Chapter

Sustainable Development: The Case for Aquatic Biodiversity in Indonesia's Peatland Areas

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Abstract

Peatlands are inland water ecosystems that are very unique and vulnerable to environmental disturbances including forest fires. In fact, the peat ecosystem has a very diverse of fish species and has the potential for consumption and ornamental fish. One of the countries that has extensive peatlands is Indonesia. Various types of ornamental fish potentially found in peatlands, as well as various species of economic importance for food. Therefore, it is very necessary to conserve and utilize biodiversity of peatlands for the purpose of optimally utilizing sustainable development. The scope of this chapter is to provide a comprehensive view of fish diversity in Indonesian peatlands from the aspect of use, threats, and conservation strategies.

Keywords: peatland, biodiversity, utilization, conservation, Indonesia

1. Introduction

Indonesia is the largest archipelagic country in the world which has a high of fish diversity. Djajadiredja et al. [1] estimates the number of fish in Indonesia as many as 4000 species. According to Froese & Pauly [2], there are 4826 species. This number continues to grow along with the discovery of new species. Helfman et al. [3] reported that every year new types of fish are found ranging from 300 to 350 species. Haryono & Gustiano [4] reported that the addition of new types of fish in the world in the 2011–2020 decade was as many as 2904 species with an annual range of 104–448 species and an average of 290 species. The new species in Indonesia, especially for freshwater fish, was reported as many as 15 species in the period 2010–2014 [5].

The number of freshwater fish species in Indonesia is 1248 species [2, 6]. Dudgeon [7] estimated the number could reach 1700 species. The high richness of freshwater fish species in Indonesia is supported by thousands of islands with a diversity of inland aquatic ecosystems. Ambari [8] reported that the area of inland waters in Indonesia reaches 55 million ha which includes rivers, lakes, swamps, reservoirs, and other puddles. The distribution area of this fish is divided into three areas, namely 1) the Sunda Shelf which includes Sumatra, Java, and Kalimantan; 2) Wallacea area or transitional area covering Sulawesi and Nusa Tenggara; and 3) the presentation of Sahul covering the Maluku Islands and Papua. In the Sunda Shelf and Sulawesi, at least 900 species have been identified [9], while in Papua as many as 400 have been reported [10]. The Sunda Shelf is the center of fish species diversity in tropical Asia, which is rich in endemic fish species. Kottelat et al. [9] reported in detail the level of fish endemicity in Sumatra, namely 11% of 272 species, Kalimantan 38% of 394 species, and Java 9% of 132 species.

Among the freshwaters that are unique physically, chemically, and biologically are peatlands. Pages et al. [11] reported that some peatlands in the tropics are located in lowland areas where there are tropical rain forests with organic material deposits for thousands to tens of thousands of years with a thickness of more than 20 m. Simbolon [12] reported that the area of peatland in Indonesia is around 21 million hectares or about 57% of the total peatland in the world. Indonesia is a country with the largest tropical peat area in the world. The characteristics of waters in peatland areas are very acidic and have a high content of organic material and low levels of nutrients [13]. Peatlans is one of the natural resources that have important hydrological and ecological functions to support life in the ecosystem. On the island of Kalimantan, peatland occurs in coastal and inland areas. According to Soekardi & Hidayat [14], Central Kalimantan has 2,162,000 ha of peatland, ranking third in Indonesia after West Kalimantan and Irian Jaya. The potential of this large area of land is still not widely used, especially for the fishery sector. Blackfish mostly live in flooded lakes or peatlands, and they are resistant to low dissolved oxygen and high temperatures and tend to let the lake ecosystem inundate when the tide is too low. Crayfish migrate from adjacent rivers or permanent water bodies to flooded lakes when floods or monsoons [15, 16]. Some catfishes (pangas, redtail, and shape) are called crayfish, while walking catfish and snakehead are blackfish.

