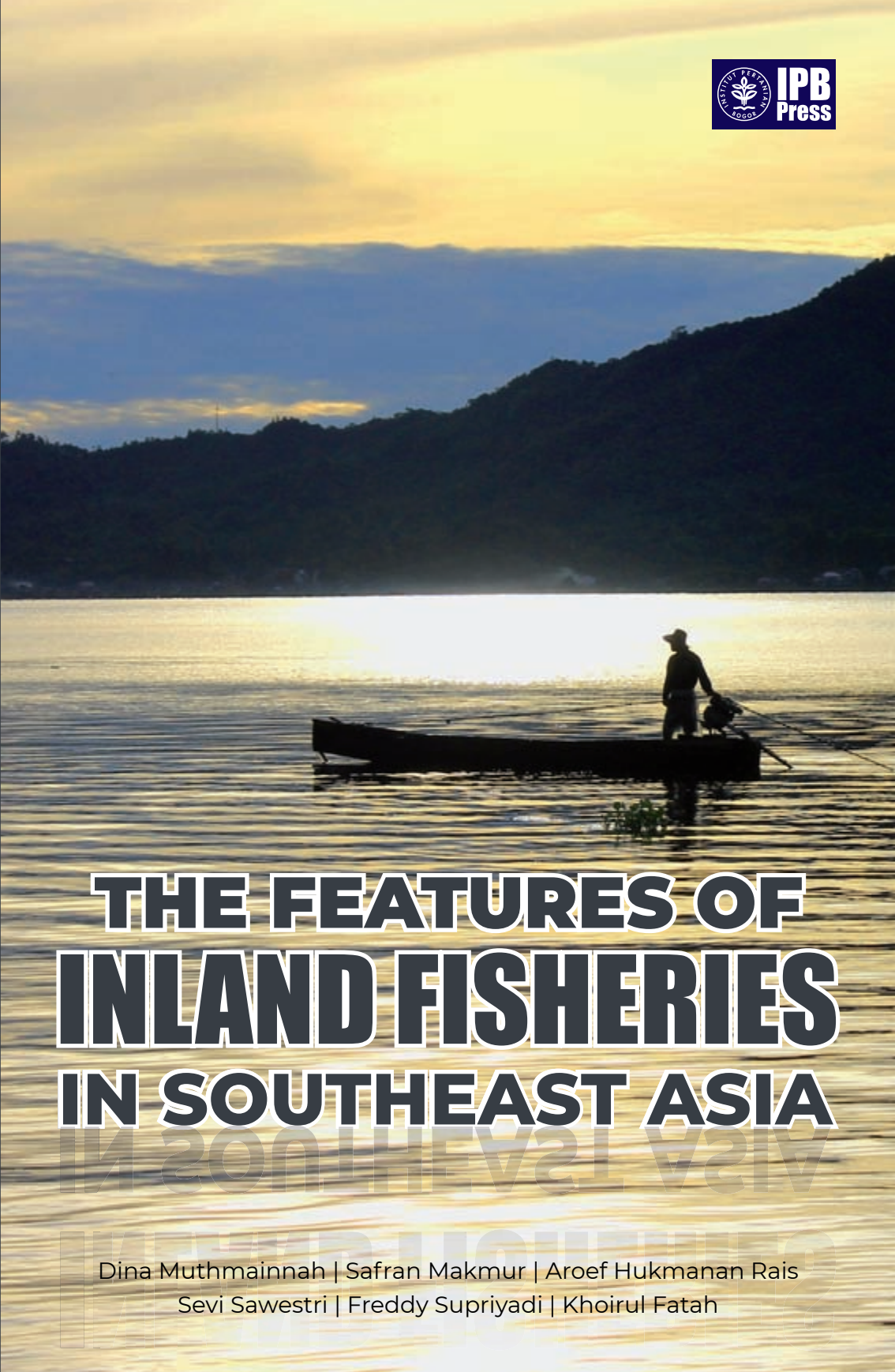

THE FEATURES OF INLAND FISHERIES IN SOUTHEAST ASIA

Dina Muthmainnah | Safran Makmur | Aroef Hukmanan Rais
Sevi Sawestri | Freddy Supriyadi | Khoirul Fatah

THE FEATURES OF INLAND FISHERIES IN SOUTHEAST ASIA

Research Institute for Inland Fisheries and Extensions

Inland Fishery Resources Development and Management Department (IFRDMD)

Sponsor by:

