

# Success of Fish Stock Enhancement and Restocking in Inland Waters of Indonesia

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## **Abstract**

Stock enhancement and restocking of fish in inland waters of Indonesia has been practiced for a long time. Since 1999, the stock enhancement and restocking practices were based on scientific evidence which include limnological characteristics, productivity and ecological niche of water bodies, structure of fish communities, life cycle and biology of the fish stocked, and development of fisheries co-management and local wisdom or knowledge approach. Some species used in stock enhancement were reviewed, and the causes of programs' successes or failures were analyzed in an attempt to determine the best approach for future stocking. Recent successes in fish stock enhancement are mainly determined by species which can be reproduced naturally in the water bodies and regularly stocked at optimum level. The Government should facilitate and support stock enhancement activities by providing local fish seeds for restocking purposes. Introduction of fish species should be done with precautionary approach especially in the lakes of Sulawesi and Papua that are inhabited by endemic species.

**Keywords:** stock enhancement, restocking, scientific evidence, precautionary approach, inland waters, Indonesia

## **Introduction**

Indonesia's Fisheries Act No. 31 of 2004 amended by Act No. 45 of 2009 stated that the inland waters of Indonesia is one of the Fisheries Management Areas which can be used for fisheries and aquaculture development. The total area of Indonesia's inland waters is 54 million ha, composed of 12 million ha of rivers and flood plains, lakes 1.8 million ha, man-made lakes or reservoirs 0.5 million ha, and swampy areas of 39.5 million ha. The country also has 5,590 major rivers (94,573 km in length) and 65,017 tributaries, 840 major lakes, 736 small lakes, 162 major reservoirs and 1,341 small reservoirs (Ministry of Public Work–Directorate General of Waters Resources, 2013).

Indonesia is also endowed with high diversity of freshwater fish species. Records with FishBase (2011) indicate that the number of fish species inhabiting the inland waters of Indonesia could reach to 1169. Kottelat *et al.* (1996) stated that the number of freshwater fish species in Indonesia is approximately 1300 species, and also suggested that the biodiversity of Indonesian freshwater fish species is the second richest in the world next to that of Brazil.

More than 798 species inhabit the Sundaland (the large islands of Borneo, Java and Sumatra, and surrounding islands), more than 68 species in the Wallacea zone (includes Sulawesi and Mollucas

Island as well as Lombok, Sumbawa, Flores, Sumba, Timor, and many smaller islands), and about 58 species in the Sahulland (Papua Island) zone of the country. Of the total of about 1300 species, about 30% are endemic species which mainly inhabit the lakes and rivers of Sulawesi and Papua.

The total fisheries production of Indonesia in 2012 which was about 18.8 million metric tons accounted for 47% of the total fisheries production of Southeast Asia, and contributed about 12% to the world's total fisheries production. The country's production from inland fisheries in 2008-2012 had been increasing at an average rate of 27% per year in terms of volume and 18% per year in terms of value, the highest increase of which was attained in 2012 (MMAF, 2012).

This trend signifies the relevance of inland fisheries to the country's food fish supply, hence, the need for sustainable management of the inland fishery resources justifying the efforts of the Government of Indonesia to carry out stock enhancement and restocking activities in the country's water bodies in order to enhance the contribution of inland fisheries not only to the economy of the country but also to the food security of it people.

## Activities and Results

The history of fisheries enhancement in inland waters of Indonesia can be divided into two periods, *i.e.*, the first period before 1999, and the second period after 1999 until at present. In the first period, fish stock enhancement is the introduction of fish in lakes and reservoirs of Indonesia which had been conducted since the Dutch colonization of the country. During that time, as much as seventeen cultured species had been stocked in some lakes (Sarnita, 1999; Kartamihardja, 2012). Generally, the objectives of stock enhancement were for increasing fish production and fish consumption of the people in the surrounding water bodies. Although the history of fish introductions dates back several hundred years, relatively little is known about the reasons for successes or failures of introduced species and the ecological consequences as these had been poorly documented. Nevertheless, it is generally agreed that introductions involve a level of risk and the certainty of success is unpredictable. The introduction of an aquatic organism will always have some impact on the recipient ecosystem and that the immediate effects on an ecosystem by an introduced species is not always indicative of the long term or permanent impact. In the early 1940s for example, the introduction of java tilapia (*Oreochromis mossambicus*) to Lake Toba had a negative impact on the declining and extinction of the population of an endemic species *Neolissochilus sumatranus* (Sarnita, 1999). Therefore, the introduction of fish into a water body must be carried out carefully and conducted with precautionary approach, especially to the lakes of Sulawesi and Papua where many endemic species inhabit (Kartamihardja *et al.*, 2010).

Generally, the activities during this period may have not been based on scientific evidence so the activities had mostly failed. Nevertheless, some successful fish stock enhancement were recorded such as introduction of common carp (*Cyprinus carpio*) in Tondano Lake in North Sulawesi; java barb (*Barbonymus gonionotus*), snake skin gouramy (*Trichogaster pectoralis*) and kissing gouramy (*Helostoma temminckii*) in Tempe Lake in South Sulawesi, and snake skin gouramy in flood plain areas of South Sumatera and Kalimantan. These species were found to have adapted to the available habitat, grown well and spawn naturally contributing significantly to the fish catch of these water bodies (Sarnita, 1999).