The existence of peatlands plays an important role in storing terrestrial carbon, the hydrological cycle, and maintaining biodiversity. Research on fish in peatland areas in Indonesia has been widely carried out in Tesso Nilo National Park [17], in Perawang, Riau Province [18] and peatlands in Central Kalimantan Province [19, 20]. Based on the research, in general, it shows that the waters in the peatlands area are important habitats for many unique and economically potential fish species. However, the threat to the existence of peatlands and the fish resources in them is getting more serious and has not been handled optimally. Thornton et al. [20] reported that the decline in peatlands in Indonesia is happening rapidly with the loss of peatlands swamp forest which has an impact on decreasing the fish population in the area. Conditions like this will indirectly interfere with the livelihoods of fishermen. Therefore, it is necessary to make conservation efforts for sustainable development. The purpose of the preparation of this manuscript is to reveal the diversity of fish species in peatland waters, their use and contribution nationally, as well as their conservation strategies.

2. Fish diversity of Indonesian peatlands

Peatlands are important habitats for aquatic biota including fish [19]. In general, the waters in peatland areas (blackwater) are poor in fauna but have unique characteristics, and many are endemic [21]. The percentage of fish fauna in peatlands areas is only 10% of the possibility that it is in non-peatlands waters. For example, Rachmatika et al. [17] reported that there are 50 species in the peatlands areas in Tesso Nilo National Park compared with non-peatlands areas in Way Kambas National Park,

Number	Areas	Number of species	Sources
1	Perawang Regency in Riau Province	17	Haryono & Tjakrawidjaja (2000)
2	The former million hectare Peatlands project in Central Kalimantan Province	75	Haryono, 2010
		39 (in rainy season)	
3	Tripa in Aceh Province	46	Muchlisin et al. (2015)
4	Sebangau in Central Kalimantan Province	55	Thornton et al. (2018)
5	Central Kalimantan Province	67	Haryono and Wahyudewantoro (2020)

Table 1.
Number of fish species of peatlands areas in Indonesia.

and the number of fish reaches 83 species [22]. The records of the species richness in some peatlands areas in Indonesia are listed in **Table 1**.

The specificity of fish communities on peatlands is very high. Anwar et al. [23] reported that the factors that cause the specificity of biota in peatland aquatic ecosystems are thought to be due to the low content of food ingredients, low pH, and low brightness, but the most influential is the very high humus acid (phenol) content. Many types of fish whose habitat is in the form of peatland waters have their own characteristics. Therefore, many have potential and have been traded as ornamental fish. Some of the fish species referred to and originating from peat waters in Indonesia include super red arowana (*Scleropages formosus*), gabus maru (*Channa marulioides*), betta (*Betta* spp.), botia (*Chromobotia macracantha*), seluang (*Rasbora* spp.), sepat pearl (*Trichopodus leerii*), *Luciocephalus pulcher, Sphaerichthys osphromenoides,* and *Chaca bankanensis*. In addition, peatland waters also store fish germplasm which is interesting for further study. The species in question is the world's smallest fish (*Paedocypris progenetica*) found in Jambi's peatlands. The adult size of this fish is only 7.9 mm in total length [24].

3. Utilization

The waters in peat areas are the habitat of various types of fish which are the main source of livelihood for many fishermen [25, 26]. Indonesia has significant potential and problems in utilizing biodiversity resources to meet human food demands by providing protein sources, enhancing well-being, and contributing to national development, due to its high number of genetic resources [27]. The Indonesian government has released a guidebook for the Strategic Plan for Indonesia's Biodiversity, which aims to increase the contribution of genetic resources as assets or natural capital in national development [28, 29], as well as a Blue Economic Development Framework for Indonesia's Economic Transformation [30].

Indonesia has regulated the sustainable exploitation of fish resources in inland waters and domesticated local freshwater fish species for aquaculture and conservation in terms of fish genetic resources [31]. The Asian red-tailed catfish, "bilih" (*Mystacoleucus padangensis*), snakehead, sheat catfish, tinfoil barb, pangas catfish, and dwarf gourami are among the 38 species that have been used, with a total production of 307,593 tons representing 7 dominant species (**Figure 1**). In comparison with overall freshwater fish output, total catches accounted for only 10% of total

