

MANUAL GUIDE
REMODELING SWAMP FISHERIES:
CONSERVATION AREA



Research Institute for Inland
Fisheries and Extensions



Inland Fishery Resources
Development and Management
Department (IFRDMD)

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MANUAL GUIDE

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MESSAGE
FROM CHIEF OF SEAFDEC/IFRDMD

Congratulations to the authors at SEAFDEC/IFRDMD on the successful publication of the guideline book.

These guidelines can be reached and applied in SEAFDEC member countries and stakeholders to promote the conservation of swamp areas while still promoting the sustainable management of inland fisheries and involving communities in preserving the health of inland waters.

Here's to the continued growth of the SEAFDEC/IFRDMD program, providing valuable insights into the sustainable management of inland fisheries in Southeast Asia!

Jakarta, April 2024

Andi Soesmono

PREFACE

This book provides an introduction to inland fisheries, discussing types of inland aquatic ecosystems, freshwater fish biodiversity in swamps, and concepts of swamp management models to be developed as conservation areas.

As a swamp fisheries management model, Patra Tani Village, located in Muara Enim Regency, South Sumatra Province, Indonesia, belongs to the Research Institute for Inland Fisheries and Extension of the Ministry of Marine Affairs and Fisheries, which developed the model in collaboration with the SEAFDEC/Inland Fishery Resources Development and Management Department. It is hoped that this model can be applied in other areas of course with various modifications tailored to local environmental conditions.

This book is a valuable resource for the development of swamps with limited supporting environments for fisheries. Its insights and recommendations have the potential to significantly contribute to the field of inland fisheries and conservation.

Palembang, April 2024

Authors

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INTRODUCTION

Indonesia is an archipelago country located in the equatorial and felt tropical weather throughout the year. Besides the strategic position, Indonesia also has large resources in land and sea territory. Indonesia has become one of the top countries with the largest biodiversity in the world. With two-thirds of the water area by the total territory of countries, Indonesia is rich with flora and fauna, including aquatic species in the sea and freshwater ecosystems. Freshwater and inland waters become essential habitats for human life, especially for rural people who live on the border of rivers. Indonesia's inland water consists of a large river basin that flows and forms a special habitat such as floodplain, lakes, oxbows, and reservoirs for the artificial habitat. The identical structure formed for each habitat based on its forming process and location made it potential for the growth of endemic fish populations and other species.

Inland waters are land that is formed by flooded of water for a while or in stable condition. The flooded land has dynamic water and it flows or stays for a moment such as a river, reservoir, lake, swamp, floodplain, and other flooded areas. Indonesia has 54 million hectares of inland waters consisting of 0.05 million hectares of reservoirs, 1.8 million hectares of lakes, 12 million hectares of rivers and floodplains, and 39.5 million hectares covered by swamps (Kartamihardja *et al.*, 2017). Besides the large potential of inland water in Indonesia, the statistic has recorded around 7,977 river basins, 1,144 main rivers, 312 large dams, 322 lakes, and more than 5,000 large flooded areas (Direktorat Sumberdaya Air, 2021).

The inland waters are multipurpose areas with various human activities. Human life and needs cannot leave freshwater sources for daily consumption. It does not include the activities through the water bodies for transportation, settlement, recreation, and support for farming, planting, and mining (Kolding & Zwieten, 2014). Many kinds of activity remain pollutants and excess material. It makes the rise of risk and threatens fish

resource lives that face environmental pressure and extinction. The change in the environmental quality of water, poisoning, pollutant accumulation, and unfriendly fishing activity were the main issues for developing sustainable fish resources (Welcomme *et al.*, 2010).

The utilization of inland water resources always involves many sectors and fishery will be a part that is impacted by the excess of all activities. The government of Indonesia has regulated the activities and utilization of inland water resources for the welfare of society to sustain them for the next generation. One of the regulations for fisheries management is Act Number. 31-year 2004, which was amended by Act Number 45-year 2009. On the technical implementation, the Act regulation has been interpreted by The Marine Affairs and Fisheries Minister Decision (PermenKP) Number 29 year-2016, about the arrangement of planning for fishing and exploitation of inland waters resources. The regulation said the ways for a technical guideline for fishing and exploitation to optimize the resource utilization, continuity, and sustainability of inland fishery resources. Besides of two regulations, the Minister of

Marine Affairs and Fisheries also decided the technical regulation on PermenKP Number 9 in the year 2020, that divided the inland water territory of Indonesia into 14 parts called “Wilayah Pengelolaan Perikanan Perairan Darat (WPP-PD)” (Figure 1).

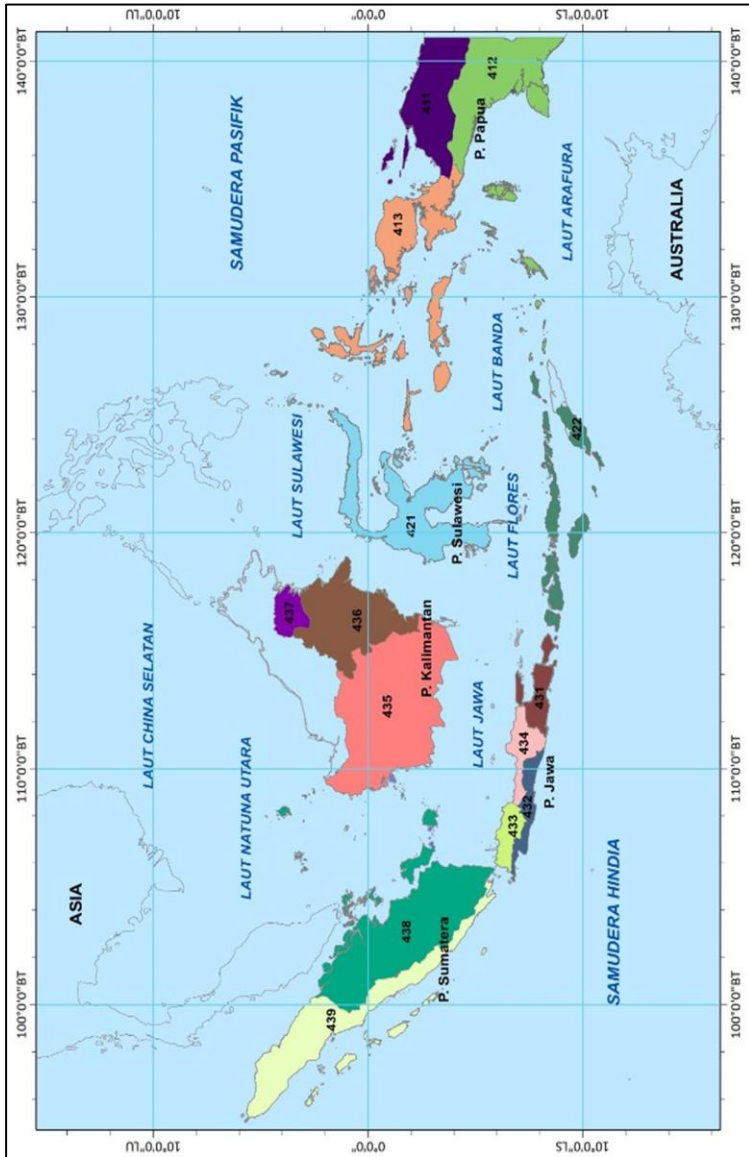


Figure 1. Indonesia's Inland Fisheries Management Areas (Wilayah Pengelolaan Perikanan Perairan Darat, hereafter called WPP-PD)

With this regulation, the government can manage the potential of fisheries resources based on the stock unit by the dominant ecosystem located in each area. The inland fishery has related to the geographic condition that varies and is identical by the topography of the land. This demarcation of the area also introduces the unit stock of fish resources that are exploited in each plain area.

