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STATUS AND POTENTIAL FOR ECOSYSTEM-BASED FISHERIES MANAGEMENT IN TEMPE LAKE, INDONESIA: AN ECOSYSTEM APPROACH TO FISHERIES MANAGEMENT (EAFM)

STATUS DAN POTENSI PENGELOLAAN PERIKANAN BERBASIS EKOSISTEM DI DANAU TEMPE, INDONESIA: PENDEKATAN EKOSISTEM PENGELOLAAN PERIKANAN (EAFM)

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ABSTRACT

The critical condition of Lake Tempe has undergone comprehensive changes over the last 10 years. Fisheries management strategy indicators with an appropriate ecosystem-based approach can reduce and prevent unbalanced environmental impacts. This research analyzes fisheries management using the Ecosystem Approach Fisheries Management (EAFM) module, the Rapid Appraisal for Fisheries Sustainability (RAPFISH) method. Six important statuses and dimensions used as attribute indicator analysis in this research are fish resource dimensions, habitat dimensions, fishing technique dimensions, economic dimensions, social dimensions, and institutional dimensions. The analysis results show that the fishery management status value for Lake Tempe is 36.072 in the unsustainable category. Based on the RAPFISH analysis, namely: (1) Economic dimensions 21.390 in the unsustainable category, (2) Habitat dimensions 36.050 in the unsustainable category, (3) Fish resource dimensions 24.483 in the moderately sustainable category, (4) Fishing technique dimensions 42.180 in the moderately sustainable category, (5) Institutional dimensions 48.070 categories are quite sustainable (6) Social dimensions 45.590 categories are quite sustainable. Based on the AHP analysis, habitat dimensions, protection of important zones for spawning grounds, nursery grounds, and water hyacinth cover problems are identified.

Keywords: EAFM, Rapfish, sustainability, Lake Tempe, fisheries management.

ABSTRAK

Kondisi Danau Tempe yang kritis telah terjadi perubahan yang komprehensif selama 10 tahun terakhir. Indikator strategi pengelolaan perikanan dengan pendekatan berbasis ekosistem yang tepat dapat mengurangi dan mencegah dari dampak lingkungan yang tidak seimbang. Penelitian ini bertujuan untuk menganalisis pengelolaan perikanan menggunakan modul Ecosystem Aproach Fisheries Management (EAFM) metode Rapid Appraisal for Fisheries Sustanability (RAPFISH). Enam status dan dimensi penting yang digunakan sebagai analisis indikator atribut dalam penelitian ini yaitu dimensi sumberdaya ikan, dimensi habitat, dimensi teknik penangkapan ikan, dimensi ekonomi, dimensi sosial, dan dimensi kelembagaan. Hasil analisis menunjukkan nilai status pengelolaan perikanan Danau Tempe 36,072 dalam kategori tidak berkelanjutan. Berdasarkan analisis Rapfish yaitu: (1) Dimensi ekonomi 21,390 kategori tidak berkelanjutan, (2) Dimensi habitat 36,050 kategori tidak berkelanjutan, (3) Dimensi sumber daya ikan 24,483 kategori cukup berkelanjutan, (4) Dimensi teknik penangkapan ikan 42,180 kategori cukup berkelanjutan, (5) Dimensi kelembagaan 48,070 kategori cukup berkelanjutan (6) Dimensi sosial 45,590 kategori cukup berkelanjutan. Berdasarkan analisis AHP yaitu dimensi habitat, perlindungan zona penting untuk spawning ground, nursery ground, dan masalah tutupan eceng gondok.

Kata kunci: EAFM, Rapfish, keberlanjutan, Danau Tempe, pengelolaan perikanan.

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INTRODUCTION

Indonesia is the second "mega biodiversity" country after Brazil, having 1,300 types of freshwater fish with a density of 0.72 species/100 km^2. Peat swamps and other waters provide important habitat for many freshwater fish species. Endemicity indicates a species is only found in a specific location, which makes it unique and valuable to the ecosystem. Species richness also reflects the health of the ecosystem as a whole (Haerunnisa, 2020). The development of freshwater fish taxonomy is very dynamic. The discovery of 79 new species in 2-3 years shows how much biodiversity is not yet fully understood. This research is important for the conservation and management of fish resources, as well as for understanding freshwater ecosystems (Cochrane, 2002). Conservation of freshwater fish in the lake is very crucial. Lakes often face various threats, such as pollution, climate change, invasion of alien species, and overfishing (Lehmuslvoto, 2005).