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Authors:
Dina Muthmainnah
Safran Makmur
Aroef Hukmanan Rais
Sevi Sawestri
Freddy Supriyadi
Khoirul Fatah

Editors:
Ngurah N Wiadnyana
Luky Adrianto
Virgilia T Sulit
Arif Wibowo

Proof Reader:
Bayu Nugraha

Layout and Cover Design:
Makhbub Khoirul Fahmi

Photos were taken by:
Subagdja
Yanu Prasetiyo Pamungkas
Nelline Notenboom

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MESSAGE

from the Secretary-General of SEAFDEC

The Southeast Asian Fisheries Development Center (SEAFDEC) has been playing the leading role in promoting sustainable fisheries development for food security in Southeast Asia. Considering that inland fisheries is important for local food security in the Southeast Asian region, SEAFDEC had in the past, initiated some activities on inland fisheries. However, these had been rather minimal due to limited capacity in terms of resources especially expertise in inland fisheries. The proposed establishment of the Inland Fishery Resources Development and Management Department or IFRDMD under the SEAFDEC framework which was announced by the Indonesian Minister for Marine Affairs and Fisheries during the ASEAN-SEAFDEC Conference in 2011 was a welcome development. The official establishment of IFRDMD and its operationalization in September 2014 had paved the way for SEAFDEC to formulate programs and activities that focus on inland fisheries and inland fishery resource conservation and management from the regional point of view. While actively recognizing the importance of inland fishery resources in terms of livelihood opportunities creation for many peoples in the rural areas, SEAFDEC also continues to enhance cooperation and collaboration with other organizations within and outside the region that are working towards the same goal of promoting sustainable inland fisheries.

This book that deals with "The Features of Inland Fisheries in Southeast Asia" prepared by IFRDMD would play a crucial role in the sustainable development of the region's inland fisheries, and provide useful

information on the accomplishments of SEAFDEC and what to expect in the future. I therefore commend IFRDMD for the achievements it had attained during its five-year existence, especially in coming up with this Book, and I also raise my expectations in the years ahead.

As the Secretary-General of SEAFDEC, I am indeed very grateful to all those who have contributed their valuable time and inputs for this Book. SEAFDEC will forever cherish the efforts and contributions that you all have imparted for the realization of this Book.

Lastly, SEAFDEC also wants to assure the stakeholders that we are not resting on our laurels as our programs and activities on inland fisheries would be enhanced. SEAFDEC would be working even much harder so that fish would continue to be available on the plates of all people, especially those in the rural areas.

Dr Kom Silapajarn

SEAFDEC Secretary-General

MESSAGE

from the SEAFDEC Council Director for Indonesia

On behalf of the SEAFDEC Council, please allow me first of all, to express our heartfelt appreciation to SEAFDEC for its continuous efforts in promoting the sustainable development of fisheries for food security in the Southeast Asian region. We, therefore, commend SEAFDEC for the achievements it had attained during the 52 years of its existence.

For Indonesia, we have gained maximum benefits from the regional initiatives of SEAFDEC, especially after the establishment of one of its Departments, the Inland Fishery Resources Development and Management Department or IFRDMD for short. Through the projects and activities of IFRDMD, the peoples in the Southeast Asian region could also be assured of the sustainable development of inland fisheries for food security in our region.

As we all know, the sustainability of inland capture fisheries is very much dependent on the quality of the aquatic habitats and ecosystems. In order to enhance the role of inland fisheries in providing livelihoods to the people, there is the need to strengthen governance for sustainable inland fisheries through the application of ecosystem approach to fisheries management. Since its establishment in 2014, IFRDMD has played a major role in the management and coordination of the project activities of SEAFDEC that aim to promote the sustainable development and management of the region's inland capture fisheries. Its initial project "Promotion of Responsible Utilization of Inland Fisheries

Resources in Southeast Asia" has paved the way for the establishment and strengthening of regional networking for sustainable inland fisheries management and fish conservation of inland water resources. Capacity building activities such as regional training courses and workshops organized by SEAFDEC, have enhanced the capacity of ASEAN fisheries officials on the responsible utilization of inland fishery resources.

With the publication of this Book, I would wish to encourage SEAFDEC to continue its excellent work in providing support to the Member Countries for the sustainability of our inland fisheries. I would also wish to express my utmost appreciation to the authors and editors for their unstinted work during the preparation of this Book. I hope IFRDMD would continue to raise the awareness of the stakeholders on the progress of its activities and achievements in the future.

