Sustainable Management of Inland Capture Fisheries for Food Security: Experience of Indonesia

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An archipelago with 17,500 islands, Indonesia is situated between latitude 06°08' N – 11°15' S and longitude 94°15' – 141°00' E and its territorial waters on 12 mile-limit basis, embrace a total area of 3,166,162 km² and coastline of about 80,791 km. The country's registered land area is about 191,944,300 ha. Economic development program has been implemented in Indonesia since 1969 but little has been done to develop its capture fisheries in inland open waters, *e.g.* lakes, rivers, reservoirs and flood plains. Efforts to achieve sustainable capture fisheries in inland open waters are generally not based on scientific information resulting in less developed technologies on inland capture fisheries, in spite the country's long history of capture fisheries in inland open waters which has been going on for centuries (Sarnita, 1987). Considering that the inland waters are the most important source of income for the rural people, there is a need to manage the country's inland open water capture fisheries for sustainability. Nonetheless, certain alternatives have been promoted in Indonesia to manage the country's inland water fisheries, and this is through stocking and restocking of inland waters with cultured fish species, and establishing of fish reserves in inland waters.

Open Water Fisheries

In many Southeast Asian countries, open waters play a significant role in increasing fishers' incomes, fulfilling the nutritional requirements of rural people by providing food fish, enhancing the local's original incomes, serving as habitats of aquatic organisms, and facilitating environmental balance. In spite of their multifunctions, open waters remain a common property, while activities carried out in open waters could be directly or indirectly influenced by the water quality that to some extent impact on the aquatic flora and fauna including fishes. Inland open water areas abound in many Southeast Asian countries as shown in **Table 1**.

Table 1. Inland open water areas in Southeast Asian countries

Country	Total land area (ha)	Inland open water area (ha)
Indonesia	191,944,300	***16,361,470
Thailand	51,400,000	**4,545,000
Philippines	29,940,400	**361,000
Malaysia	33,123,800	**307,460
Singapore	60,200	*3,000

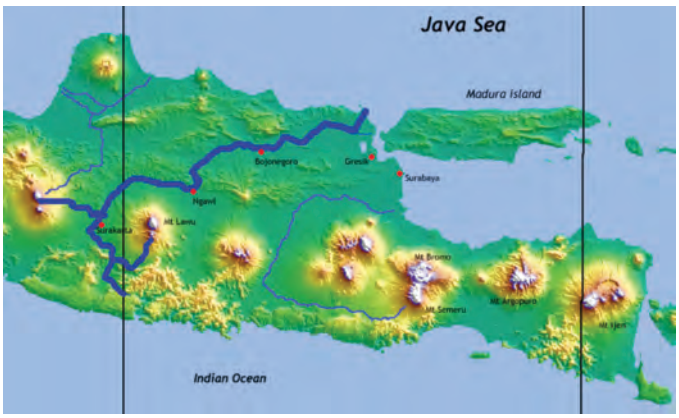
*Source: * Fernando (1980); ** Baluyut = (1983); *** Sarnita (1987)*

As shown in **Table 1**, Indonesia has the largest area of inland open waters compared with the other Southeast Asian countries. However, based on the country's fishery statistical information there is a tendency for Indonesia's fisheries production from open waters to decrease, considering that some fish species are already becoming extinct due to environmental degradation and overfishing activities. Modification of water bodies by constructing dams and reservoirs limit the movement of migratory fish species which could possibly result in their extinction.

Map of Indonesia

Furthermore, land reclamations also lead to loss of specific habitats, for example, conversion of swampy forests into aquaculture areas reduces the spawning grounds of some important fish species, depriving them of reproduction and eventually driving them to virtual eradication. The continued practice of irresponsible fishing activities such as the use of electricity for fishing (*strum*), filtering device (*tuguk*), poison (*racun*) and non-selective gear also leads to destruction of fish stock populations. Some fishing operations that make the target fishes unconscious (*bius*) and the use of large operating gear such as "*ngesar*" (active seine), "*ngesek*" (active barrier), "*empang*" (barrier with traps chamber) could lead to overfishing that results in decreasing fish population, especially, those fish species that spawn only once in one year.