One of the potential areas with a large swamp in Indonesia is located in South Sumatra and it is placed in 438 WPP-PD areas. The 438 WPP-PD includes five provinces they are Lampung, South Sumatra, Jambi, Riau, and Bangka-Belitung.

The 438 WPP-PD has a similarity of habitat typology dominated by large and long rivers that flows to the Java Sea on the east part (Husnah *et al.*, 2019). These rivers give specific characteristics to the border sides with a wide area of the floodplain and peat land on the downstream and middle areas. The floodplain is characterized with low acidity water pH, shallow water, and low dissolved oxygen. It will dramatically change with water fluctuation and rainfall rate. The unique

habitats are supposed to have the different characteristics of fish inside of this habitat. They can live with the high stress of low pH acidity and dissolved oxygen. The freshwater commodity also has high economic value for food and consumption for local people.



INLAND FISHERIES ECOSYSTEM

The diversity of fishery resources is adequately related to the various ecosystem formed as a unique habitat for many species. Each species has different habits for its life cycle such as its reproduction, feeds, migration, and protection. Each ecosystem has a special characteristic as pictured in the environmental interaction. The main form of the tropical ecosystem, we know kinds of it, they are rivers, lakes, reservoirs, swamps, and floodplains. In this part, we try to understand the uniqueness of each and the essential portion of the fish habitat.

Rivers

A river is a water body that flows from the upstream in a mountainous to the downstream area or sea. The river is the way of water that comes as rain in the plateau area and runoff ways on the border around. Rivers have become the primary surface freshwater resource that humans directly use for a variety of purposes. Besides its

consumption needs, the river is also used as a water resource for farming and ponds. The river system and border are also used for the settlement of rural people.

The river was very close to the people who lived there a long time ago, which caused the river to be the source of life. The South Sumatra Province and the Musi River, or “Batang Hari Sembilan,” are very similar. The total length of the Musi River is around 750 km, which flows from Bengkulu mountainous to the Banyuasin regency that faces the Java Sea. The Musi River consists of nine large rivers: the Komering River, the Rawas River, the Leko River, the Kelingi River, the Lematang River, the Ogan River, and the Rupit River, with a total water body coverage of around three million hectares.

Lake

A lake is an area filled with water, surrounded by land, and formed by tectonic or volcanic phenomena. A lake is one localized by a river basin that is 10 meters deep or more. The water bodies of lakes usually have high transparency and less sediment contain, and some of them have high nutrients. Lakes are also utilized as

sources of freshwater for consumption. Related to fisheries activity, most people use lake as a fishing ground, and aquaculture ponds using floating cage systems. The diversity of fish is adequately related to the river's connectivity, vegetation, and the species that are introduced to it.

Reservoir

Reservoirs are artificial waterbodies that are made by the dam of the river or by digging some area to be lowland and filling with water. The reservoir has been built for a specific purpose; some of it is used for irrigation of farming areas, electricity production, or as a source of freshwater. To avoid crashes or accidents, some of them are forbidden from entering and doing any activity, including fishing. Other sectors, such as fishing, aquaculture, and tourism, have access depending on the administrator's decision. The reservoir has the potential for the fishery as a natural habitat, feeding area, nursery, and breeding ground.

Swamp

Swamp is a lowland that is always filled with water for a while or permanently. The water sources of the swamp come from the runoff process as rainfall excess. The water from the rain will be flowing and assembled on the lowland. Most of the swamp areas are located in the middle stream and downstream areas. Swamp is called the transition ecosystem between land and water (ecotone). Shallow water level, high substrate, and overgrown dense water plants that float at the surface. Swamps are not essential for freshwater resources for humans, but they are important for fish. With much substrate decomposition inside, this location is rich with nutrients, which are the source of energy for the live flora and fauna around this ecosystem.

Floodplain

The floodplain has an identical character to the swamp, but this ecosystem only forms around the big river that usually floods once a year or more. South Sumatra has a large potential for floodplains as a consequence of its large river borders. The Musi River and its tributaries flood every year and create a new ecosystem. The floodplain is important for the fish population, especially

for breeding and feeding habitat. The fish that live in this ecosystem adapt to low dissolved oxygen levels and low pH levels (acid). They can live by taking oxygen directly into the air using a special organ called the "labyrinth." As transition habitats, floodplains have high nutrients that are important for the organism at the first trophic level.

Productivity

The essential thing of the inland fishery or freshwater fish commodity is important for protein fulfillment because it is easy to find and has low prices. The better consumption of freshwater fish also supports the food security of the people. The products of the freshwater fish have various tastes, diverse ways of cooking, and nutritional ingredients. It has become a particular attraction value for consumers compared to poultry, livestock, and seafood product (Welcomme, 1983).

On postharvest, the freshwater fish will be consumed as a fresh product and preserved as dry and salty products. The product by the post-harvest process can rise the quality, and price on the market.

The fishing activity by local people could be income and give welfare as economic activity. The contribution through this activity becomes an essential benefit for rural people on a low economic level. Fishing can be the main occupation for people to fulfill their needs in economics and daily consumption (Muthmainnah & Gaffar, 2017).

Besides fishing activity, the potential of freshwater can be utilized as an aquaculture commodity that is productive for rising people's income and investment. The aquaculture of freshwater fish also opens the chance to accept workers for local teenagers. Aquaculture as a local commodity has become an interesting business for many people because of the needs and economic benefits that are always open and easy to accept in the market (Manila, 1989). The aquaculture activities not only stop the consumption of the product but also the contribution by a transaction of indigenous species market.

The many ways of aquaculture technology have been developed and adopted depending on their environment,

location, or species. Floating cage, artificial pond, and hatchery are developed following the acceptability of people's knowledge and capital. As we know the large potential of fisheries resources in Sumatra Island not only comes from the variety and diversity of fish species but also from land used for fishery activities.

The people can utilize the water bodies for free and rent them for a while. Especially in South Sumatra Province, some parts of the water body have been auctioned by the local government for limited exploitation (Nasution & Sastrawidjaja, 2011).

The auction of water bodies in South Sumatra has become the potential income for the local government. The local government in villages or districts can manage the potential income for social welfare with support for the development of public facilities.

The fishery production has shown the process of production of fishery commodities by exploitation and manufacturing activities on their local resources. The South Sumatra Province's potential for the fishery is

reported in statistical data, it pictures the various and comparative production among each regency (Table. 1). In Table 1, we can show production of aquaculture has the largest compared to capture fishery. The high value of capture fishery production in some regencies. It explains that the fisheries' environmental condition is still protected and well for the natural habitat of a fish population. The fishing or capture fishery is dominant compared to aquaculture activities.

The social structure and perception of fishery activities for capturing fish in a wild are stronger than those developed in the aquaculture sectors. The aquaculture sector will rise, especially for the region that has minimum access to fishery resources and complicity of demand for fishery products.

Table 1. The Aquaculture and Capture Fisheries Production in South Sumatra Province.