Based on the National Lake Indonesia meeting regarding sustainable lake management, 9 critical lakes in Indonesia were determined that require a comprehensive management strategy and Lake Tempe is one of the critical lakes. Lakes are dynamic, highly complex, vulnerable to various pressures, and difficult to understand using a partial approach. Water and land spaces in lake areas have different characteristics and are interconnected ecologically, economically, and socially. On the other hand, coastal areas have a variety of environmental services and resources so they are more often overexploited. So, generally, there are always conflicts over space utilization, both inter-sectoral and sectoral with each stakeholder having various interests (Brown, 2001). The taxonomy of fish, especially freshwater fish in Indonesia, has experienced very rapid development and in approximately 2-3 years has grown with the addition of 79 new types (Cochrane, 2002).

Studies on fish taxonomy are still being developed but not much effort has been put into their management and conservation. So, it is currently urgent that freshwater fish conservation be followed up. One of the habitats for freshwater fish is lakes. Apart from that, it also includes rivers, mountains, and lowlands (Lehmuslvoto, 2005). One of the lakes that has the potential to produce fish for local and regional consumption is Lake Tempe which is located in South Sulawesi. Current conditions of Lake Tempe are severe, aquatic plants indicate a eutrophic state and turn the lake into a swamp, there is almost no lake water during the dry season. An ecosystem approach must be applied in environmentally sound management of the Lake Tempe fishery which takes into account all aspects of the environment and subsystems within it that influence and are related to each other. The impact of an environment where ecosystem management is unbalanced is a decrease in fisheries productivity (Yusuf, 2010).

The condition of the waters of Lake Tempe is defined as the expansion of settlements, docks, industrial development, tourist parks, transportation routes, deforestation, and environmentally unfriendly fisheries causing the abundance of fish species to decline, with catches becoming increasingly small. The decline in fish species composition and productivity in Lake Tempe is a very important problem to pay attention to, also caused by excess fishing, non-selective fishing gear, and habitat destruction. Meanwhile, the composition of Lake Tempe's fish is shifting due to the natural

process of recruitment and reproduction being hampered, resulting in dominant fish species becoming increasingly rare and some species are even rarely caught. The decreasing population of fish species and size can make some types of fish not pay attention to their growth.

Activities to introduce commercial fish species such as tilapia, gourami, and goldfish have been carried out in Lake Tempe. To maintain the sustainability of rare fish populations, efforts are needed to manage the presence of these fish concerning aspects of the aquatic environment, conservation management, and taking into account the socio-economic aspects of the characteristics of the Lake Tempe area, which are important elements in efforts to design or implement Co-management (Kurniawan et al., 2022). Meanwhile, precise population and biological information regarding endangered fish in the waters of Lake Tempe is still very limited. Degradation and the level of utilization of fish that experience over-exploited fishing activities is a fisheries management issue (Mulyawan, 2016). In fisheries management, three things that need to be considered are fish resources and their ecosystem, community socio-economics, and fisheries policy itself.

Looking at the current condition of fisheries, current fisheries management pays little attention to the condition of the ecosystem and only prioritizes the socio-economic interests of the community (Pradnya, 2020). Even though the fishing gear used by fishermen is in accordance with existing regulations, it is necessary to regulate fishing gear so that it is not modified without paying attention to existing regulations, thereby making the fishing gear no longer effective and could threaten the sustainability of fish resources (Sulistyowati et al., 2018). Ecological, social, economic, and policy aspects must be considered in implementing fisheries management in Lake Tempe, Wajo Regency. The application of EAFM in this research can support effective fisheries in conservation management through assessing ecosystem indicators and human welfare in the future and contribute to the blue economy for achieving sustainable development goals (SDGs) targets. This is appropriate for several basic considerations in fisheries development and conservation that are needed as a solution for basic data for determining management policies and utilization of aquatic resources so that the Lake Tempe fishery is sustainable.