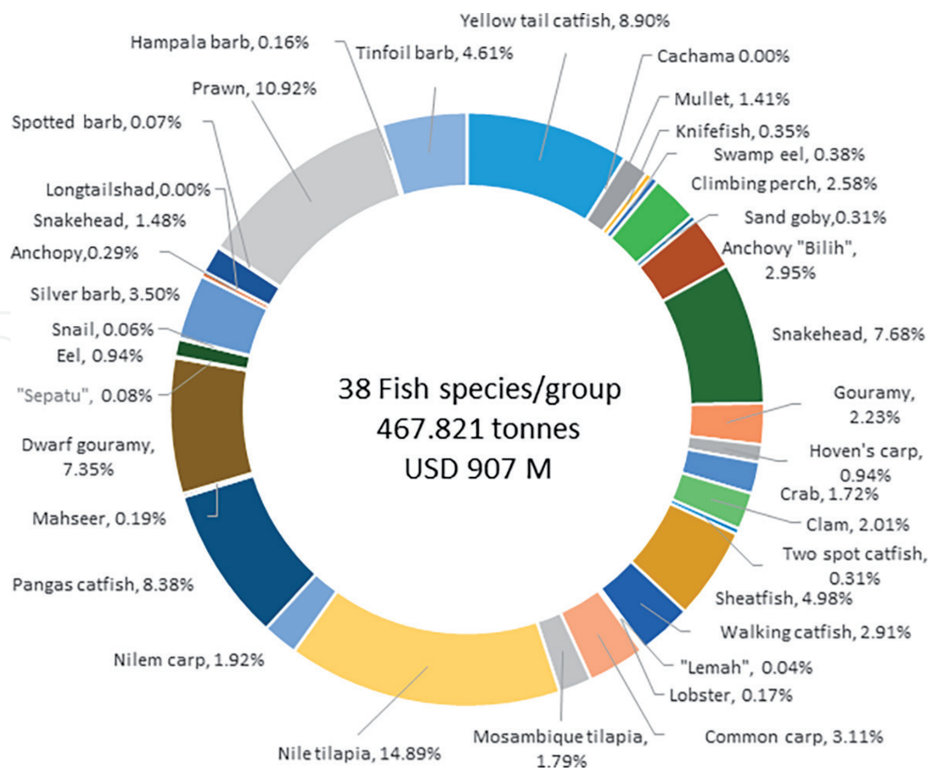

Figure 1.
Total capture production of Indonesian freshwater fish in 2017 [32].

freshwater fish production. Meanwhile, aquaculture produced 3.3 million tons, accounting for 90% of overall production. Nile tilapia, African catfish, pangas catfish, common carp, and giant gourami are five species that make significant contributions to aquaculture productivity. Despite the abundance of fish genetic resources, the low number of species and fish productivity imply that genetic resource exploitation is not yet ideal.

On the other hand, overexploitation of fish genetic resources and habitat as well as water pollution, land conversion, degradation, and climate change have harmed freshwater ecosystems [33, 34]. As a result, adequate strategic programming and planning are urgently needed to prevent fish biodiversity losses and improve the use of freshwater genetic resources.

The first strategy can be used to boost fisheries productivity in both the fisheries and aquaculture sectors by optimizing a variety of fish genetic environments. In general, the capture fisheries dominat the use of peatlands' fish resources. Meanwhile, pond culture using water from tidal rivers continues to dominate the growth of freshwater fish farming on peatlands. As a result, it is frequently hampered by the presence of acidic water with a pH of 3 or below, which causes complete fish mortality. The low pH factor, that it may be argued, is the most significant impediment to the growth of fish farming in Central Kalimantan Province.

A solution to solve the existing low pH problem is required to maximize the potential of peatlands through fisheries. The optimal use of indigenous fish that have adapted to the environment is a strategy that can be implemented using a biological approach. In general, fish that can take/breathe oxygen from the air (air breathing) dominate local fish in peat waters, such as betok/papuyu fish (*Anabas testudineus*), tambakan/biawan (*Helostoma temminckii*), siamese sepat (*Trichopodus pectoralis*), carp/kalui (*Osphronemus goramy*), cork/haruan (*Channa striata*), and to snakehead (*Channa micropeltes*). Another biological option is to introduce fish from outside the area, as well as designed fish that are resistant to peat waters with low pH. Siamese catfish (*Pangasianodon hypophthalmus*), African catfish (*Clarias gariepinus*), and BEST strain tilapia (*Oreochromis niloticus*) are among the fish that have been imported and developed in peat waters (Bogor Enhanced Strain Tilapia).