One of the open waters in Indonesia that had undergone modifications and experiencesd ecological pressure is Bengawan Solo River or Solo River, for short, while the Musi River in South Sumatera and Kapuas River in West Kalimantan also underwent few modifications. Musi and Kapuas Rivers have areas devoted to fishery resource conservation such as Lake Belaiaram and Sentarum in West Kalimantan, and Lake Teluk Rasau and Lake Cala in South Sumatera. At least half a million Indonesian fishers are fishing in the country's inland open waters every year.



Bengawan Solo River on the island of Java in Indonesia is approximately 600 km long with basin size of 16,100 km^2

Dam constructed in Solo River

Contribution of Open Water Fisheries to National Economy of Indonesia

Flood plain areas are among the major open waters with high productivity. In South Sumatera for example, these areas supply the local communities' requirements for nutritious food from fish with an average food demand of 23 kg/capita/year. The flood plains in South Sumatera had been managed by the Ogan Komering Ilir (OKI) and Musi Banyuasin (MUBA) Regencies. Records have shown that an average of 16,700 metric tons of fish per year is contributed by OKI and another 11,600 metric tons/year by MUBA to the country's total fisheries production from inland capture fisheries. The number of fishers under OKI is 5000-9000 KK (family). Using traditional gear (hook and lines, cast net, traps), the average catch of fishers is 2-6 kg/day/fisher with average price of Rp.7000-Rp.10,000/kg (as of 1992).

Map of Indonesia showing Sumatra (traditionally known as Sumatera)

However, some fisher groups are using large fishing gear such as *tuguk* (filtering device), *ngesar* (active seine) and *hampang* (barrier traps) with fish catch of 10.0-20.0 metric tons/year for *tuguk*, 2.0-5.0 metric tons/season (August-September) for *ngesar*, and 0.5-1.0 metric tons/season (April-May) for *hampang*. The country's open waters also contribute to the local's original incomes (*pendapatan asli daerah* (PAD)), which is mainly used for development projects. The Regencies of OKI and MUBA contribute to PAD from the proceeds of the retribution and auction of flood plain areas, which are auctioned every year by the local government. Such auction system is one of the ways of authorizing fishers to use the open waters in order to minimize competition and fighting for rights in the fishing areas. In 2003, the contribution of OKI Regency to PAD from the auctions of flood plain areas comprised 40-45% of the total PAD valued at 1.0 billion Rupiah. As of 2011, the average yield of open water capture fisheries in Indonesia was 309,721 metric tons/year. At an average fish price of Rp. 5000/kg (2001 prices), this implies that the averge value of the total catch from open water capture fisheries could amount to Rp.1,548,605,000,000 (as of March 2017, 1.0 US$ = Rp. 13,361).

Status of Inland Capture Fisheries in Indonesia

Fish species

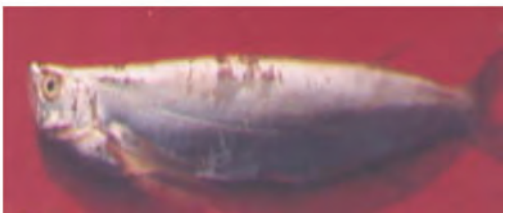
The inland open waters of Indonesia embrace a diversity of fishes, and more than 800 fish species from two orders of fish, namely: Ostariophyci and Labyrinthici dominate the fish populations in Sumatera and Kalimantan with more than 368 species (Sarnita, 1977). In the report of Kottelat *et al*. (1993), the continental flat of Sunda has 798 fish species, the continental flat of Wallacea with 68 fish species, and the continental flat of Sahul has 106 fish species. Kapuas River has more than 200 freshwater fish species (Dudley, 1996), while Barito River has more than 104 fish species and Musi about 120 fish species (Prasetyo *et al*., 2004; Samuel *et al*., 2001; Utomo *et al*., 1993). Many kinds and abundance of fish species are found to be more dominant in middle streams found in many swampy forest areas than in the upper and lower streams.

