# Management Model of Sustainability Fisheries at Lake Tempe, South Sulawesi, Indonesian

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Abstract: Tempe Lake is a lake in South Sulawesi potential as a producer of fish for local and regional consumption. In the dry season, Administratively, Tempe Lake lies in two areas, namely Wajo and Soppeng. Location of the three lakes adjacent and connected by rivers during the rainy season the water level rises, causing three lakes together. Therefore the aim of this study are: 1) Determine the composition of the type and size of fish in Lake Tempe, 2) Analyze the status of sustainability and management strategies based on the social, economic, institutional, fish resources, habitat, and technology, and 3) to formulate policy alternatives in the management of fisheries of Lake Tempe especially endangered fish. The experiment was conducted in October 2012 - March 2013 (pre - study) in three districts namely Wajo, Soppeng, and Sidrap to identify the composition of fish species in Lake Tempe. Data on the composition of the catch can be obtained in conjunction with the catch - effort data is catching. Data were collected at regular intervals to describe the general composition of catches from each gear from various times and regions in the fishing season. Data should be analyzed carefully in conjunction with environmental fluctuations and changes in environmental conditions that systematically. Research continued in May-August 2014 to determine the spatial and temporal distribution of endemic fish in Lake Tempe and to determine the factors that threaten the extinction of fish endemic to retrieve data directly through six stations. Assessment of the status of conservation of Fisheries in Lake Tempe determined using RAPFISH (Rapid Appraisal for Fisheries Sustainability) developed by Fisheries Center University of British Columbia (Kavanagh, 2001. In RAPFISH analysis conducted several stages, namely: 1) Determination of attributes, 2) Sensitivity analysis, 3) Dimensions of sustainability status management, and 4). Multidimensional sustainability status. This study uses 30 attributes of 6 dimensions (social, economic, habitat, fish resources, technology, and institutional) in RAPFISH analysis. Each attribute and criteria in each dimension refers to the manual modification EAFM module (Ecosystem Approach for Fisheries Management). Therefore, it is necessary fisheries research in the field of complex and multidisciplinary. Thus, an assessment of the sustainability or sustainability of fishery resources can not be reviewed in one dimension but involves various dimensions and needed a solution to overcome this. As well as basic data for the determination of policy management and utilization of aquatic resources in order to preservation of endangered fish populations can be sustained.

Keywords: Management model, suistainability of fisheries, Tempe lake, EAFM Modul

# **1. Introduction**

Indonesia is a country "megabiodiversity " second only to Brazil has 1300 species of freshwater fish with a density of 0.72 species / 100 km2 . Habitats rich in freshwater fish include rivers in the mountains and lowlands , peat swamps , and lakes . Wealth species (species richness ) and endemism (endemism) are two very important attributes in biodiversity (Kottelat et al . 1993) .

Taxonomy of freshwater fish, especially fish has developed very rapidly, within a period of 2-3 years there has been an additional 79 new types (Cochrane , 2002). Taxonomic studies of fish continues , but not coupled with management efforts. So at this time conservation of freshwater fish has been urged to be addressed. One of freshwater fish habitat is a lake (Lehmuslvoto , 2005).

Tempe Lake is a lake in South Sulawesi potential as a producer of fish for local and regional consumption. In the dry season, Tempe Lake is divided into three parts, namely Lake Sidenreng, Labuaja Lake, and Lake Tempe. Administratively, Tempe Lake lies in two areas namely Wajo and Soppeng. While Sidenreng Lake and Lake Labuaja located in Sidrap. Location of the three lakes adjacent and connected by rivers during the rainy season the water level rises, causing three lakes fused. Tempe Lake occupies three districts in seven districts . The widest part of the lake lies in Wajo which consists of four districts, namely Tempe, Sabbangparu, Tanasitolo and Belawa. Soppeng two sub -districts and Donri Marioriawa - Donri , and the narrowest part is Sidrap with a sub-districts Pancalautan. Geographically Lake Tempe is located between 119 053 ' - 120 004 ' east longitude and 4003' - 4009 ' south latitude. Lake water surface elevation varies between 3 m in the dry season to approximately 10 m above sea level in the rainy season (Bappedal, 2010; local government district. Wajo , 2012) .

Tempe Lake is one of the lake in South Sulawesi, which includes the type of exposure lake flooded with Geographical location of Tempe Lake on the coordinates between 3°39 ' - 4°16 , latitude and 119° 53 ' - 120° 27'BT. Tempe Lake Area which has 14 406 hectares, located in three Regional District : Wajo (9.425Ha), Soppeng (3,000 ha), Sidrap (2,896 ha). In the rainy season Tempe Lake area of 45,000 hectares, drought around 1,000 hectares. Wide catchment area of Lake Tempe is 4,587 km<sup>2</sup> and has a depth of 3 to 5.5 meters in the rainy season, while in the dry season 0.5-2 meters. Tempe lake water source comes from the 23 rivers that are included in the 2 DAS ( DAS When and Das Walannae). At this time the condition is severe Tempe lake, aquatic plants indicate eutrophic conditions and alter the function of the lake into a swamp, in the dry season the lake water is almost non-existent.