Local or native fish in peatland waterways, in general, have significant economic significance for the communities surrounding the peatlands. Due to extremely high price spikes that occur during specific seasons, peat fish can cause inflation, particularly in the Kalimantan region. It is thought that with a little aquaculture technology, it will be possible to maximize the potential of current local fish in order to increase the fishing community's welfare in a sustainable way. Local fish in peat waters with the ability to adapt directly in these waters can also be used in a sustainable biological development strategy, either through domestication or conservation programs based on local wisdom that will be able to develop local fisheries in the context of optimizing peatland waters.

Fisheries growth is inextricably linked to the development of fish commodities, which are the primary source of foreign cash for the country. Fish placed into peatland waters must have a monetary value for the individuals who raise them. Furthermore, these fish are capable of adapting to the harsh circumstances found in peat bogs. It is projected that peat waters' production and productivity will rise as a result of the farming technology that can be implemented in peat waters via introduced species of fish. The peat waters for fish culture with Siamese Catfish, Catfish, and Tilapia is for the utilization of peat waters.

To improve the peatland aquatic environment, an environmental management method can be applied, such as using materials that can be used to raise the pH content of the waters. This strategy is still in use today, since it is a practical way that can be used by all parties. Ponds must be prepared in numerous phases before they can be used for peatland fish farming. In the future, it is intended that fisheries development for community empowerment and welfare, such as catfish and snakehead fish farming in Indonesia, will be adopted [35, 36].

4. Threats

Waters in peat areas are unique ecosystems and are important habitats for various types of fish. However, this ecosystem is vulnerable to various disturbances, especially from human activities. Yesi and Tantoro [26] reported that more than 90% of the area of peat swamp forest in Southeast Asia has been degraded or converted. Many peatlands have been converted into oil palm plantations, acacia plantations to provide raw materials for the paper industry, and expansion for agricultural land. The clearing of peatlands into oil palm plantations is very intensive and continues to this day, especially in Sumatra and Kalimantan. However, this does not mean that in other areas there is no conversion of peatlands into oil palm plantations. Even the opening of oil palm plantations has also penetrated the easternmost region of Indonesia [37, 38]. Conversion of peatlands into plantation areas is a serious threat to the sustainability of the fish resources in it. Land clearing will change the ecological function of the surrounding waters, including increasing sediment and turbidity levels, increasing water temperature, reducing food sources for fish from outside the waters (allochthonous), decreasing shelter for fish, and changing river currents and flows. In addition, waste from the use of weed killers and fertilizers will enter the waters of rivers, lakes, and swamps, which are important habitats for fish and other aquatic biota.

Conversion of peatlands into agricultural areas is also easy to find in Indonesia. Yesi and Tantoro [26] reported that agricultural activities on peat areas in Riau are with crop commodities such as pineapple, chili, and tomatoes. Previously, Haryono [17] reported that Central Kalimantan is a province whose peat area was once used as a million-hectare peatland development project for agricultural activities, especially for rice fields. However, the success of these activities was not as expected, so many were stopped. The impact of these activities is the number of artificial canals that change the condition of the natural waters.

The threat to the sustainability of fish resources in the waters around peatlands is forest fires. Almost every year, especially in the dry season, forest fires occur in peatland areas [19, 39, 40]. The causes of forest fires in Indonesia include land clearing, and some are unintentional. The intensity of these forest fires is very high and a concern for human health. The forest fires will have a negative impact on the sustainability of fish communities in the surrounding waters. In fact, fish whose habitat is in peatland waters have a unique pattern and color intensity, and many are endemic species [19, 41]. In addition, there are peat mining activities which are used as fuel [18].

Waters in peatland areas are also a focus for inland fishermen [13, 26]. If there is a decrease in the diversity of fish species, it will have an impact on a decrease in their income. In general, fishermen in peatland areas still catch fish using environmentally friendly tools. However, some of them use fishing gear that is not environmentally friendly, including using electric shocks, poison/tuba, and nets placed at the mouths of creeks.