Box 1: Important freshwater fish species that are now seldom found in Indonesia's flood plains			
Local Name	**Scientific Name**	**Local Name**	**Scientific Name**
Tangkleso	*Shclerophages formosus*	Sengarat	*Belodonticthys dinema*
Kapas-kapas	*Rochteichthys micropeltis*	Temparang	*Macrothiricthys microphirus*
Ikan Elang	*Datniodes quadrifsciatus*	Puntung hanyut	*Balantiocheilos melanopterus*
Timah-timah	*Cryptopterus apagon*	Lumajang	*Cyclocheilichthys enoplos*
Mok-mok	*Hemisilurus scleronema*	Dalum	*Bagarius yarelli*

Tengkeloso (*Schlerophages formosus)*

Elang (*Datnoides quadrifsciatus*)

Parang (*Macrothiricthys microphirus*)



Sengarat (*Belodonticthys dinema*)

Fig. 1. Some freshwater fish species which are almost extinct in inland waters of Indonesia

Box 2: Important freshwater fish species with extremely decreasing populations			
Local Name	**Scientific Name**	**Local Name**	**Scientific Name**
Patin	*Pangasius* spp.	Tebengalan	*Puntius bulu*
Tapa	*Weellago leeri*	Jelawat	*Leptobarbus hoeveni*
Belida	*Chitala lopis*	Tilan	*Mastocembelus armatus*
Semah	*Tor douronensis*	Botia	*Botia macracanthus*
Betutu	*Oxyeleotris marmorata*	Kalui	*Osphronemus goramy*
Sidat	*Anguilla* spp.	Toman	*Channa mricroleptes*

Box 3: Introduced fish species in Indonesia open water bodies		
Species	**Location**	**Remarks**
O. mossambicus	Lake Toba (Nort Sumatera) in 1948	Established in 1952, became the dominating fish stock in this lake
T. pectoralis, C. batracus, H. temminckii, B. gonionotus	Lake Tempe (South Sulawesi) in 1937-1940	Yield during 1963-1975 averaged at 900 kg/ha/year
O. goramy, T. pectoralis	Lake Toba (North Sumatera) in 1920	Were not established
P. hypophthalmus, O. niloticus, B. gonionotus	Gajah Mungkur Reservoir (Central Java) in 1981-2003	Established in 1999/2000, in 2004 became dominating fish stocks in this reservoir

However, overfishing has been observed in many swampy forest areas that host capture fishing activities, *e.g.* in Kapuas, Barito, Musi, and the Lubuk Lampam flood plain areas. As a result, large size of some economically-important fishes have been overfished and become extinct (Utomo *et al*., 1993; Hoggarth and Utomo, 1994; Utomo, *et al*. 2003). Some of the most economically-important fishes that are now rarely found in Indonesia's flood plain areas are shown in (**Box 1**) with some almost extinct (**Fig. 1**). Some fish species with extremely decreasing populations are shown in **Box 2**, while some fish species that had been introduced in Indonesia's inland waters are shown in **Box 3**.

Fishing Gears and Methods

Many kinds of fishing gears are being operated in the inland open waters of Indonesia, especially in middle streams that comprise many flood plains. These include small gears, *e.g.* hook and line, cast net, pot traps, as well as large gears that capture large quantities of fish, *e.g.* barrier trap, filtering

Fig. 3. *Ngesek* (active barrier)

Fig. 2. *Tuguk* (filtering device)

device, active seine. The peak fishing season of *hampang*, *selambau* (filtering net), *tuguk* (**Fig. 2**), and *bubu* (pot trap), is at the end of the wet months (April-May) and the begining of wet months (October-November), catching the fishes that move from the flooded areas to rivers and from rivers to flooded areas, respectively. For the active barrier *ngesar* or *ngesek* (**Fig. 3**) and *beje* (pond trap), their peak fishing seasons is during the dry months (July-September) when the depth of swampy areas and river is shallow allowing the fish to be caught by these gear. Meanwhile, *jaring* (gill net), *pancing* (hook and line), and *jala* (cast net) could catch fish throughout the whole year.