RESEARCH METHODS

Time and Location of Research

This research was conducted in the period October 2022 until May 2023 in the Lake Tempe area, Wajo Regency, Soppeng Regency and Sidrap Regency, South Sulawesi.

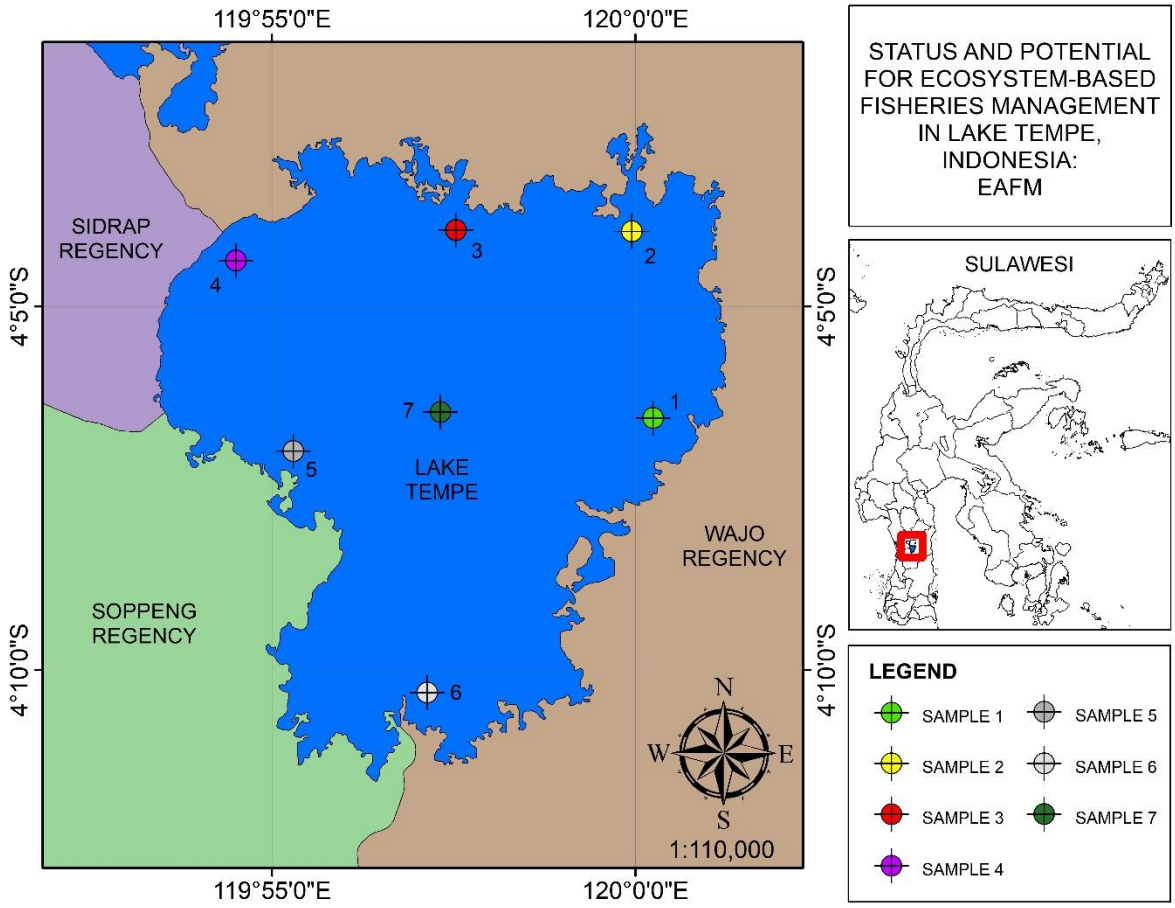

Figure 1. Map of Research Locations

Information:

- Green : Sample 1
- Yellow : Sample 2
- Red : Sample 3
- Purple : Sample 4
- Silver : Sample 5
- Gray : Sample 6
- Dark Green : Sample 7

Data Types and Sources

Primary and secondary data are the types of data used for this research which were obtained from respondents through distributing questionnaires and direct interviews. Secondary data comes from related institutions, such as the South Sulawesi Province Maritime and Fisheries Service, Wajo Regency Maritime and Fisheries Service, Soppeng, Sidrap, South Sulawesi Provincial Central Statistics Agency, BAPEDALDA. Secondary data searches were obtained from books, journals, and related publications.