Regency/City	Production by Capture			Production by Aquaculture		
	Fishery (Tons)			Fishery (Tons)		
	2018	2019	2020	2017	2018	2019
Ogan Komering Ulu	1,000	1,159	1,215	667	416	605
Ogan Komering Ilir	3,783	5,896	5,327	148,512	71,093	93,793
Muara Enim	3,674	4,577	3,337	211,517	4,964	8,855
Lahat	91	349	642	2,509	35	286
Musi Rawas	2,962	744	477	15,894	70,334	97,082
Musi Banyuasin	3,236	47,464	25,120	66,578	80,023	42,193
Banyuasin	5,627	22,246	10,665	22,132	40,458	59,241
OKU Selatan	2,237	195	249	46,308	823	3,498
OKU Timur	2,042	1,609	688	5,212	44,957	69,027
Ogan Ilir	9,878	8,503	8,509	5,204	7,967	11,171
Empat Lawang	2,404	3,687	1,020	3,818	416	599
Pali	124	1,632	626	-	251	723
Musi Rawas Utara	3,574	4,813	1,664	10	6,212	237
Palembang	2,033	1,730	1098	100	61,494	237
Prabumulih	-	44	130	1,211	603	774
Pagar Alam	-	161	355	3,745	32,041	2,198
Lubuk Linggau	47	161	84	4,864	16,972	4,365
Sout Sumatra	93,355	104,971	61,194	538,282	439,058	472,369

**Data: Statistic Report of South Sumatra (2021).*

The Banyuasin and Musi Banyuasin have reported high production by the fishing or capture fisheries in South Sumatra. Both of them are the regencies irrigated by the middle and downstream parts of the Musi River. Downstream of the Musi River becomes the potential area for capture fisheries in South Sumatra.

The mixing of the various species between the white fish (freshwater fish), and saline fish happened here. The downstream river also becomes the potential area for breeding, feeding, and nursing many fish populations. Most fishing activities downstream used a large and massive catch of fishing gear. (Muthmainnah & Gaffar, 2017). They are used to block and cut the fish migration method for the catch of various sizes.



FRESHWATER FISH BIODIVERSITY

The biodiversity of fish can and does serve as an indicator of ecosystem health. Unfortunately, these impacts threaten freshwater biodiversity and have declined in many areas. Aquatic ecosystems (inland and marine) represent the most biodiverse human food sources. The biodiversity includes vascular plants, algae, and animals such as crustaceans, mollusks, reptiles, amphibians, and finfish. Freshwater ecosystems cover only about 1 percent of the earth's surface but provide habitat for over 40 percent (13,000) of the world's freshwater fish. Another 2,000 species of fish can also live in brackish water.

Many freshwater species are essential to aquaculture as broodstock sources for spawning and early life history stages (e.g., eggs, larvae) for growing. Non-native aquatic species can contribute significantly to the production and value of inland fisheries and aquaculture.

According to Welcome (2001), there were three categories of fish based on their principal behavioral guilds and the nomenclature initially as follows:

Whitefish: This guild groups large, strongly migratory fishes from several families that move significant distances within the river channel between feeding and breeding habitats. The fish may pass their whole life history in the main river or move onto the floodplain to feed. They are generally intolerant of low dissolved oxygen concentrations, preferring migration to escape the adverse conditions downstream during the dry season. Whitefish are usually one-shot spawners, scattering numerous eggs, which may remain to hatch in situ and be pelagic or semi pelagic, being swept downstream with the current.

Blackfishes: This guild consists of fish that move only locally from floodplain water bodies to the surrounding plain when flooded, and return to the pools during the dry season. They are adapted to

remain on the floodplain at all times, often having auxiliary respiratory organs that enable them to breathe atmospheric air or behavior that allows them to maintain the eggs and newly hatched fry in relatively well-oxygenated conditions.

Greyfish: These species are intermediate between the floodplain-resident and the long-distance migrant guilds. Greyfish generally execute short migrations between the Floodplain, where they reside at high water for breeding and feeding, and the main river channel, where they shelter in marginal vegetation or the deeper pools of the waterways over the dry season. The species are less capable of surviving deficient oxygen levels but have elaborate reproductive behaviors, enabling them to use the floodplain for breeding.

The large diversity of fish species for freshwater fish in South Sumatra should raise attention and awareness for the sustainability of fish resources. The diversity of freshwater fish will be strongly affected by climate change and environmental pressure.

The latest research and publication reported the recent situation in the fish population.

Table 2. Freshwater Fish Species caught in the Musi River of the South Sumatra.

No	Family	Species	Common Name	Local Name
1	Cyprinidae	<i>Osteochilus vittatus</i>	Bonylip barb	Palau
2		<i>Cyclocheilichthys apogon</i>	Beardless barb	Seberas
3		<i>Leptobarbus hoevenii</i>	Hoven's carp	Jelawat
4		<i>Barbonymus schwanenfeldii</i>	Tinfoil barb	Lampam
5		<i>Puntiplites bulu</i>		Tebengalan
6		<i>Puntigrus tetrazona</i>	Sumatra Barb	Pirik elang
7		<i>Osteochilus melanopleura</i>		Aro
8		<i>Barbichthys laevis</i>	Sucker barb	Bentulu
9		<i>Osteochilus microcephalus</i>		Buing
10		<i>Thynnichthys thynnoides</i>		Damaian
11		<i>Labiobarbus ocellatus</i>		Lambak Usang
12		<i>Hampala macrolepidota</i>	Hampala barb	Sebarau
13		<i>Balantochelius melapterus</i>	Tricolor sharkminnow	Puntung hanyut
14		<i>Rasbora sp</i>		Seluang
15		<i>Haludaria fasciata</i>	Melon barb	Semuringan
16		<i>Labiobarbus festivus</i>	Signal barn	Siambut
17		<i>Labeo chrysophekadion</i>	Blackshark minnow	Sihitam
18	Channidae	<i>Channa pleurophthalmus</i>	Snakehead	Bujuk
19		<i>Channa striatus</i>	Striped snakehead	Gabus
20		<i>Channa micropeltes</i>	Indonesian snakehead	Toman
21		<i>Channa melasoma</i>	Black snakehead	Serkoh
22	Anabantidae	<i>Anabas testudineus</i>	Climbing perch	Betok
23		<i>Trichopodus pectoralis</i>	Snakeskin gourami	Sepat siam
24		<i>Trichopodus trichopterus</i>	Three spot gourami	Sepat Mato Merah
25		<i>Trichopodus leerii</i>	Pearl gourami	Sepat Daun Buluh
26	Helostomatidae	<i>Helostoma temminckii</i>	Kissing gourami	Tembakang
27	Belontiidae	<i>Belontia hasselti</i>	Malay combtail	Selincah
28	Bagridae	<i>Mystus gulio</i>	Long whiskers catfish	Lundu
29		<i>Mystus micracanthus</i>		Biran
30		<i>Hemibagrus nemurus</i>	Asian redtail catfish	Baung
31		<i>Mystus nigriceps</i>	Twospot catfish	Beringit
32	Clariidae	<i>Clarias macrocephalus</i>	Bighead catfish	Lele
33	Siluridae	<i>Wallago leerii</i>		Tapah
34		<i>Kryptopterus schilbeides</i>		Lais kocor
35		<i>Kryptopterus cryptopterus</i>		Lais tapah
36	Pangasidae	<i>Pangasius macronema</i>		Riu-riu
37		<i>Pangasius polyuranodon</i>		Juaro
38	Cobitidae	<i>Chromobotia macracanthus</i>	Clown loach	Kejublang
39	Pristolepididae	<i>Pristolepis grootii</i>	Indonesian leaffish	Kepor/Sepatung
40	Nandidae	<i>Nandus nebulosus</i>	Bornean leaffish	Setambun
41	Mastacembelidae	<i>Mastacembelus unicolor</i>	Spinny eel	Tilan
42	Cynoglossidae	<i>Cynoglossus feldmanni</i>	River tonguesole	Lidah
43	Tetraodontidae	<i>Tetraodon sp</i>		Buntal
44	Chandidae	<i>Parambassis wolffii</i>	Duskyfin glassy perchlet	Spengkah
45	Eleotridae	<i>Oxyleotris marmorata</i>	Marble goby	Betutu