More specifically, the fishing season of *hampang* (**Fig. 4**) set between river and swampy border takes place at the start of ebb tide (April-May). *Beje* which is operated in swampy areas and resembles a "pond trap," is made by digging a hole in the pond and setting a seine to catch fish the moment the water goes down. Its fishing season takes place when the water level is low or during the dry months (August-September). *Mangumpai* (seine with fish aggregating device (FAD)) is actively operated using a seine installed in the river during dry season.

Selambau is a wiring-formed cone pocket or bag (**Fig. 5**) and usually set in small rivers for catching migratory fishes, and its catch season is in April-May until the water level goes up in November. Fishing activities using *traps* in flood plain areas are very effective when the water level goes down (May-July) but the duration is not more than two weeks. The fishing gears dominating in the flood plain waters are traps, because fish would move according to the water fluctuation and traps are set to adopt with such water fluctuation.

Some gillnets such as "*rengge*" and "*lelangit*" with mesh sizes ranging from 1.0 inch to 7.0 inches, are operated in long rivers, *e.g.* Sambujur and Negara Rivers. *Lelangit* is operated horizontally with the surface waters for catching fishes that are taking oxygen from the air (*tilap*), while *merengge* is a kind of gillnet operated vertically in the waters blocking the fish migration. Fishing activities using *merengge* and *mangumpai* could be done in all seasons but considerable amount of catch could take place during the dry months when the water level is low. *Selambau*, *hampang*, *mangumpe* and *beje* are common in the flood plains of swampy areas. Fishing season of *hampang* and *selambau* is at the end of the wet months (April-June), blocking and barriering the fish that migrates from *lebak* or flood areas to rivers or lakes. At the end of the wet season, water from flood areas flows to deeper water bodies or to rivers and lakes. The fishing season of *selambau* takes place when the water goes down (from April to June) and the catch would be about 100 kg/day in one week but decreasing to 0.5-1.0 kg/day. The fish often caught by *selambau* includes *riu* (*Pangasius* spp.), *benangin*, *lais-laisan* (*Cryptopterus* spp.), and *biawan* (*Helostoma temminckii*).

Mangumpe and *beje* are generally operated in the dry months (July-September) when only the deeper water bodies (river, lake and *lebung*) would have water. *Beje* is designed to catch fish that exist in *lebung* or *beje*, whereas, *mangumpe* catches the fish from rivers or lakes. The measurement of *beje* varies between 10x2 m^2 and 20x2 m^2 as well as 20x3 m^2. The fish that is often caught by *beje* includes *haruan* or *gabus* (*Channa striatus*), *biawan*, *sepat siam* (*Trichogaster pectoralis*), *papuyuh* (*Anabas testudineus*) and *kepor* (*Pristolepis fasciatus*). The catch could vary from 200 kg/*beje*/season (prior to 1980) to 30 kg/*beje*/season (now). *Mangumpai* (*rempa*) measures 90 meters and can catch between 100 and 200 kg/day (duration of season is two weeks), but had been

Fig. 4. *Hampang* (barrier trap)

Fig. 5. *Selambau* (filtering net)

decreasing to 20-30 kg/day. The fish caught includes *sepat siam, haruan, papuyuh* and *grembes* (not an economical fish). Catching of *udang galah* or freshwater giant prawn (*Macrobrachium rosenbergii*) with hook and line is also very much affected by season and location. For example at Village Alow-Alow which is close to the mouth of Barito River, where in dry season salinity is 8.5 ppt, the catch could be 0.5 kg/person/day (5-7 hooks and lines), while in wet season where salinity = 0.15 ppt, the catch could be 1.0 kg/day (maximum). At Village Pulau Kembang close to Banjarmasin City, in dry season (salinity = 3.0 ppt), catch could be 1.0 kg/person/day (5-7 hooks and lines).

