application of the concept: where management and utilization can be done when the application of management and utilization will be carried out, and how the management and utilization of the resources can be applied. The technical measures can be done through restrictions on fishing areas, determining the appropriate fishing season for each type of target species, and limiting the minimum size and number of catches; also, the types of fishing gear used.

Restricting fishing to certain areas will help the ecosystem develop naturally and balance the structure and dynamics of the ecosystem due to fishing pressures. The management strategy that can be carried out in limiting fishing areas is establishing the marine protected areas (MPA), which can be managed together by the government and local communities. Considering the implementation of this strategy, due to the unavailability of MPA in the coastal areas of Ternate Island, the application of this strategy is essential for an ecosystem-based approach for sustainable coral reef fisheries management.

The advantages that can be obtained from the application of MPA include: increasing the production and export of eggs and larvae (spillover larvae) and net emigration of juvenile and adult organisms (adult spillover). The resulting spillover can supply the functional groups of ecosystem trophic on a broad spatial and temporal scale, and can provide benefits to fishery activities in the provision of germplasm of fishery resources. The challenges in implementing this strategy are reduced fishing areas and access to resources for the community, which can lead to management conflicts, if not involving all stakeholders concerned in the management and utilization of coral reef fisheries resources in the coastal area of Ternate Island.

Determining the appropriate fishing season for each target species can be done by implementing a fishing ban at certain times, mainly when the fish recruitment occurs in the ecosystem. The application of this strategy must be adjusted with accurate scientific information about the spawning and recruitment season of each target species, so the fishing season that does not affect the reproduction and recruitment patterns of fish resources can be implemented. Also, with the application of restriction seasons, it can help to know about the spawning areas for target fishes so that the maximum protection
of these areas can be done to protect and maintain the sustainability of coral reef resources in the coastal area of Ternate Island.

Technical measures that can also be applied in developing a sustainable coral reef fisheries management strategy in the coastal area of Ternate Island are through limiting the minimum size and number of catches and types of fishing gear used. The advantage that can be obtained from the application of this strategy is the protection of fish resources to be able to reach their reproductive size, especially in the group of coral reef ecosystem organisms that play an important role in maintaining the sustainability of coral reef ecosystems in the coastal areas of Ternate Island. Problems that may be encountered in the implementation of these strategies, for example, race to fish and promote the capture of large fish, which can affect the trophic level composition in coral reef ecosystems. This problem must be anticipated by the preparation of appropriate controlling and law enforcement operational tools to support the management and sustainable use of coral reef fisheries resources in the coastal areas of Ternate Island. Institutional and governance strengthening in the management and utilization of coral reef fisheries resources in the cross-sectoral scope also become the main thing that must be prepared in supporting the sustainable management of coral reef fisheries in the coastal area of Ternate Island [20].

2.4. Access right
Access right implementation for management and utilization of coral reef fisheries in the coastal area of Ternate Island can be implemented through individual transferable quotas (ITQs) for the fisherman, and development of community marine tenure (CMT) through territorial user right fisheries (TURFs) approach for the coastal community. Catch quota implementation through harvest regulation for every fishery user so the catch stability can be maintained and increase the number of workers in coral reef fisheries on the coast of Ternate Island. The implementation of these strategies must be supported by good governance, distinct regulations, as well as sustain monitoring to every fishing activities in coral reef fisheries.

Development management strategies for coral reef fisheries resources using the TURFs approach can provide opportunities for the local community to manage and utilize the fisheries resources in their coastal areas, especially to specific resources that impact the sustainability of the ecosystem as well as to increase community income. Conflict on territorial usage between regions may occur as constraints to these strategies, as well as overlapping regulation in coastal area utilization on Ternate Island due to sectoral egos by each stakeholder who feel they have rights to manage and utilize the coastal area on Ternate Island.

Fisheries management studies currently provide much understanding of the ecosystem approach (ecosystem approach), which gives more understanding to ecosystem-based management. These understandings may lead to different understandings in interpreting the approach, especially between presenting an understanding of the systems thinking approach in considering the aquatic environment, and an approach with ecological considerations (the purpose of managing ecosystems) in fisheries management. The factor that generally becomes a differentiator in an ecosystem-based approach is an approach that includes interactions between natural systems and the needs of social systems. Fisheries management, such as coral reef fisheries at the coastal area of Ternate Island, requires treatment with long-term consequences resulting from management decisions taken at this time. It also means that consideration of the linkages between various resources as a whole management system is more important than management that is carried out separately [21, 22].

3. Conclusion
Management and utilization of coral reef fisheries that are not accompanied by an understanding of each component's structure and function can increase the amount of disturbance to the ecosystem and adversely affect the structural components of the coral reef ecosystem in the coastal area of Ternate Island. Therefore, the stability of the coastal ecosystem of Ternate Island is essential to maintain the resource sustainability. Ecosystem-based fisheries management in the coral reef fisheries at Ternate
Islan Island requires all stakeholders, including fishers, scientists, public officials, recreationist, conservation groups, and consumer groups, to be involved throughout the process. The inclusion of stakeholders’ opinions and knowledge is needed for the process, helping to learn the ecosystem process, ensuring more participation and hence less enforcement and monitoring, and giving legitimacy to the entire management structure.

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