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Tempe lake fisheries management must implement environmentally sound ecosystem approach . Management approach that takes into account all environmental components and sub - systems within it are connected and influence each other. Environmental degradation of the lake that greatly impact on the decline in fisheries productivity is the environmental impact of an unbalanced ecosystem management (Joseph , 2005).

Fisheries problems that occur in Tempe Lake is declining production and species composition. The decline in production occurs due to excess fishing, the use of nonselective fishing gear, and habitat destruction. The shift in the composition of fish occur due to barriers of reproduction and recruitment process naturally. This causes some dominant fish , and other types of fish increasingly scarce even some types are ENDAGERED ly caught . The decline in fish populations followed by a decrease in the size of fish as a result of the reproductive process that accelerated the growth of some types of fish ignore him ( The imagery, 2000).

Factors causing the decline in the number of fish populations by Moyle and Leidy (1992), can be caused by : a). Habitat degradation, b). pollution, c). introduction of foreign fish , d). commercial exploitation. According Whitten et al. ( 1987) that affect the decline in fish species diversity in South Sulawesi is the introduction of foreign fish. Lodging in Lake Tempe 'done the introduction of commercial fish species such as carp (*Cyprinus carpio*), (Oreochromis mossambicus), (Oreochromis niloticus), and carp (*Osphronemus gouramy*).

Degradation of habitat / environment, among others, have an impact on the quality of the aquatic environment both in water bodies and in the bottom waters and living organisms (Reid and Miller, 1989). According Wargasasmita , (2000) extinction of freshwater fish is estimated to range from 78 % due to changes in habitat, so that loss of function as a place to live , feed , breed and shelter cause the fish are not able to adapt to changes in their environment . To preserve endangered fish populations remain sustainable, it is necessary for the existence of fish management efforts is related to the environmental aspects of the lake waters. While the biological information and the exact population of the endangered fish in the waters of Lake Tempe is still very limited.

In the implementation of fisheries management in Tempe Lake Wajo should consider the ecological, economic and social policies and factors. It is further described in the report of Nippon Koei Co., Ltd. (2003) in Joseph (2005) that the development of fisheries in Lake Tempe based on several considerations, namely : (1) The condition now fishery in Lake Tempe, (2) Fisheries and potential fish, (3) aspects of limnology and ecological conditions Tempe Lake, (4) Projected consumption of fish communities living around Lake Tempe, and (5) National development plans, regional and provincial concerns into three areas. To support the development of fisheries in Lake Tempe, required the determination of Fisheries Development Center . The center is under the coordination of the three governments around Lake Tempe (Soppeng, Wajo and Sidrap ) and controls the development of fisheries , namely fishing , aquaculture and conservation of fisheries resources . This development center will work closely with universities , research institutes , other concerned parties and professionals to think about : the innovation of fisheries technology , how to accelerate the increase in the income of fishermen and fish farmers , good farming practices with a mechanism of cooperation between fishermen , the company 's core and fish farmers , standard fishing facilities , how to speed up production , and others .

Research on the conservation of endangered endemic fish is important to provide an overview of the fish's ability to sustain life as well as the development of endemic fish from time to time . Pressure exploitation and habitat degradation affect the survival of fish in one place . Data last 5 years showed a decrease in the production of certain fish in Lake Tempe . Therefore , it is necessary fisheries research in the field of complex and multidisciplinary . Thus , an assessment of the sustainability or sustainability of fishery resources can not be reviewed in one dimension but involves various dimensions ( Pitcher and Preikshot , 2001) and needed a solution to overcome this . As well as basic data for the determination of policy management and utilization of aquatic resources in order to preservation of endangered fish populations can be sustained

Fisheries in Indonesia requires careful planning and management in order to be sustainable fisheries activities . Having regard to the characteristics of freshwater fishery in Lake Tempe especially endangered fish as well as the concept of sustainability assessment of fisheries , it is necessary to see how the sustainability of the fisheries of Lake Tempe on multiple dimensions of sustainability , namely habitat , fish resources social, economic, technological and institutional law .

Some aspects of sustainability can be used as one of the bases to see the status of the sustainability of the fishery waters so that it can be used as a reference in formulating policy of sustainable management of fisheries resources or endangered fish in the region. Therefore, this research is necessary and very important because the sustainability of endangered fish in Lake Tempe.