5. Conservation strategy

The preservation and utilization of biodiversity is referred to as conservation. The main factors affecting freshwater biodiversity loss include habitat degradation, overexploitation, water pollution, invasive species, and climate change [7]. The economic value of biodiversity loss is estimated to be 10 to 100 times larger than the cost of protection [42]. Indonesia has ratified the Convention on Biological Diversity (CBD), the Cartagena Protocol on Biosafety to the Convention on Biological Diversity, and the Nagoya Protocol on access and benefit-sharing of genetic resources to domestic regulations in order to participate in genetic resource conservation. These are crucial factors for a country participating in global frameworks for long-term development. When genetic resources are transferred to other countries through biopiracy and unsustainable uses, ensuring fair benefit-sharing is critical.

The government has released regulations for a material transfer agreement to preserve fish specimens analyzed and created overseas in the fisheries sector since 2010. It is critical to increase awareness, since technology advancements are likely to be used in biopiracy of material genetic information transmitted through digital sequence information. To conserve the diversity of genetic resources, it is necessary to anticipate this issue early. For example, in order to improve the identification of indigenous fish, DNA barcoding must be implemented [43]. This has been done in a number of economically important freshwater fish, including the snakehead *C. striata* [32, 35], Asian redtail catfish *Hemibagrus nemurus* [44], striped catfish *Pangasius hypophthalmus* [45], and African catfish *Clarias batrachus* [44].

Conservation-based fish genetics was carried out through the development of procedures based on quotas, licenses, distribution, monitoring, and assessment for the limited use of fish genetic resources. In the conservation of vulnerable endemic freshwater fish, the government also backed the International Union for Conservation of Nature (IUCN) and the Convention on International Trade in Endangered Species of Wild Fauna and Flora (CITES). To safeguard native species, a regulation was also created to limit the spread of invasive species. There are a total of 145 invasive species that have been prohibited from entering the country. Similarly, the government has regulated the introduction of new aquaculture species to Indonesia. The new species must be recorded, approved, monitored, and evaluated on a regular basis. A fish restocking scheme was also implemented.

Freshwater habitat is one of the most threatened ecosystems because it competes directly with human use [46]. Between 1970 and 2014, the global trend of freshwater biodiversity dropped by 83 percent (Reid et al., 2019). In most Indonesian freshwaters, there has been a growing tendency of fish biodiversity loss. Between 1890 and 2010, the diversity of native freshwater species of the Ciliwung and Cisadane rivers in West Java province decreased by 92.5%, from 187 to 20 species, and 75.6%, from 135 to 39 species, respectively [47]. The number of fish in the Djuanda reservoir declined from 31 to 18 species over a 40-year period from 1968 to 2007, and the ratio of native to alien fish decreased as well [48]. In addition, 14 native freshwater species on Sumatra Island were classified as threatened, with seven of them being endemic to the island [49]. Muchlisin [50] also discovered more than 19 foreign species that have been introduced to Indonesian freshwater. The majority of fish are invasive and have a negative influence on native species in natural ecosystems. In Indonesian mahseer *Tor soro* and *Tor tambroides*, indigenous fish populations are declining [51]. *T. tambroides, Notopterus* spp., striped catfish *Pangasius nasutus*, mad barb *Leptobarbus hoevenii*, marble goby *Oxyeleotris marmorata*, and Dinema catfish *Belodontichthys dinema* [52].

As a result, freshwater fish biodiversity management has become a critical issue in Indonesia, as most aquatic freshwater resources have been overexploited, as it is seen by a growing number of vulnerable species. Conservation initiatives based on three target conservations, including species, habitat, and ecoregion, can be implemented to address this issue [53]. Aquaculture is one of the most advanced species conservation approaches for increasing fish biodiversity. A genetic improvement was primarily implemented in expediting fish breeding and improving fish production for the aquaculture program's success [44]. In 2018, aquaculture contributed roughly 57.14 percent (5.4 million tons) to overall fisheries production in Indonesia, and it is expected to continue to rise significantly in the future [31]. Despite the fact that Indonesia is one of the world's fifth largest aquaculture producers, Nile tilapia *O. niloticus*, African catfish *C. batrachus*, Thai striped catfish *P. hypophthalmus*, carp *Cyprinus carpio*, and giant gourami *O. goramy* have dominated the primary aquaculture production. Only the giant gourami is a native species among the five most popular. According to Gustiano et al. [54], Indonesian farmers have cultivated 30 freshwater species, but only 15 of them use national best aquaculture methods. It has been brought to our attention, and we are aware of it.