Data Analysis

Determining indicators and attributes using the EAFM (Ecosystem Approach Fisheries management) module and assessing the sustainability status of the Lake Tempe fishery is determined using the RAPFISH (Rapid Appraisal for Fisheries Sustainability) method.

Table 1. Recapitulation of Dimensions and Attributes

Dimensions	Attributes	Definition	Data Collection Methods
1. Fish resources	1. Production trends	fishery catch production/year to see data on changing trends in the last 10 years	Secondary data of at least 5 years from each fisheries unit, Logbook, Observer uses data on the dominant fish production in Lake Tempe, namely tawes fish, sepat fish, and tilapia fish
	2. Fish size trends	Total length with minimum and maximum size, mode	Secondary data and primary data use the dominant fish sizes in Lake Tempe, namely tawes fish, sepat fish, and tilapia fish
	3. Composition of fish species	Target species used, non-target species used and not used	Secondary data (research report), monitoring, and logbook
	4. Proportion of juvenile fish caught	Percentage of fish caught before reaching maturity	Secondary data (research results reports), monitoring, and logbook
	5. Diversity of fish species	Diversity of types fish in the lake	Secondary data, interviews with fishermen, and observations in the last five years
	6. ETP species	Populations of ETP species (Endangered species, threatened species, and protected species) are appropriate	Survey and monitoring, logbook, and observations in the last three years using CITES criteria
2. Habitats	1. Shallowing rate	The level of shallowing due to lake sedimentation	Secondary data (research report), monitoring, logbook, and interviews
	2. Level of pollution	Waste produces pollutant substances such as pesticides and ammonia: B3-hazardous & toxic substances), using parameters from Minister of Environment Decree 51/2004 concerning Lake Water Quality Standards	Secondary data (research report), monitoring, logbook, and interviews
	3. Eutrophication	Eutrophication uses chlorophyll a parameter	Secondary data (research results report)
	4. Water hyacinth cover	Cover/area (%) of water hyacinth in waters	Secondary data (research report), monitoring, logbook, and interviews
	5. Important habitat	The extent, time, and fertility of waters in the protection zone (sacred zone) for spawning, nursery and feeding ground	Monitoring, logbook, and interviews
	6. Brightness	The brightness level of Lake Tempe as measured by the Secchi Disk	Secondary data and primary data

Dimensions	Attributes	Definition	Data Collection Methods
3. Fishing Technology	1. Destructive fishing methods	Fishing is destructive as seen from the use of fishing tools and methods that are destructive and/or do not comply with applicable regulations	Fisheries inspector reports, interviews with fishermen, police reports, and using report data from the Wajo DKP supervision
	2. Capacity and fishing effort	The amount of fishing capacity divided by fishing activity	Survey, logbook, and interviews with fishermen
	3. Modification of fishing equipment	The use of fishing gear that has a negative impact on fish schools	Survey, logbook, and interviews with fishermen
	4. Selectivity of fishing gear	Fishing activities are associated with extent, time, and diversity of results catch	Capture Fisheries Statistics, logbook, and survey
4. Economy	1. Asset ownership	Changes in the value/amount of PT business assets (obtained from fishing business)	Survey data and interviews on the average RTP income of fishermen used as asset ownership
	2. Fisherman's household income	Fishery Households are households of fishermen, fish processors, and fish traders whose main income is generated from fishery activities	Survey data and interviews on the average RTP income of fishermen using a sampling approach which is measured and compared with the 2015 MSEs originating from fishing activities
	3. Fisherman savings ratio	Savings to net income (I-O) ratio: Bank interest rate	Survey data and interviews on the average RTP income of fishermen by calculating savings which are measured between income and expenses. Credit interest information can be obtained at BI during the survey
5. Social	1. Local wisdom	Utilization of local wisdom that is created and adhered to along with fisheries management	Secondary data and primary data with surveys and interviews of types of local wisdom have been created from generation to generation and are still valid today
	2. Fisheries conflict	Conflicts in policy, conflicts over fishing gear and territory, and conflicts between sectors	Secondary data and primary data using surveys and interviews on types of fisheries conflicts, frequency of occurrence, causes, and sanctions for conflicts
	3. Stakeholder participation	Involvement of stakeholders, traditional institutions, NGOs, and related agencies	Secondary data and primary data with surveys and interviews regarding participation are carried out continuously in accordance with the stages of fisheries management. The percentage of involvement is measured by the number of