The aim of this study are :

- 1) Determine the composition of the type and size of fish in Lake Tempe
- 2) Analyze the status of sustainability and fish management strategies based on the social, economic, institutional, fish resources, habitat, and technology.
- 3) Formulate alternative fisheries management policy in Tempe Lake particularly endangered fish

# 2. Methods of Research

The experiment was conducted in October 2012 - March 2013 (pre - study) in three districts namely Wajo, Soppeng, and Sidrap to identify the composition of fish species in Lake Tempe. Data on the composition of the catch can be obtained in conjunction with the catch - effort data is catching. Data were collected at regular intervals to describe the general composition of catches from each gear from various times

and regions in the fishing season. Data should be analyzed carefully in conjunction with environmental fluctuations and changes in environmental conditions that systematically.

Research continued in May- August 2014 to determine the spatial and temporal distribution of endemic fish in Lake Tempe and to determine the factors that threaten the extinction of fish endemic to retrieve data directly through six stations namely : 1.Sungai out -take (estuary Cenranae - Wajo), 2 Rivers in -take (estuary When - Wajo), 3. River in -take ( estuary Belokka - Wajo ), 4.Sungai in -take ( estuary Wette ) Kab.Sidrap, 5. River in -take (Stones River estuary - Soppeng ), 6. The in -take (Walannae River estuary and river Woronge ) Kab.Wajo.

Assessment of the status of conservation of fisheriesfish in Lake Tempe determined using RAPFISH (Rapid Appraisal for Fisheries Sustainability) developed by Fisheries Center University of British Columbia (Kavanagh, 2001). In RAPFISH analysis conducted several stages, namely: 1) Determination of attributes, 2). Sensitivity analysis, 3). Dimensions of sustainability status management, and 4). Multidimensional sustainability status.

#### 1. Determination Attributes

This study uses 30 attributes of 6 dimensions (social, economic, habitat , fish resources , technology , and institutional) in RAPFISH analysis . Each attribute and criteria in each dimension refers to the manual modification EAFM module (*Ecosystem Approach for Fisheries Management*) of the CTF , WWF , and PKSPL - IPB (2012) and Ali et al . (2012) and adapted to the results of observation in the study area .

#### 2. Sensitivity Analysis

To view the attributes that give effect to the sustainability index sensitivity analysis (leverage analysis). The most sensitive attributes will contribute to sustainability in the form of changes to the *Root Mean Square* (RMS) that is on the X axis ( scale sustainability). The larger the value the greater the change in RMS role is the more sensitive attributes in the formation of sustainability on a scale value of sustainability.

## 3. Sustainability Status Dimensions

Index value and status of sustainability in this study were grouped into four categories keberlanjutan.Setiap status attribute estimated scores, ie the maximum score of 3 to 1 for good condition and bad condition, and them to a state of good and bad. Score is the definitive mode values are analyzed to determine the points that reflect the position of the sustainability of the system under study relative to the good and bad points with statistical MDS ordination techniques . Scores estimate each dimension is expressed with the worst scale of 0% to 100 % best.

## 4. Status Multidimensional sustainability

The program is a joint -dimensional weighting method combined pairwise comparisons (*pairwise comparison*) of the *Analytical Hierarchy Process* (AHP) with weighting by using Expert Choice program 9.5. Then each dimension of sustainability index multiplied by the weight of each

dimension of AHP analysis results are described in terms of hierarchy .



## 3. Results and Discussion

The study was conducted in three districts Tempe Lakes region (Kab.Wajo, Soppeng, Sidrap). Collection of secondary data and primary data include: the composition of fish species in Lake Tempe, types of fishing gear used, the economic, the social, cultural and institutional dimensions are very influential in the management of endagered fish in Lake Tempe.

Data production catches of fishermen on Lake Tempe in each district simplified in the form of Table 1 below. Table 1. Production of fisheries in Lake Tempe

VEAD	PRODUCTION (ton)			
IEAK	WAJO	SOPPENG	SIDRAP	
2005	9785,00	2847,00	770,00	
2006	10474,00	2896,00	683,00	
2007	13525,00	3133,00	276,00	
2008	13519,00	2650,00	371,00	
2009	11178,00	2455,00	606,00	
2010	11272,80	2.372,30	3.013,70	
2011	10960,31	3.386,30	3.222,10	
2012	10920,70	2.629,56	2.231,93	
2013	11794,35	3.173,20	2.790,66	



According to the table and the chart above, obtained information that the average fish production in Lake Tempe increased. There is a considerable difference siginifan production in the three districts, fisheries production (2013), the highest in Wajo with 11794.35 tons / yr, followed Kab. Soppeng with 3.173.20 tons / yr and lows Kab.Sidrap with 2.790.66 tons / yr. One of the causes of high fish production in Wajo due Wajo have catchment area larger fish (70%) compared to other districts. In addition to the production data of the catch, also obtained data on the composition of fish caught and the type of fishing gear in Lake Tempe, as in Table 2.