One of the in situ conservation projects is aquatic habitat conservation, which entails a variety of measures to safeguard threatened animal populations in their natural habitat and ensure ecosystem viability [55]. There are 131 water conservation areas covering 15.76 million hectares in the country, which are allocated among different levels of government [56]. However, marine and coastal habitats account for the majority of conservation areas, with inland waters like lakes and rivers accounting for fewer than 10%. The way freshwater environment conservation efforts are implemented varies by location. Fisheries sanctuaries have existed on the island of Sumatra for a long time, regulating local traditions. The majority of areas have not been legally protected as a basic conservation need. However, in some locations, some local governments have begun to develop formal systems to identify conservation candidates [57]. The best conservation program for lake and reservoir ecosystems is habitat rehabilitation, whereas rivers, wetlands, and estuaries ecosystems are fisheries sanctuary, according to research in Sundaland seas comprising Sumatra, Borneo, Java, and Bali [58].

Adrianto [59] suggested that integrating fish resource management with community socioeconomic well-being is a critical strategy for the success of Indonesia's fisheries conservation programs. Riepe et al. [60] have reported that a successful freshwater conservation program is based on an economic strategy in four European countries: Norway, Sweden, Germany, and France. The work enhanced the native fish population, water quality for domestic use, river accessibility, and electrical supply, all of which help the community greatly.

Ex situ conservation refers to the care and breeding of living animals outside of their natural habitat [55]. Ex situ conservation comprises wild species domestication and cultivation efforts. Domestication is a set of acts taken by humans to gradually adapt wild animals to living and breeding outside of their natural habitat under controlled conditions [61]. This primarily entails acclimating fish to new environmental settings, providing artificial feed responses and ensuring that they are capable of developing and sexually mature enough to produce characteristics. Domesticated fish can also have extra characteristics that are desirable to fish farmers, such as fast growth [62]. As a result, breeders must comprehend the domesticated species' biological and genetic performance, illness, and socioeconomic features (Fabrice, 2018). Focus group discussions can be used to consider which fish species should be considered for domestication [63, 64]. This program is critical for the development of aquaculture-based native species that are combined with tradition and local wisdom to help rural communities achieve food security and poverty alleviation [65]. Fish farmers have domesticated a small number of native freshwater fish for human consumption, including the silver barb (*Barbonymus gonionotus*), bonylip (*Osteochilus vittatus*), giant gourami (*O. goramy*), and kissing gourami (*Helostoma temminckii*) [31], but productivity remains low. The government, on the other hand, has been successful in releasing and promoting domesticated animals.

6. Conclusions

Indonesia still has valuable fish genetic resources that must be preserved and exploited for economic well-being and national development, but it also faces enormous pressures on these resources and their habitat. As a result, conservation management and strategic planning must be adequately executed in order to improve its exploitation and avoid losses of fish biodiversity, which is one of the country's most valuable assets. Here are some suggestions for dealing with the problems: aquaculture species.

1. The execution of strategic strategies for the preservation of fish genetic resources through aquaculture development based on freshwater fish endemic is required. The government should boost legislation and policy development by releasing an international framework based on the Genetic Resources Act that has been publicly ratified as the primary regulation. Despite the fact that Indonesia has accepted international accords on genetic resource biodiversity conservation, the resulting legislations are sectoral entities with a variety of duties and objectives.

2. To maximize the efficiency of existing rules, synergic cooperation across institutions and stakeholders responsible for managing genetic resources and habitat preservation and usage needs to be strengthened from national policy, scientific approach, and execution.

3. The value of genetic resource preservation should also be emphasized to local communities so that they can participate and benefit from its use.

4. To strengthen the skill and competency of technical and management staff, advanced technological training and education for genetic preservation and biopiracy investigation should be done.

5. Ex situ conservation of endemic and threatened freshwater fish species must be supported by the preservation of endemic and threatened fish species in the inland water habitat (in situ conservation).

6. To ensure the species' long-term viability, the breeding process and restocking of endemic fish species in their natural habitat should be closely monitored.

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