Table 2 also shows the diversity of freshwater fish records based on research and observation on latest the five years (Muthmainnah & Gaffar, 2017). The method of sampling and fishing season also affect the dynamic situation in field observation. Fish of high economic and ecological value such as sepat (*Trichogaster sp*), tembakang (*Helostoma temminckii*), gabus (*Channa striata*), tapah (*Walago leeri*), and baung (*Hemibagrus sp*), should be protected and guaranteed for living to ensure the sustainability of population (Kartamihardja *et al.*, 2017).

IV

THREATEN AND CHALLENGES

The Musi River or “Batanghari Sembilan” is the main river in the South Sumatra Province, with various human activities around. The anthropogenic impact on the Musi River has caused it to become a critical river in Indonesia, along with 14 rivers in Indonesia. The role and existence of the Musi River for the South Sumatra people are very close. The pressure of the environment is impacted by multisectoral utilization, including industry, farming, transportation, forestry, fisheries, and settlement are contributed inside (Wiadnyana & Husnah, 2011). Fisheries, as one sector of water bodies, are always impacted by the dynamic change of the environment. The pollution and change in the land use of rivers are dominant contributions to the ecological pressure of the fish population. The loss of endemic species and change in body size is the first signal that the population has under pressure.

In this part, we would like to give an overview of the source of the ecological pressure and the impact on the fisheries sectors. The general issues will be explored, especially the environmental degradation due to anthropogenic impact, the destructive and illegal fishing practices, and social conflict on fishery management and utilization.

Environment Degradation

Environmental obstruction cannot be avoided as the excess of human activities to utilize the resources. The decrease in fish populations in some locations and moments is dominated by ecosystem pollution, debris, and poisoned material thrown into and inside the fish habitat. Industrial, farming, mining, and transportation are the main activities that affect and contribute to change in the environment (Strayer *et al.*, 2010). The direct impact of pollution is the rise in mortality rates, even the poisoning effect, the destruction of feed resources, and the moving population (migration) to find other safe habitats for biological life (Reid *et al.*, 2018).

Besides the degradation of fish habitat, degradation at the global level also happened. Global warming, or climate change, is indicated by the rise in world temperature due to the increase of carbon dioxide in the atmosphere. Habitat destruction, especially for forests and green zones, is massive and uncontrolled; exploration through burning forests, bad planning of land use, and sedimentation in the water bodies affect the stress of fisheries habitat directly (Sharma *et al.*, 2007). The change in the weather cycle is reacted to by the change in reproduction pattern, breeding cycle, and fish migration.

The fish needs media, habitat, and locations that support the reproduction cycle. With the change in environmental conditions, the resources for reproduction will change dramatically. The loss of feed resources and essential nutrition for reproduction will affect the pattern of their life cycle. The reproduction pattern can be changed from total breeding to partial breeding, and it affects the quality of next-generation health (Archer & Partridge, 1999). Previous research has shown a decrease in water quality that passes the limited basic health water quality

standard set by Government Regulation (Peraturan Pemerintah) Number 82 of 2001 (Rosyidah, 2018).

Destructive and Illegal Fishing

The bad excess of fishing activities can come from illegal, unfriendly fishing gear practices, and destructive activities. The unfriendly fishing gear practices are sources of destructive and illegal fishing. It can kill or destroy one population on one-time fishing. (Adeyemo, 2003) cites a few examples of such practices: electric fishing “strum”, booming, poisoning waters, fish size selection, and interrupting the fishway (migration). Fishing using electricity sometimes can be useful for population sampling in a small area. But for simple practice, it is very harmful to the fish population, especially for fish that stay in shallow waters. The effect of electricity will destroy the embryo without killing the target species (Oberlercher & Wanzenböck, 2016). The fish embryo will be waned and decrease the descendant. The obstruction of habitat also happens when fishing using fish boom. The habitat on an abnormal condition, and does not fulfill the capacity needs for fish life. The

fish population will move to seek a safe place (Halls *et al.*, 2013).

The unfriendly fishing gear also threatens the fish population. It catches unselective sizes of fish and takes them all, from the juvenile to the large size. The unfriendly fishing gear not only comes from unselective species size targets but also causes the installation to block migration ways. The block of the migration lane will stop the broodstock and juvenile movement to find suitable habitat, and they will die immediately (Polet & Depestele, 2010). Sadly, we know the fish that are caught do not take or consume all sizes and species. The fisher takes the high-value species by consumption size by market. More than 40% of fish caught only become bycatch and are just thrown away (Larocque *et al.*, 2012). The decrease and loss of juvenile and small fish will endanger the life cycle of all populations. Juveniles and small fish are the food source for the trophic level above (Raby *et al.*, 2011). The effect of the pressure on the fish population can be traced by research that publish the diverse condition in the past and recent times. Research in the Musi estuary proves some species have been lost only by five years. In 2008, there were 143 species found

in Musi river estuary, while 89 species found in 2013 (Rais *et al.*, 2017).

Social Conflict in Fishery Management and Utilization.

Resource utilization to exploit their potential in the open area will be involved the interaction by many sectors or personnel. Fisher who takes part in resources in some water bodies will rub with other users in farming, transportation, industrial, and mining sectors. Conflict among them will cause the utilization of limited resources for multipurpose activities. Besides among sectors, the conflict also happened between fishers inside. The conflict will cause unclear demarcation, fishing areas, various fishing gears, and some destructive and endangering fishing activities (Polet & Depestele, 2010). The theft and destruction of fishing gear by others' fishing groups or another village also happen often.

South Sumatra Province has local wisdom that has been practiced for more than 100 years, it is called “Lelang Lebak and Lebung” or waterbodies auction. This auction is just done in a small river or large canal, floodplain area, and oxbow lakes. This system is used to reduce the local conflict between fishers and other sectors. Through the auction, the local government also can take benefits or

income to support the fulfillment of the people. The income from auction activity will be managed by the local government (village) to build or rehabilitate the fish ecosystem (Nurfirmanephie, 2011).



MANAGEMENT OF FISHERIES RESOURCES BY CONSERVATION APPROACHES

Conservation is one way to manage natural resources, including fishery resources. FAO has defined fishery management as the integration process of data and information collection, analysis, planning, monitoring, controlling, supervision, and law enforcement (Firdaus & Sari, 2017). The conservation area which is very important to ensure the natural habitat is always available without disruption. Protection for the population is the same as letting the population live naturally without disturbance and threat. Act Number 31 year-2004, amended by Act Number 45 year-2009, said a conservation zone for fisheries should be established based on sustainability and continuity principles.