Catch Composition by Fishing Gears

***Hampang* (barrier with traps chamber)**

Baung (*Mystus nemurus*) is caught by *hampang*, the sizes of which vary from 10 to 34 cm. Small *baung* is easily caught because the slits of the woven bamboo vary between 1.0 and 2.5 cm, while big fish with hard dorsal and pectoral spiny fins could not penetrate the gear. Based on field observations, *Mystus nemurus* could mature after 20.0 cm in total length and 110 g body weight. If under 15.0 cm in total length and 40 g body weight, the fish will not be of economic value. *Baung* is useful when captured at the size which is over 20.0 cm in total length and 4 cm body height, the size at which the fish could reproduce and develop gonads in the waters.

Haruan (*Channa striata*) is caught by *hampang* at sizes between 6.0 and 41.0 cm length. The small fish is easily caught because of the bamboo slits are woven very closely (1.0-2.5 cm) but big fish with relatively large diameter of body fish could not penetrate the gear. From field observations, *haruan* at 13.0 cm total length, 35.0 g body weight, and 1.8 cm body height is usually caught. Gonadal maturity of the fish could be attained when fish reaches 18.0 cm total length, while the economical size of *haruan* (market size) is over 17.0 cm (Makmur, 2003; Kartamihardja, 1994). *Haruan* could also be caught when the size is over 18.0 cm total length, 80 g body weight and 2.5 cm body width.

Sepat siam (*Trichogaster pectoralis*) is caught by *hampang* at sizes between 13.0 and 18.0 cm. This fish reaches gonadal maturity when the size is over 12.0-13.0 cm in length and 25-30 g weight, at which size the fish also has marketable values (Utomo dan Ondara, 1987). *Sepat siam* under 12.0 cm is rarely caught by *hampang* because *sepat siam*'s body is thin and flat (*pipih*). At 12.0 cm length, its body is thick at 1.5 cm and no hard spiny fins so that the fish can easily penetrate the gear. Based on the field observations, *sepat siam* captured by *hampang* are generally adult fish with developed gonads.

***Beje* (seine with pond traps)**

Haruan is also caught by *beje* at sizes that vary from 14.0 to 40.0 cm in total length, while sizes smaller than 14.0 cm with body diameter of 1.9 cm, are rarely captured. This is because the mesh size of net is 1.5-2.0 cm, while the head and body of *haruan* is cylindrical (*silindris*) with no hard spiny pectoral or dorsal fins, so that it could easily pass the mesh size of the gear (pond traps).

Papuyuh (*Anabas testudineus*) is caught by *beje* when the size is between 8.0 and 20.0 cm. Based on field observations, *papuyuh* could mature when the size is over 11.0-12.0 cm in length and 30.0-40.0 g weight. Under 8.0 cm long and 15.0 g in weight, this species has no economic value. Small *papuyu* are easily caught by *beje* because the mesh size of nylon nets is 1.5-2.0 cm, while *papuyuh* with hard spiny on the dorsal and pectoral fins could not penetrate the nets. At 8.0-10.0 cm in length, its body height is 2.0-2.5 cm, and body thick of 1.2-1.5 cm. *Sepat siam* (*Trichogaster pectoralis*) is also caught by *beje* when the size is between 11.0 and 16.0 cm. However, it is more useful if the fish is captured when the size is approximately 12.0 cm in length and weighing 35.0 g to give the chance and opportunity of the species to mature in the water.