**Table 2:** Composition of fish at Lake Tempe

NO	FISH	WAJO	SOPPENG	SIDRAP
1	Mas	$\checkmark$	$\checkmark$	
2	Mujair	$\checkmark$	$\checkmark$	
3	Tawes			
4	Gabus	$\checkmark$	$\checkmark$	
5	Sepat siam	$\checkmark$	$\checkmark$	
6	Betok	$\checkmark$	$\checkmark$	
7	Nilem		-	
8	Betutu		-	
9	Belosok		$\checkmark$	-
10	Belut		-	-
11	Pepetek		-	-
12	Belanak		-	-
13	Tambakan	-	-	-
14	Lele		-	
15	Sidat		-	-
16	Udang			-

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NO	FISHING GEAR	WAJO	SOPPENG	SIDRAP
1	Jaring Insang tetap/lanra Gill	2	2	2
	nets)	v	v	v
2	Jaring Angkat/ serok		-	
3	Rawai		$\checkmark$	
4	Pancing		-	
5	Perangkap (sero)		-	
6	Perangkap (jermai)		-	
7	Perangkap (bubu)		$\checkmark$	
8	Jala		-	
9	Garpu tombak		-	-
10	Timpo			-

Based on the research results, and referring to the IUCN conservation status categories (*International Union for the Conservation of Nature and Natural Resources*) within the classification of the species of living creatures are

endangered, obtained information on the status of fish species which consists of categories extinct, endagered, critical / endangered, low risk (normal) and less information. Categories various types of fish in Lake Tempe shown in Table 4.

Table 4: Category / Conservation Status of Various Type	s
of Fish in Lake Tempe	

Indonesian Fish Name	Latin Fish Name	Category
Betok	Anabas testostides	Normal
Sidat	Anguilla sp	Endangered
Sepat Siam	Trichogaster pectoralis	Normal
Gabus	Ophiocephalus striatus	Normal
Nila	Tilapia niloutica	Normal
Lele	Clarias batracus	Endangered
Tawes	Punctius javanicus	Normal
Mas	Cyprinus carpio	Normal
Nilem	Osteochilus hasselti	critis
Belanak	Mugil sp	Endangered
Betutu	Oxyeleotris marmorata	Normal
Tambakan	Heleostema temminckii	extinct
Bungo	Glossogobius aureus	critis
Belut	Fluta alba	Normal
Udang Putih	Palaemon spp	Normal
Kakap Putih	Lates sp	critis
Pepetek	Leoignathus dussumier	Endangered
Rebon	Metapeneus sp	Norma
Remis	Anadara sp	Normal

Categorization status fish species above, based on the results of direct observation by looking at the total population, calculate abundance indices, see a decrease area of existence and quality of habitat, exploitation rates (actual) current and future possibilities, the effect of introduced species, inherbreeding, pathogens, competitors pollutants and parasites. In addition to the above dimensions of fisheries resources, are also synchronized with some of the factors causing the decline of fish production in Lake Tempe covering the economic, social , technological ( fishing gear used), and institutional dimensions.



Based on data analysis using AHP, then obtained the status of fisheries management on Lake Tempe in good condition at 50.583.

## 4. Conclusion of Research

- 1)Based on production data fisherman catches of the year 2005-2013, Wajo the highest production areas of the catch, then in Soppeng and lows in Sidrap.
- 2)Based on the results, obtained some fisheries problems that occur in Tempe Lake are as follows :
  - a) The decline in bio-diversity and fish production in Lake Tempe. The decline in production occurs due to excess fishing, the use of non- selective fishing gear, and habitat destruction resulting scarcity of fish endemic (Beloso,cranky, mullet, and gouramis)
  - b) A shift in species composition due to the introduction of alien species, inhibition of reproduction and recruitment process naturally. This causes some dominant fish, and other types of fish increasingly scarce even some kind is endagered ly caught
  - c) Tempe lake degradation that affect aspects of ecology and fish resources, especially fish endemic . Silting of the lake are very fast (15-20 cm /year) due to the lake tempe receive solid waste disposal of several major rivers (river and river When Walannae) which empties into the lake tempe. Consequently sedimentation took place very quickly,
  - d) Lack of synchronization three districts namely Wajo, Soppeng, and Sidrap in the management area and time fishing at Lake Tempe,
  - e) There is no comprehensive policy by 3 districts / cities which are central Tempe lake fisheries management .
- 3)Based on data analysis using AHP, then obtained the status of fisheries management on Lake Tempe in good condition at 50.583.

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