The outlines of the preservation and conservation concept have been divided into territorial/area conservation and species conservation. The area conservation concept has focused on one area that is

identified as an essential area for natural life. The protection of this type releases the regulation forbidding people to enter to hunt, explore, and disrupt the living organism inside. For instance, in South Sumatra, we know “Berbak-Sembilang” National Park, which is rich in mangrove species. Area conservation can protect more than one species; the protection can cover many species inside the habitat. The weakness of this type of protection is the difficulty of observation and monitoring with limited personnel resources. The difference between protection for the species that focuses on one species that is threatened is indicated inside the red list of threatened species appendix. This protection has been supported by strong regulations that provide specific habitat protection, exploitation prohibition, species transferring, and consumption. The protection in this model has been implemented for “red arwana” (*Scleropages formosus*), “belida” (*Chitala lopis*), and “ikan dewa” (*Tor sp*).

The people in some regions are aware of developing their sanctuary areas. They divided their fishing grounds into the protection area and the fishing grounds. They protect them by their group and give the local prohibition

regulation. Establishing the small sanctuary in their area has no less of a management issue. The main issue for managing the conservation and protection of habitat in Indonesia is a classical problem. The total area of the conservation area is not equal to the natural habitat that is needed for the bio-ecological life cycle. The conservation has far locations for surveillance, and they have been shallowed by sedimentation or full coverage by shrubs (Kasim *et al.*, 2017).

South Sumatra has the potential for freshwater fisheries resources management through the utilization of the floodplain area that covers around 60% of the province. This should raise awareness among all stakeholders about the sustainability of fishery resources. Considering the characteristic of the floodplain in South Sumatra, it can be utilized for sanctuary and germplasm areas to increase productivity.

The sanctuary that is developed should be qualified based on an ecological characteristic (Utomo, 2014):

- 1) It is adequate for the water level, and it never dries at the peak of the dry season.
- 2) There are three types of adequate sanctuary: (1) A small sanctuary of the “lebung” type with a 0.5-hectare coverage area should be spread over more than one location. The species that fit this sanctuary type are betok (*Anabas testudineus*), keli (*Clarias melanoderma*), sepat (*Trichogaster pectoralis*), gabus (*Channa striata*), etc. (2) River sanctuary type, with a minimum one-kilometer length, and available for small caves or soil basins. The species that fit this sanctuary type are lais (*Kryptopterus kryptopterus*), baung (*Hemibagrus nemurus*), jelawat (*Leptobarbus hoevenii*), guramy (*Ospronemus guramy*), tapa (*Wallago leeri*), lampam (*Barbonymus schwanenfeldii*), etc. The oxbow-lake sanctuary type has a minimum coverage of 20 hectares, and the species that fit this sanctuary type are *white fish* (river fish) and *black fish* (swamp fish).

- 3) It has good water quality, and is not indicated by water pollution or poisons in which natural feeds such as periphyton, benthos, and plankton are available.
- 4) It has riparian plants around the sanctuary area. It is important for the feeding grounds, nursery grounds, and spawning grounds of fish. The essential riparians are putat (*Barringtonia acutangula*), mentangis (*Ixora mentangis*), menyawai (*Elaeocarpus submonoceras*), melayak (*Croton californicus*).
- 5) It has high water fluctuations (2 m–5 m). During the rainy season and high tide, fish can spread in all directions, following the water coverage to find the best location. And when the tide is low, the fish can go back to the sanctuary area.
- 6) The sanctuary should have a connection to other water bodies that are not blocked and are available for migration way.
- 7) The sanctuary's existence should be informed to the local people and get participation and support from all stakeholders around the sanctuary.

VI

FLOODPLAIN UTILISATION STUDY CASE IN PATRA TANI VILLAGE

History

South Sumatra became one of the development centers for agriculture, especially for the coconut industry in 1980. The center was located in Patra Tani, Muara Enim Regency. The coconut industry was developed as the largest company in Southeast Asia for coconut production from research, farming, cultivation, and postharvest. This industry was initiated by Indonesia's government, and the operation was under by PERTAMINA company (the oil and gas national industry of Indonesia). The Patra Tani story is also strongly related to the name of "Pertamina". The name "Patra Tani" consists of the word "Patra" which means "Pertamina" as the operator of industry, and "Tani" which means agriculture. Patra Tani was operated with high technology from research and development products of agriculture. Unfortunately, data and information about the large activities of this industry have not been found until now. Based on local people's

information, the industry in Patra Tani ended in 1985, and the land asset was returned to the local government Muara Enim Regency.

During the same period for agricultural development, South Sumatra became one of the pilot areas for developing the fisheries, aquaculture, and resources of Indonesia under the “SWAMP” Project. Most of this project was research for floodplain fisheries, management of peat land for aquaculture, and postharvest of local fish products. Since the “Patra Tani” company was closed and the land asset was still being needed for research activity, the Muara Enim government decided to grant the asset for research continuity. The fisheries project was under the Sub-Research Institute for Inland Fisheries of the Agricultural Research and Development Agency, Department of Agriculture, for research around 1985. To support the government research program, the Muara Enim government gives permits and allows their assets to be used for research activities under the Ministry of Agriculture.

For research activities, the Department of Agriculture makes Patra Tani the research installation especially for developing aquaculture technology of floodplain and peat land. Farming, sheltering, breeding ponds, and laboratory facilities were prepared to support the research activities. Until now, the Patra Tani Installation research has coverage of around 49.2 hectares, with a total of 10 hectares having been built with ponds and shelters. Some research has been done on this installation, starting from a study for identifying the acidity of peat land, rehabilitation of critical land to aquaculture, and breeding technology for local fish such as *Trichogaster pectoralis*, *Anabas testudineus*, and *Macrobrachium rosenbergii*.

Plan and Activity

Since the Ministry of Marine Affairs and Fisheries was established in 1999, the activities of research in Patra Tani stopped for a while. The research activities changed from aquaculture to fisheries resource-focused. The fisheries resource research does not utilize the ponds and other facilities for supporting the activities. The Patra Tani installation is only used for the observation station

and for collecting data periodically on fisher activity, water level, and fish productivity. With the dimmish of research activities, the Patra Tani installation looks abandoned.

The utilization of government assets, especially land and buildings, has been intensive. There is no exception to the Patra Tani research installation; it should be active and reproductive to support the vision and mission of the organization. The Research Institute for Inland Fisheries and Extension (RIIFE) or Balai Riset Perikanan Perairan Umum dan Penyuluhan Perikanan (BRPPUPP) started the revitalization of the facilities, started renewing the water installation, and repaired the hatchery ponds. The utilization to support research, the development of technology, and public consultation should be established immediately.

With collaboration works by RIIFE/BRPPUPP and other stakeholders including SEAFDEC-IFRDMD and FAO-IFish, the Patra Tani research installation has to encounter a new vision. Since 2019, collaboration works with SEAFDEC-IFRDMD have been programmed to

develop a conservation concept called “SPEECTRA” or “Special Area for Conservation and Fish Refugia”. This concept is expected to be a solution and attract many stakeholders to establish the simple concept of conservation in their area. SEAFDEC-IFRDMD has contributed to develop pond infrastructure and facilities to support the research inside the Patra Tani installation.