***Selambau* (filtering net)**

Sepat siam is caught by this gear when the size is 9.0-15.0 cm. Fishing activity using *selambau* does not give the chance for small species to develop and reproduce because fishes are usually caught at sizes under 12.0 cm. Besides, species under 10.0 cm in length and 15 g in weight do not have economical values. The other species which was caught by *selambau* is *sepat bujur* (*Trichogaster* spp.) when size is 5.0-9.0 cm in length, making *selambau* a non-selective gear. From field observations, *sepat bujur* could mature at 8.0 cm in length and over. In order to sustain the fishery resources in inland waters, small-sized fishes caught by the abovementioned fishing gears should be released back to the water to give them the chance to develop in the waters. For example, *baung* (usually caught when size is under 20.0 cm length), *haruan* (under 18.0 cm length), *papuyuh* (under 11.0 cm length), and *sepat siam* (under 12.0 cm length).

Production from Inland Fisheries

The fish production potentials from inland waters in Indonesia are not very high. In general, from its open waters the production potentials could be about 50-60 kg/ha/year. It has been estimated that production potentials from open waters in Sumatera could be 90-110 kg/ha/year, the open waters in Sentarum West Kalimantan at 125-150 kg/ha/year, while open waters at the eastern part of Wallace's line have low production potentials.

Based on the monitoring and interview of fishers with more than 5 years experience in fishing, the production trend has been decreasing every year by 10 to 15% because of increasing fishing activities and destruction of the ecosystem. The fish production from inland waters of Indonesia from 1997 to 2000 is shown in **Table 2**.

Table 2. Fish yield from inland waters of Indonesia (1997-2000) in metric tons

Year	Yield		
	Capture Fisheries (A)	Total inland fisheries (B)	A/B (%)
1997	304,258	968,660	31.4
1998	288,666	918,463	31.4
1999	327,627	1,074,647	30.5
2000	318,334	1,103,060	28.9
Mean	309,721	1,016,209	30.5

Thus, in order to increase the catch, the number of fishing gears operating in these waters should be decreased while the mesh size increased so that only large fishes could be caught instead of the small ones. In fact, many species of fish have extremely decreased, *e.g. bakut/betutu* (*Oxyeleotris marmorata*), *patin* (*Pangasius* spp.), *jelawat* (*Leptobarbus hoeveni*), *pipih/belido* (*Notopterus chitala*), and *tebirin/lais-laisan* (*Cryptopterus* spp.). The fish species which are now difficult to find include *belantau*/*parang-parang* (*Macrochirichthys macrochinus*) and *tangkeleso* (*Schlerophagus formosus*). The species that do not clearly decrease are those small sized fishes such as *seluang* (*Rasbora* spp.). This is because small fishes have potency to develop faster than large fishes (Effendie, 1997), besides large fishes are more intensively caught because of their high prices. *Haruan* and *baung* are examples of such large fishes, but the fishing exploitation (E) for both species could not be increased because the values of E of both species are already more than the optimum value of 0.50 (Gulland in Pauly, 1984), *i.e.* E= 0.57 for *Channa striata* and E= 0.71 for *Mystus nemurus*. While *sepat siam* is an example of a small fish, its fishing exploitation (E= 0.41) is still under the optimum value (E=0.50). Therefore, catching *sepat siam* could still be increased. Decrease in fish potency could be mainly caused by increasing fishing effort, while fishers continue to use dangerous fishing gears such as *stroom* (electric fishing). During the ocular observation, it was noticed that the swampy forests in freshwater areas serve not only as spawning ground but also as feeding and protecting grounds for the fish. However, many fishers reported that traces of chemical agents used to preserve wood, could still be observed in the waters causing deaths to many fish stocks that inhabit the waters.

Environmental Conditions in Fishing Areas

Many issues and concerns should be addressed in order to promote sustainable management of open water fisheries in Indonesia, especially in enhancing the quality of fishing in the country's inland open waters. These include sedimentation, enforcement of fishery laws and regulations, and pollution. Sedimentation in open waters has been occurring for years due to high exploitation of the forest, continued adoption of shifting agriculture, and to a certain extent, establishment of recreational resorts in the mountainous areas.