Dimensions	Attributes	Definition	Data Collection Methods
			stakeholder types and not individual stakeholders' interests
	4. Utilization of fishermen's experience	Utilization of local/individual fisherman knowledge related to fisheries management	Logbook, interview about the use of fishermen's knowledge in fisheries management. Evaluation is carried out during each management cycle and a participatory manner
6. Institutional	1. Compliance with rules of fisheries management that has been determined both formally and non-formally	The level of compliance of all stakeholders with formal and informal rules of the game	Secondary data regarding reports on formal violations from supervisors, interviews (key person) on non-formal violations including compliance with their regulations and regulations above them
	2. Completeness of management rules	List the completeness of regulations in fisheries management available, to regulate the use of fish resources by the EAFM domain, namely; regulations related to 6 dimensions of sustainability	Secondary data by recording regulations in accordance with national regulations and local governments should also make derivative regulations
	3. Decision making mechanism	Whether or not there is a decision-making mechanism (SOP) in fisheries management	The survey was carried out by: inter-institutional document analysis and stakeholder analysis through interviews/questionnaires
	4. Fisheries management plan	Whether or not there is an RPP for the Lake Tempe fisheries management area	The survey was conducted using interviews/ questionnaires: is there an RPP for Lake Tempe or not? Has an RPP been implemented or not? The survey was carried out by: inter-institutional document analysis and stakeholder analysis through interviews/questionnaires
	5. Level of synergy between management policies and institutions	The higher the level of synergy between institutions (lower span of control), the better the level of effectiveness of fisheries management	

This research contains index value categories and sustainability status. Each attribute is given a score, where if the condition is good then it is given a score of 3, whereas a score of 1 is given if the condition is bad (Table 2).

Table 2. Index Categories and Sustainability Status (RAPFISH)

Index Values	Categories
Index value < 50	poor management status
Index value 50 – 75	good management status
Index value > 75	very good management status

Source: Pitcher (1999)

RESULTS AND DISCUSSION

Tempe Lake Fisheries Sustainability Status in Every Dimension

The sustainability index for Lake Tempe management shows the fish resource dimension is in the poor category with a value of 24.480. This indicates that there are serious problems in lake's fisheries management. Furthermore, the attributes predicted to influence the technological dimension are fisheries production, trends in fish size, composition of species caught, proportion of fish caught, diversity of fish species, and ETP species found.

The sustainability index value of Lake Tempe in the habitat dimension is 36.050, which indicates that the ecological and habitat conditions in this lake are classified as less than sustainable. So, the attributes predicted to influence the sustainability of Tempe Lake management from an ecological dimension are the level of pollution, shallowing rate, water hyacinth cover, eutrophication, important habitat, and brightness. The sustainability index value of Lake Tempe in the fishing technique dimension is 42.180, which shows that management in the fishing technology dimension is classified as less than sustainable. Attributes that are predicted to influence the technological dimension are fishing gear modification, destructive fishing, fishing gear selectivity, fishing effort, and fishery capacity.

The sustainability index value of Lake Tempe in the economic dimension is 21.390, which shows that the economic conditions of management of this lake are classified as poor and unsustainable. Attributes that influence this dimension are fishermen's household income, asset ownership, and savings ratio. The low sustainability index for the economic dimension is caused by habitat degradation and low fisheries production in Lake Tempe. The sustainability index value for Lake Tempe which shows the social dimension is 45.590, indeed indicating that this aspect is in the less sustainable category. Attributes that are predicted to influence this dimension are fisheries conflicts, stakeholder participation, local wisdom, and the use of local knowledge in lake management. Attributes that are predicted to influence the institutional dimension are compliance with rules, decision-making mechanisms, completeness of rules in management, level of policy and institutional synergy, and having an RPP fisheries management plan which can be seen in Table 3 and the sustainability status of the Lake Tempe fishery in Figure 2.