Besides infrastructure, the FAO-IFish project also gets a chance to rehabilitate fish stock with broodstock and a breeding program for local fish. After rehabilitation of area and assets, RIIFE or BRPPUPP has the vision of introducing the Patra Tani installation to the integrated fishery activity to preserve local fish species in South Sumatra. The promotion of South Sumatra fishery resources to the public and educating the next generation on sustainable awareness are important things.

Conservation Activities

The main purpose for establishing the conservation area is to protect the fish population from threats by human activities outside the protected area. Fish conservation should be provided during the fishway migration, and have connectivity to the river. The protection system can be grown naturally and made artificially. Natural protection can be formed by the riparian, vegetation, cave underwater, rocks, and lowland (Aryani *et al.*, 2020). Whereas artificial protection can be made by replanting the littoral area, dam, wood barrier, or artificial holes made in a floodplain area. The protection area is not only established as a shelter for hiding from enemies or hunters but also provides a suitable location for breeding, putting their eggs, and juvenile feeding. Space is required for the installation of fishing gear in an efficient location. The hunter will be hard to apprehend and restricted to entering buildings.

The Patra Tani installation is located near the Musi River and has connectivity by canalization. The first step to revitalizing the Patra Tani installation research is to rehabilitate the canal that surrounds the installation. The deep of the canal is around 2–3 meters. With this depth, water from the river can flow inside the installation and fill the ponds and their wetland. Water transfer from the river is very important to ensure the transfer of nutrients, washing the acidity on the soil, and fish movement. The changes in nutrients from the inside installation to the river nutrient can renew the soil condition. The phosphate, nitrogen, and minerals essential to the river can come inside and change soil-saturated conditions. Besides the transfer of nutrients, the water changes can be a way to transport the fish population to the shelter and protection area.

The depth canal can be used by the fish population to find the available place to live and stay. The canal that connects the river and lowland of the installation is a good chance for fish to spread inside the installation. The vegetation and lowland can protect the fish from their

predator, and the natural condition can let them grow naturally. Natural life can let the population recover by itself, and the new cohort will be formed as the new generation.

SPEECTRA as the New Concept for Conservation

One way to preserve the fish resources is to build a conservation area that protects the fishery resources around the habitat. Each habitat has different characteristics for the conservation area. Especially for floodplain areas, the conservation zone needs to connect to the rivers as the water sources and species movement. The Patra Tani installation is one of the floodplain areas that is flooded by the Musi River once a year. The intensity of floods from the river has been reduced for the last five years. To flow and transfer the water, a canal needs to be built. For establishing the conservation zone in the critical area with low flood intention, SEAFDEC-IFRDMD, and RIIFE were initiated to develop a conservation system that adopts many conservation concepts in Indonesia and innovates the function to be easy for implementation. The SPEECTRA (Special Area for Conservation and Fish Refugia) is one concept of

conservation that can be implemented in critical areas, especially the floodplain. The main concept of SPEECTRA is that fish that come from the river can enter the system, but they cannot return to the river because the mouth of the system has been closed.

The build process for SPEECTRA by SEAFDEC-IFRDMD and RIIFE started in 2019. There are five models of SPEECTRA that are designed to follow the land contour, sources of water, and species behavior. The design of SPEECTRA is introduced in the following pictures:

a. SPEECTRA model 1

The first model is the system that let the fish come inside the system and be restrained to the system (Figure 2). The SPEECTRA model 1 uses a bamboo barrier to control the population movement. The pond was dug around 4 meters deep to avoid the water drying. The fish will be trapped and grow in the system. They can adapt to the environmental situation and breed inside. The juvenile formed will be released, traversing the bamboo barrier, and returning to the rivers.



Figure 2. The SPEECTRA model 1 with bamboo barrier.

b. SPEECTRA model 2

The SPEECTRA model 2 is the conservation zone that combines with the farming pool. The combination of farming land and pools for fisheries can benefit farmers (Figure 3). This model is one hectare wide, and the average of pools deep is around 4 meters. The farming plant can be fertilized for the water, and utilized for alga growth. Mutualism symbiosis between farming and fishery can be implemented well. The juvenile can grow inside the system, or they can swim to the outside system through point “D”.

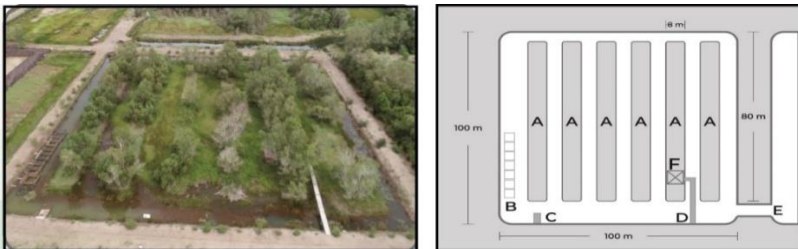


Figure 3. The SPEECTRA model 2 with farming system.

c. *SPEECTRA Model 3*

The SPEECTRA model 3 is the pool with additional connectivity pools situated in the center of the system (Figure 4). The connectivity pools functions as a shelter to protect fish inside the system. The total wide area reaches two hectares, and four meters deep. The shelters can be alternative ways for each species to hide and avoid their predators. Point “C” allows the juvenile to move both within and outside the system.

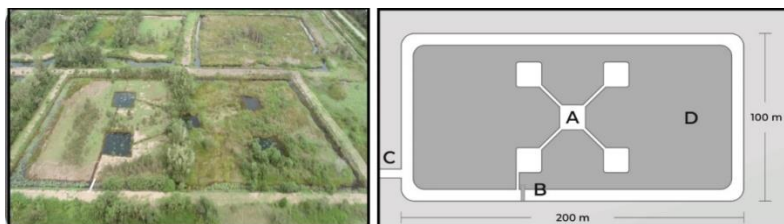


Figure 4. The SPEECTRA model 3 with small connectivity pools inside.

d. *SPEECTRA Model 4*

The SPEECTRA model 4 takes the concept of agroforestry, which combines the forestry and fishery around the system (Figure 5). The nutrient can be produced by the tree and transported to the water body. The nutrient can enrich the water for phytoplankton

growth. Besides that, this SPEECTRA has connectivity to model 3. The connectivity can be the way to transport and movement of fish inside the system.



Figure 5. The SPEECTRA model 4 with forest in the center of the system.

e. SPEECTRA model 5

This system is the largest SPEECTRA in the installation, which covers five hectares. The vegetation in this model is combined with trees and grasses (Figure 6). The system has connections to other SPEECTRAS, including number 4 and the main canal. With the low land inside, fish can use the vegetation for breeding and protect themselves.



Figure 6. The SPEECTRA model 5 with grasses land.

Carrying Capacity Study of the Environment

The carrying capacity study aims to ensure the artificial environment through the revitalization of a canal, and the development of SPECTRA has been successful. The new environment that is built should be adequate to provide life components such as nutrients, quality of water, natural feeds, and shelter for protection. To study and observe this capability, research that supports SEAFDEC-IFRDMD has been established. There are three methods to approach this goal: a study on growth analysis of the dynamic population, growth and condition factors as indicated by the adaptation of species to the environment, and water quality observation.

The purpose of the population dynamics analysis is to ensure the new population can succeed in being released into the new environment. In this method, the approach uses the measurement of the length distribution species that are caught every month. The measurement uses the dominant species in the SPECTRA ponds, for instance, the *Trichogaster leeri* (sepat merah). The sample is collected every month to measure the total length and

weight. The length of data can be classified based on the length class of each individual. The moving of the total population in each length class compared to the sampling periods can address the change in population structure. The changes in population structure can indicate that new recruitment has been done in the SPECTRA system (Figure 7). Figure 7 shows the movement of the class length every month of observation. 5 cm individuals dominated in January, and this height fluctuated and climbed in February and the following month. The movement of the length class has indicated to the population is growing and has adapted inside the SPECTRA ponds.