As a result, many small reservoirs in Java are now covered with sediments, and land is becoming non-productive while some places had been converted into urban areas. Pollution caused by industrial and domestic wastes is another problem, as exemplified in the case of the water quality of Solo River. In Cirata Reservoir, fish cage culture makes use of 25,000 units, which is 6 times more than the carriying capacity of only 4,000 units. Upwelling in the begining of rainy season usually causes fish mass mortality. Fishing activity in open waters is difficult to control, while illegal fishing activities (*e.g.* electric fishing, use of poison) are still rampant in spite of the enactment of the Law of Fisheries No.9 1985. Results of case studies conducted in Kapuas, Musi and Barito Rivers, indicated that the middle streams of these rivers have many flood plains and swampy forests that have potentials for increased fish production.

The important vegetations of swampy forests consist of *putat* (*Barringtonia acutangula*), *mentangis* (*Oxora mentangis*), *menyawai* (*Elacocarpus submonoceras*), and *melayak* (*Croton* spp). These vegetations sustain the function of the swampy forests as spawning, feeding and nursery grounds.

Pollution also seriously impacts on the survival of aquatic organisms. Results of a case study in Solo River in Java indicated that industrial and domestic wastes have caused heavy pollution of the water. Solo River now has high concentration of COD (1.0 – 127.5 mg/l), low oxygen (0.0 – 1.2 mg/l), and high fenol concentration (0.2 – 1.4 mg/l), among others. As a resuilt, stocks of economically important native fish species had been lost. Now, the River is inhabited by aquatic species that are not economical, *e.g. sapu sapu* (*Liposarcus pardalis*).

The socio-economic condition of inland fisheries in Indonesia

Educational attainment of fishers in Indonesia is mainly at the basic or elementary level but they have the ability to read and write. Many fishers take up informal education, such as courses in traditional fish processing. However, they are knowledgeable on and experienced in fishing methods, making fishing gears and fish processing for more than 10 years. The inland open water fishers in Indonesia are mostly traditional fishers who use traditional gears, most of which are made by themselves. Their methods of fishing used are based on their own experience. Based on the amount of time spent for catching fish, the fishers could be grouped into four, especially those coming from South Sumatera, namely: "*Pengemin*" Fishermen, "*Bekarang Tetap*" Fishermen, "*Bekarang Ttidak*

Box 4. Four groups of open water fishers

1. *Pengemin*" Fishermen: fishers who get the license to catch fish from the government and can access the area (lebak lebung) through auction which is held every year in South Sumatera. "Pengemin" fishermen are fulltime fishers.
2. "*Bekarang Tetap*" Fishermen: fishers who lease part of area to the "Pengemin" fishermen for one year and are full time fishers.
3. "*Bekarang tidak tetap*" fishermen: fishers who lease part of area to the "Pengemin" fishermen for specific time only and catch fish only for 3-4 months, *e.g.* they lease to catch fish with hook and line during flooding time (January-March). During low water condition (July-September) they lease an area to catch fish with long line or similar gears.
4. "*Sambilan*" Fishermen (Part-time fishermen): fishers who catch fish at their free time, and usually help "Pengemin" fishermen and receive money, *e.g.* they help Pengemin in dropping active seines at capturing time, helping pick the fishes when filtering device is used. These fishers are also classified as occasional fishermen.

Tetap" Fishermen; and "*Sambilan*" Fishermen or Part-time Fishermen (**Box 4**).

The distribution of inland open water fishers in Indonesia is shown in **Table 3**, which is likely not according to the open water areas but based on the population in an island. The total fish harvested from inland water fisheries may not be considerably high (1,016,209 metric tons/year), but inland capture fisheries production annually contributes about 30.5% (309,721 metric tons/ year) to the country's total production from inland capture fisheries.