In the second period since 1999, fish resources enhancement in Indonesian inland waters, especially in lakes and reservoirs started with experimental research and were therefore based on scientific evidences, such as productivity and ecological niche of the water bodies, structure of fish communities, life cycle and biology of the fish stocked (Kartamihardja, 2007). Some successful fish stock enhancement in some lakes and reservoirs are presented in **Table 1**. A significant result of restocking is transplantation of the bilih fish (*Mystacoleucus padangensis*), an endemic species of Singkarak Lake in West Sumatera to Toba Lake in North Sumatera, where fish productivity increased to 350 kg/ha/yr or 1400% five years after stocking (Kartamihardja & Purnomo, 2006; Kartamihardja & Sarnita, 2010; Kartamihardja, 2012). The bilih fish inhabits all over of the lake and reproduces naturally in the inlet river to the lake (Wijopriyono *et al.*, 2010). In 2000, the Siamese (stripped) catfish (*Pangasianodon hypophthalmus*) introduced into the Wonogiri Reservoir in Central Java was observed to grow well and spawn naturally in the deepest part of the Keduwang river mouth entering the Reservoir thereby contributing significantly to the fishers' catch (Adjie *et al.*, 2010; Kartamihardja & Purnomo, 2004; Kartamihardja *et al.*, 2011).

Milkfish (*Channos channos*) stocking into Djuanda (Jatiluhur) Reservoir was meant not only to promote the utilization of phytoplankton abundance as result of the enrichment from floating net cage activities but also to mitigate the improvement of water quality from micro-algae bloom (Maskur *et al.*, 2010). Stocking of the giant freshwater prawn into the shallow reservoir, Darma in West Java resulted in rapid growth and significant catch, although the number of prawn juveniles stocked was below the optimum (Kartamihardja *et al.*, 2004).

The reasons for fish stock enhancement into a new water body can vary. Some of the goals of stock enhancement which have been identified include: enhancing commercial or subsistence fisheries; restoring degraded fish communities including the recovery of rare, threatened or endangered fish species; enhancing food supply; creating new or diversified fisheries for associated social and economic benefits; establishing biological control agents for micro-algae and mitigating the water's quality.

**Table 1.** Productivity of lakes and reservoirs after stock enhancement

Lakes/ Reservoirs	Area (ha)	Species stocked	Productivity before stock enhancement (kg/ha/yr)	Productivity after stock enhancement (kg/ha/yr)	Increase in productivity	Economic value* (IDR/ha/yr)
Toba Lake	112,000	Bilih ( <i>Mystacoleucus padangensis</i> )	22.0-28.0	340.0-400.0	350.0 (1400%)	5,250,000
Wonogori Reservoir	7,800	Siamese catfish	26.0-35.0	59.0-62.0	30.5 (102%)	457,500
Mahalayu Reservoir	275	Siamese catfish	60.0-75.0	102.0-129.0	49.5 (73%)	742,500
Darma Reservoir	400	giant freshwater prawn	75.0-123.0	99.0-128.0	14.5 (15%)	217,500
Jatiluhur Reservoir	8,300	milkfish	27.0-32.0	178.0-181.0	150.0 (508%)	2,250,000
Sempur Reservoir	255	milkfish	3.5-4.0	7.9-9.2	5.0 (133%)	na

\*Note: Economic values were analyzed 2-5 years after the start of stock enhancement activities

Source: Kartamihardja (2015)

### Lessons Learned

Based on the successful implementation of the stock enhancement in Indonesian inland waters, lessons could be learned. In culture-based fisheries activities, stocking of fish was undertaken regularly, while in fish restocking conducted the fish stocked were those that spawn naturally. Fish seeds were stocked at an optimum level. In the management of fish stock enhancement, regulations on fishing, marketing system, and strengthening of management institutions were developed. In addition to enhancing the participation of communities around water bodies, a co-management system had also been developed. Co-management using Fishers' Group (as community institution) is a formal process of sharing the responsibility and

authority between the government and organized groups in a decentralized approach to decision-making that can be replicated (Pomeroy *et al.*, 2001). Without co-management, decision making could lead to top-down management that involves fewer users in fisheries management, and often resulting in communication barrier. The success or failure of stock enhancement is also determined by the availability of data and information on the results of monitoring carried out continuously. Therefore, the monitoring activities should be carried out by fishers' groups and local communities as the main champion in the management and direct beneficiaries of the stock enhancement activities.

### Recommendations and Way Forward

Indonesian inland waters bodies have different limnological characteristics, especially in terms of productivity (potential fish yield), fish species inhabiting, and their functions. These different characteristics resulted in varied levels of stock enhancement successes. Community participation around water bodies has determined the success and sustainability of the fish stock enhancement. Therefore, in the future fish stock enhancement should include the following strategies.

- Identification of water bodies suitable for stock enhancement, such as its productivity, niche ecology, structure of fish community and its trophic level
- Selection of fish species to be stocked based on biological, social as well as economic aspects
- Species to be introduced should be plankton feeder and/or herbivore (fish stocked mainly

utilizing the natural food such as plankton or aquatic weeds)

- Introduction of fish species should be done with precautionary approach especially in lakes of Sulawesi and Papua inhabited by endemic species
- Development of local hatchery to provide seeds or fingerlings of fish species to be stocked, which the Government could facilitate and support local fish hatcheries
- Establishment of regulations on fishing and development of co-management regime and coordination among users
- Development of best practice guidelines on stock enhancement in Indonesian inland waters which should take into consideration certain characteristics of specific water bodies

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