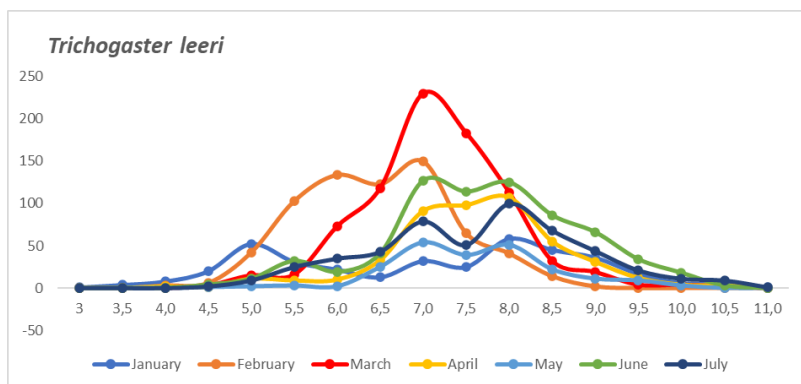


Figure 7. The dynamic population change of the *Trichogaster leeri* (sepat merah).

The analysis of growth by length-weight relationship model is a simple analysis for understanding the current situation of growth in relation to the environmental condition. The sample for this analysis is made up of the same individuals. The information that can be collected in this analysis is the maximum length and weight, the growth pattern, and the condition factor of the population. The maximum and minimum length has indicated the maximum length for each individual in the system. This data can be compared to the previous data or other research to prove the availability of the system. The growth pattern can indicate the growth model of the population; the growth can be isometric (length and weight are equal), or allometric (length and weight are not equal). The condition factors can be interpreted as the adaptation capability of the population to stay in the SPECTRA environment.

Water quality monitoring is a routine observation each month. The data collected included dissolved oxygen, pH, water temperature, and water level fluctuation (Figure 8). The aim of the activity is to observe and find the pattern of change in the water condition inside the SPECTRA

system. Water conditions also can give a picture of the readiness of the water bodies in the system for the new population. The low pH and dissolved oxygen are difficult to accept for common species, especially species from the river. They need to adapt, or the water and the pond should be reclaimed to avoid the pH and oxygen dropping dramatically.



Figure 8. Monitoring the water quality in the SPECTRA system.

Education and Tourism Development Concept

One of the aims of the revitalization of the Patra Tani installation is to become the center for educating stakeholders, including students at every level, and the public. People can gain a pleasant experience and new knowledge by seeing the installation facilities. The tourist can get information about Floodplain characteristics, fish species, technology that can be adopted, and the fish postharvest process (Figure 9).



Figure 9. SPECTRA installation in Patra Tani

The education activity involves elementary school, junior high school, senior high school, and university. The activities include the knowledge sharing on how to understanding the potential of peat land and Floodplain for fisheries business and the utilization of peat land with special characteristics and treatment such as washing the land, pH normalization, and hoarding. Besides environmental studies, the student can learn about the native species of the floodplain and how they can adapt to the critical water conditions. The study is not only about the environmental side, but it also allows tourists and

students visit the postharvest process by the native fish species. Postharvest is part of the business process of fisheries activities, and the understanding of the production component is useful for them.

Aquaculture Technology for Indigenous and High Economic Value Commodity

The sustainability of native fish is very important to preserve fish resources. RIIFE/ BRPPUPP collaboration with SEAFDEC-IFRDMD provides the Patra Tani installation for developing better knowledge about native species aquaculture. The nursery hatchery and ponds for juveniles and broodstock are prepared well in this installation (Figure 4 A–D). The training has involved fisheries stakeholders, including the extension officers, students, and the open public (Figure 10). The native species developed are tembakang (*Helostoma temmenckii*), sepat (*Tichogaster pectoralis*), lele (*Clarias sp*), and gabus (*Channa striata*).

The practice and development of technology include steps, which are:

1. The preparation of the broodstock in the ponds, broodstock selection, gonad maturation, breeding process, and rearing of the seed in the hatchery.
2. Preparation of ponds for nursery and enlargement of juvenile stadia to fingerling size.
3. Preparation to make the feed on every stadia of fish, including the natural feeds and instant feeds.
4. Culture fish for harvest size, including monitoring the growth periodically, fish diseases, and water treatment control.



(A)



(B)



(C)

(D)

Figure 10. (A) The hatchery facilities in Patra Tani installation; (B) The activities of training for the maturation of broodstock, (C) The rearing ponds for juveniles; (D) The fish cultured ponds to harvest size.

VIII AFTERWORD

Governments must find the will and way to preserve existing intact floodplain rivers as strategic global resources, and begin to restore hydrologic dynamics, sediment transport and riparian vegetation to those rivers that retain some level of ecological integrity. Floodplains must be viewed as conservatories of regional biodiversity and as fundamental units of river ecosystems that facilitate water, fisheries and wildlife resources, among many other natural goods and services.

Most importantly, floodplains are natural flood control structures, and they should be used that way. Non-governmental organizations and multinational institutions also play a leading role in transferring basic research information to the public and to decision-makers, and in securing protection for biodiversity hot spots. Their role in conserving and restoring floodplains and wetlands must increase in the near future in relation

to the fast-growing scientific knowledge about the importance of floodplains and communities' welfare.

REFERENCE

- Adeyemo, O. K. (2003). Consequences of Pollution and Degradation of Nigerian Aquatic Environment on Fisheries Resources. *The Environmentalist*, 23, 297–306.
- Air, D. S. (2021). *Data Sumberdaya Air*. Water Resource Data Center. <https://pdsda.sda.pu.go.id/>
- Archer, S. N., & Partridge, J. C. (1999). Optical Structure and Visual Fields in Birds: Their Relationship with Foraging Behaviour and Ecology. In *Adaptive Mechanisms in the Ecology of Vision* (p. 485).
- Aryani, N., Ariyanti, D. O., & Ramadhan, M. (2020). Pengaturan Ideal tentang Pengelolaan Daerah Aliran Sungai di Indonesia (Studi di Sungai Serang Kabupaten Kulon Progo). *Jurnal Hukum Ius Quia Iustum*, 27(3), 592–614.
- <https://doi.org/10.20885/iustum.vol27.iss3.art8>
- Biology and Physiology of Freshwater Neotropical Fish, Academic Press. Pages 1-19. ISBN 9780128158722, <https://doi.org/10.1016/B978-0-12-815872-2.00001-4>.
(<https://www.sciencedirect.com/science/article/pii/B9780128158722000014>)
- Firdaus, M., & Sari, Y. D. (2017). Pemanfaatan dan Pengelolaan Kawasan Konservasi Sumberdaya Perikanan (Studi Kasus di Lubuk Panjang-Barung Balantai, Kabupaten Pesisir Selatan, Sumatra

Barat. *Jurnal Sosial Ekonomi Kelautan Dan Perikanan*, 5(1), 1.