Inland Fisheries Management System

Management of open waters through the establishment of fish reserves is being practiced in Indonesia even prior to the 14th century. In East Kalimantan, the King of Kutai in the early 14th century established three fish sanctuaries along the Mahakam River, namely: Danau Loakang, Batu Bumbun and Danau Gab (Sarnita *et al*., 2001). In North Sumatera, the former local dukes living around Lake Toba established sanctuaries for the endemic *batak* fish (*Neolissochilus* spp., *Tor* spp.). During the Dutch occupation period, more fish reserves were established.

At the present time, there are 131 fish reserves in open waters of the country. However, only few reserves remain in good condition and are well-functioning, such as Danau Mahligai Fishery Reserve and Taman Ciri Fishery Reserve in Jambi; Danau Tujuh in Upper Kapuas River, West Kalimantan; and *ikan kancra* (*Tor* sp., *Labeobarbus* sp.) reserves in Kuningan District, West Java. Nonetheless, little has been done in the management of open water habitats to improve the quality of fisheries in open water bodies. In 1932-1957, eradication of aquatic weeds (especially water hyacinth) in Rawa Pening, Central Java, was carried out. After the weed eradication, the fish yield in the reservoir increased from 3.5 kg/ha in 1931 to 7.0 kg/ha in 1943, and to 124.0 kg/ha in 1957 (Sarnita, 1971). In 1960, the aquatic weeds of Rawa Jombor, a small reservoir in Central Java, were also eradicated. As a result, fish production of the reservoir increased up to 600.0 kg/ha/year (Sarnita and Djajadiredja, 1968). In 1962-1964, aquatic weed control was carried out in open waters of Kalimantan, but such eradication scheme did not have any impact on the fish production of the said open waters (Sarnita, 1971). Another effort in habitat improvement was done in Jatiluhur Reservoir in 1970, where a cladoceran *Daphnia similis*, was introduced into the reservoir, and developed well until 1977 (Sarnita, 1983).

Management of capture fishery in inland waters in Indonesia until today has been carried out using the top-down management method, which is not very effective because the government body (either local or central government) plays a very important role in the management activities. The government makes fishing rules and other iinstruments, and also administers the implementation of the rules. Local fishers, people living surrounding the water bodies and other stakeholders play only small roles in the management system.

Conclusion

Indonesian inland open waters consist of tidal swampy areas (39.90 million ha), rivers and floodplain areas (11.95 million ha), and lakes and reservoirs (2.1 million ha). Open waters play very important role in making available nutritious food from fish, providing resources that increase fishers' incomes, increasing the original local's incomes, hosting numerous aquatic organisms, and maintaining environmental balance. In 2000, the total production from Indonesia's inland open water fisheries was around 306,600 mt or about 28% of the country's total inland fisheries production. The potential area for capture fisheries in open waters is estimated to be over

Table 3. Distribution of inland water fishers in Indonesia

Island	1997		1988		1999		2000	
	Full-time	Part-time	Full-time	Part-time	Full-time	Part-time	Full-time	Part-time
Sumatera	58,515	119,715	64,444	201,305	70,343	208,872	64,555	229,822
Java	52,844	76,254	10,234	11,687	8,145	9,240	8,751	116,371
Lesser Sunda	9,382	8,651	782	737	895	844	633	16,135
Kalimantan	50,653	94,725	51,220	78,398	54,624	91,858	54,286	85,908
Sulawesi	10,450	14,063	8,156	10,882	8,105	10,834	7,504	14,232
Moluccas & Western Papua	3,704	9,670	4,728	12,139	4,841	12,424	4,886	15,322
Total	**185,548**	**323,078**	**139,564**	**315,148**	**146,953**	**334,072**	**140,615**	**477,790**

Logging

Flood plain in swampy forest

Flood plain in middle stream

Industrial pollution near Solo River

10 million ha with potential production of about 1,028,250 - 1,150,300 mt, specifically in floodplain areas that have been known to provide high productivity. However, inland open waters remain common property and are subjected to sedimentation, pollution, and weak enforcement of fishery laws and regulations. As a result, fisheries production from the country's inland open waters has tendency to decrease, while some fish species are becoming extinct.

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