Table 3. Monte-Carlo RAPFISH Analysis Results

Dimensions	Sustainability Values (%)	Monte Carlo Index
Fish Resources	24.483	25.577
Habitats	36.050	36.202
Capture technology	42.180	41.835
Economy	21.390	23.176
Social	45.590	45.227
Institutional	48.070	48.056

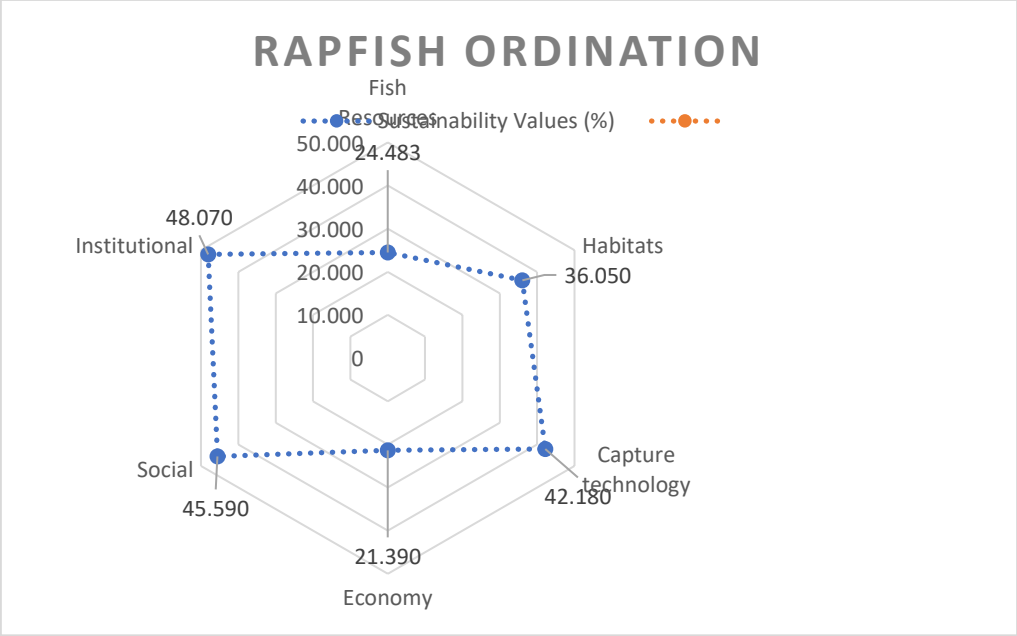

Figure 2. Sustainability Status of the Lake Tempe

Based on the research results, there are 19 types of fish in Lake Tempe (Table 4). Changes in the number of fish species in Lake Tempe over 30 years, from 20 species to 17 species. According to Haerunnisa, et. al., (2015), a diversity of 20 species of fish was found, namely betok, tawes, sepat siam, snakehead, carp, belosoh, eel, tambakan, catfish, nilem, eel, tin head, julung-julung, bete bete, mullet, and snorting. When related to the types of fish caught from 2005–2023, 3 types of fish are no longer found in Lake Tempe, namely tambakan fish, tinhead fish, and julung-julung fish.

Table 4. Diversity of Fish Types in Lake Tempe

No.	Jenis Ikan	1990	2010	2023
1	Goldfish (*Cyprinus* carpio, Linneaus 1758)	√	√	√
2	Tilapia fish (*Tilapia* mosambica,Peters 1852)	√	√	√
3	Tawes fish (Pontius gonionatus, Bleaker 1850)	√	√	√
4	Fish cork (*Ophiocephalus striatus*,Bloch 1793)	√	√	√
5	Siamese shoes (*Trichogaster* petroralis, Regan 1910)	√	√	√
6	Betok (*Anabas testudineus*, Bloch 1792)	√	√	√
7	Nilem (*Osteochilus haselti*, *Valenciennes, 1842*)	√	√	√
8	Betutu (*Oxyeleotris* marmorata, Bleaker 1852)	√	√	√
9	Belosok (*Glossogobius aureus, Akihito & Meguro 1975*)	√	√	√
10	Eel fish (*Monopterus albus, Zuiew 1793*)	√	√	√
11	Mullet (*Mugil cephalus*, *Linneaus 1758*)	√	√	√
12	Tin head (*Aplocheilus panchax*)	√		√
13	Tambakan (*Heleostema temminckii, Cuvier, 1829)*	√	-	√
14	Cecopong (*Therapon microchantus*)	√	-	-
15	Catfish (*Clarias punctatus, Valenciennes 1840*)	√	√	√
16	Bete (*Leoignathus equulus, Forsskål 1775*)	√	√	√
17	Eel (*Anguilla marmorata, Quoy & Gaimard, 1824*)	√	√	√
18	Fresh Shrimp (*Caridina spongicula, Linneaus 1758*)	√	√	√
19	Broom (*Hypostomus plecostomus, Linneaus 1758*)	-	-	√