<https://doi.org/10.15578/jsekp.v5i1.5788>

Froese, Rainer., Pauly, Daniel (eds.). 2017. *Paedocypris progenetica* in Fishbase. September 2017 version

Halls, A. S., Conlan, I., Wisesjindawat, W., Phouthavongs, K., Viravong, S., Chan, S., & Vu, V. A. (2013). Atlas of deep pools in the Lower Mekong River and some of its tributaries. *MRC Technical Paper*, 31, 1–69.

https://login.proxy.lib.duke.edu/login?url=https://search.proquest.com/docview/1560138962?accountid=10598%0Ahttp://pm6mt7vg3j.search.serialssolutions.com?ctx_ver=Z39.88-2004&ctx_enc=info:ofi/enc:UTF-8&rfr_id=info:sid/Aquatic+Science+%26+Fisheries+Abstract

Husnah, Nugroho, E., Prianto, E., Dewi, S. P. ., Aisyah, Purwoko, R. ., Firdaus, M., Noviendri, D., Triharyuni, S., Hikmah, Kurniasari, N., Kaban, S., Pramodya, R., & Handanari, T. (2019). Potensi, Pengembangan Dan Pemanfaatan Perikanan KPP PUD 438. In N. Wiadnyana & Lukman (Eds.), *Potensi, Pengembangan dan Pemanfaatan Perikanan KPP PUD 438*. AMAFRAD Press.

[Inland fisheries. FAO Technical Guidelines for Responsible Fisheries. No. 6. Rome, FAO. 1997. 36p.](#)

Kartamihardja, E. S., Purnomo, K., & Umar, C. (2017). Sumber Daya Ikan Perairan Umum Daratan Di

Indonesia-Terabaikan. *Jurnal Kebijakan Perikanan Indonesia*, 1(1), 1.

<https://doi.org/10.15578/jkpi.1.1.2009.1-15>

Kasim, K., Prianto, E., & Kecil, G. S. (2017). Fisheries Resources Management Through Ecosystem Approach. *Jurnal Kebijakan Perikanan Indonesia*, 9(2), 115–124.

Kolding, J., & Zwieten, P. A. M. Van. (2014). Sustainable fishing of inland waters. *Journal Limnology*, 73, 132–148.
<https://doi.org/10.4081/jlimnol.2014.818>

Larocque, S. M., Colotelo, A. H., Cooke, S. J., Blouin-Demers, G., Haxton, T., & Smokorowski, K. E. (2012). Seasonal patterns in bycatch composition and mortality associated with a freshwater hoop net fishery. *Animal Conservation*, 15(1), 53–60.
<https://doi.org/10.1111/j.1469-1795.2011.00487.x>

Luiz Roberto Malabarba, Maria Claudia Malabarba,. 2020. Chapter 1 - Phylogeny and classification of Neotropical fish, Editor(s): Bernardo Baldisserotto, Elisabeth Criscuolo Urbinati, J.E.P. Cyrino,

Manila, M. (1989). *The Environmental Impact of Aquaculture and the Effects of Pollution on Coastal Aquaculture Development in Southeast Asia*. July.

Muthmainnah, D., & Gaffar, A. K. (2017). Environmental Management and Sustainability Fish And Fisheries in Floodplain Swamp in Middle Part of

Musi River. *Indonesian Journal of Environmental Management and Sustainability*, November. <https://doi.org/10.26554/ijems.2017.1.1.1-5>

Nasution, Z., & Sastrawidjaja, S. (2011). Moda Produksi Pelelangan Sumberdaya Perikanan Perairan Umum Lebak Lebung. *Buletin Ilmiah Marina Sosial Ekonomi Kelautan Dan Perikanan*, 6(2), 46. <https://doi.org/10.15578/marina.v6i2.5813>

Nurfirmanephie. (2011). *Lelang Lebak Lebung*. <https://nurfirmanephie.wordpress.com/2011/03/31/lelang-lebak-lebung/>

Oberlercher, T. M., & Wanzenböck, J. (2016). Impact of electric fishing on egg survival of whitefish, *Coregonus lavaretus*. *Fisheries Management and Ecology*, 23(6), 540–547. <https://doi.org/10.1111/fme.12197>

Polet, H., & Depestele, J. (2010). *Impact assessment of the effects of a selected range of fishing gears in the north sea*. Instituut voor Landbouw en Visserijonderzoek.

Raby, G. D., Colotelo, A. H., Blouin-demers, G., & Cooke, S. J. (2011). Freshwater Commercial Bycatch : An Understated Conservation Problem. *BioScience*, 61(4), 271–280.

<https://doi.org/10.1525/bio.2011.61.4.7>

Rais, A. H., Rupawan, R., & Herlan, H. (2017). Hubungan Kepadatan Ikan Dengan Kondisi Lingkungan Perairan Estuari Di Kabupaten Banyuasin. *Jurnal Penelitian Perikanan Indonesia*, 23(2), 111.

<https://doi.org/10.15578/jppi.23.2.2017.111-122>

Reid, A. J., Carlson, A. K., Creed, I. F., Eliason, E. J., Gell, P. A., Johnson, P. T. J., Kidd, K. A., Maccormack, T. J., Olden, J. D., Ormerod, S. J., Smol, J. P., Taylor, W. W., Tockner, K., Vermaire, J. C., Dudgeon, D., & Cooke, S. J. (2018). Emerging threats and persistent conservation challenges for freshwater biodiversity. *Biological Reviews*. <https://doi.org/10.1111/brv.12480>

Rosyidah, M. (2018). Analisis Pencemaran Air Sungai Musi Akibat Aktivitas Industri (Studi Kasus Kecamatan Kertapati Palembang). *Jurnal Online Universitas PGRI Palembang*, 3(1), 21–32.

Sharma, S., Donald, J., Shuter, A., M., C. K., & J., B. (2007). Will northern fish populations be in hot water because of climate change? *Global Change Biology*, 13, 2052–2064.

<https://doi.org/10.1111/j.1365-2486.2007.01426.x>

Strayer, A. D. L., Dudgeon, D., & Strayer, D. L. (2010). Freshwater biodiversity conservation: recent progress and future challenges. *Society for Freshwater Science*, 29(1), 344–358. <https://doi.org/10.1899/08-171.1>

Tan, H.H. and P.K.L. Ng. 2005. The labyrinth fishes (Teleostei: Anabantoidei, Channoidei) of Sumatra, Indonesia. *Raffles Bull. Zool. Supplement* (13): 115–138

Utomo, A. D. (2014). The Role of Floodplain Fish Reserve to Fish Production. *International Conference for*

Inland Fisheries.

Welcomme.R.L. (1983). *River Basin*. Food and Agriculture Organization (FAO).

Welcomme, R.L. (2001) *Inland Fisheries: Ecology and Management*. Blackwell Science, Oxford.
<http://dx.doi.org/10.1002/9780470995693>

Welcomme, R. L., Cowx, I. G., Coates, D., Be'ne', C., Simon Funge-Smith, A. H., & Lorenzen, K. (2010). Inland capture fisheries. *Philosophical Transactions*, 365, 2881–2896.
<https://doi.org/10.1098/rstb.2010.0168>

Wiadnyana, N. N., & Husnah, H. (2011). Upaya Pengelolaan Perairan Sungai Musi, Sumatra Untuk Keberlanjutan Pemanfaatan Sumber Daya Ikan. *Jurnal Kebijakan Perikanan Indonesia*, 3(1), 13.
<https://doi.org/10.15578/jkpi.3.1.2011.13-26>

Appendixes