There are 14 types of fishing equipment in Lake Tempe, which is more than in other districts (Table 5). The size of the fishing area, potential fish resources, and the number of fishermen greatly influence the number of fishing gear in an area. Based on the tools used by fishermen to catch fish, it is known that there are fishing tools that damage the environment, namely mini trawls (jabba),

barges, fish bombs, and fish stroms. Even though there are regional regulations that regulate the use of fishing gear and fishing areas, fishermen still use them today (Ninef et al., 2019). There are 14 types of fishing gear in Lake Tempe consisting of passive and active fishing gear, which are used in catching fish species.

Table 5. Types of Fishing Gear in Lake Tempe

No.	Types of Fishing Tools	Wajo	Soppeng	Sidrap
1	Throwing net (net)	√	√	√
2	Lift net (barge)	√		√
3	Fixed gill net	√	√	√
4	Hand fishing	√		√
5	Hand fishing line	√		
6	Bamboo trap	√	√	
7	Trap	√		√
8	Iron trap	√	√	√
9	Mini trawl	√	√	√
10	Spear fork	√		
11	Timpo	√	√	√
12	Julu	√		√
13	Fish bomb	√		
14	Stun fish	√		

Sensitivity to the Sustainability of Lake Tempe Fisheries in Every Dimension

Table 6. Stress Values and Coefficient of Determination (RAPFISH)

Dimensions	Stress	r2
Fish Resources	0.15	0.93
Habitats	0.16	0.93
Capture technology	0.15	0.91
Economy	0.15	0.91
Social	0.16	**0.93**
Institutional	0.16	0.93

All the attributes studied reflect the sustainable status of Lake Tempe management quite accurately and can be justified based on the results of the RAPFISH analysis. Which shows a stress value below 0.25 and an R2 value = 0.95. This is in line with what was stated by Hartono, et. al., (2005), that if the stress value is <0.25 and the R2 value is close to 1.0 then the analysis results are quite adequate. There is no difference in the sustainability index for integrated management of Lake Tempe. This means that the variation in scoring due to differences in opinion is relatively small, errors in making scores for attributes are relatively small, errors in data entry and missing data can be avoided, and the analysis process carried out repeatedly is relatively stable.

CONCLUSIONS AND SUGGESTION

Conclusion

The diversity of fish species has changed in Lake Tempe over the past 10 years, accompanied by a decline in fish size and production. The sustainability index shows that the fisheries management status of Lake Tempe in Wajo Regency is in the poor management category with a management status value of 36.072. Therefore, management strategies are needed to support sustainable fisheries in Lake Tempe. The sustainability index above consists of an economic

dimension of 21.390 and a habitat dimension of 36.050 in the unsustainable category, a fish resources dimension of 24.483, a fishing technique dimension of 42.180, an institutional dimension of 48.070 and a social dimension of 45.590 in the moderately sustainable category. Synergy and collaborative improvement in the habitat dimension through conservation efforts in the upstream and buffer areas of the Lake Tempe watershed.

Suggestion

Strengthening the institutions of all stakeholders in Lake Tempe fisheries management so that they can jointly implement the principles of sustainable management. Establish regular study forums (FGD) for the development and management of Lake Tempe fisheries involving researchers, academics, fishing communities, government, entrepreneurs, NGOs, donor agencies, and other parties with an interest in Lake Tempe fisheries. Increasing the APBD through the management of Lake Tempe by increasing the lake's function as a fishery and agricultural resource center, craft center, tourism center, and research and education center. Lake Tempe fisheries management using the EAFM approach is expected to provide sustainable management results.

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