Furthermore, my appreciation is also extended to SEAFDEC for providing generous support and cooperation throughout the past years, and specifically for implementing activities that are beneficial to the countries in the region.

Mr Nilanto Perbowo

Secretary General

Ministry of Marine Affairs and Fisheries Republic of Indonesia

PREFACE

During the ASEAN-SEAFDEC Conference in June 2011, the former Minister of Marine Affairs and Fisheries of Indonesia, *His Excellency Dr Fadel Muhammad* put forward the proposal to establish a regional center for inland fisheries considering that the four established SEAFDEC Departments focus on marine fisheries and aquaculture. Recognizing the importance of inland fisheries for food security, livelihood and wellbeing of peoples in the whole Southeast Asian region, the SEAFDEC Council of Directors unanimously supported the proposal during the subsequent year. Such plan finally came into fruition two years later when the Government of Indonesia represented by *Prof Syarief Widjaja*, the Secretary-General of the Ministry of Marine Affairs and Fisheries (MMAF) and SEAFDEC Council Director for Indonesia, signed the National Legitimacy Document on 2 September 2014 for the official establishment of the Inland Fishery Resources Development and Management Department (IFRDMD) in Palembang, Indonesia as the fifth Department of SEAFDEC.

IFRDMD then became operational in 2015 upon completion of the construction of buildings, laboratories, and other facilities. However, prior to such development, the first set of activities of IFRDMD had already been ongoing during the last quarter of 2014, at its temporary site in the compound of the Research Institute for Inland Fisheries also in Palembang. The conduct of such initial activities enabled the IFRDMD to promptly address the regionally important and relevant issues at the soonest time possible. IFRDMD then initiated in 2015, the implementation of the project "Promotion of Responsible Utilization of Inland Fisheries Resources in Southeast Asia" which is scheduled to be completed in 2019, and aimed at reviewing the activities and

methodologies for promoting inland fisheries in the ASEAN Member States (AMSs) and in finding the ways and means for ensuring the sustainable development of inland fisheries. The Project aims to promote effective inland fisheries management measures in the AMSs, and implement studies on the development of habitat conservation and resources enhancement measures suitable for Southeast Asia.

During the past five years, several activities have been carried out by IFRDMD that focused on reviewing the activities and methodologies for promotion of inland fisheries, promoting co-management and rights-based fisheries management applicable to inland fisheries in Southeast Asia, establishing habitat conservation and resources enhancement measures appropriate for Southeast Asia, and organizing regional training courses aimed at improving the management of inland fisheries. The outputs from such activities have been compiled and used at inputs for this Book.

At this juncture, we acknowledge the support of the Japanese Trust Fund VI that enabled IFRDMD to carry out the aforementioned five-year Project. We also thank the Member Countries and research officers of SEAFDEC Secretariat and Training Department for their cooperation and invaluable help during the collection of data and information necessary to complete this Book. We appreciate the efforts and support of *Dr Arif Wibowo* (IFRDMD Chief), *Dr Takuro Shibuno* (IFRDMD Deputy Chief) and *Dr. Satoshi Honda* (Former IFRDMD Deputy Chief), *Dr Lilly Aprilya Pregiwati* (SEAFDEC National Coordinator for Indonesia), and the main staff of SEAFDEC National Coordinator for Indonesia, *Ms Aniza Suspita*.

Last but not the least, we dedicate a first achievement of inland fisheries book to the Late *Mr Budi Iskandar Prisantoso* for hard work at the beginning of the establishment of IFRDMD, and *Dr Achmad Poernomo* who push IFRDMD to publish this book.

The Editorial Team

TABLE OF CONTENTS

TABLE OF FIGURES

CHAPTER 1
INTRODUCTION

Numerous bodies of inland waters are widely distributed in Southeast Asia and the fisheries production from such waters is one of the sources of people's animal protein. The capture fisheries sector, utilizing these inland waters, provides employment opportunities and revenues to millions of peoples in the rural areas.

1.1 Background

Inland waters refer to permanent water bodies found inland from the coastal zone areas and whose properties and uses are characterized by permanent, seasonal, or intermittent occurrence of flooding. Aside from their role as fish habitats, inland waters are also used as fishing grounds by capture fisheries as well as sites for fish culture. Inland waters generally refer to lakes, rivers, brooks, streams, ponds, inland canals, and dams. Similarly in Southeast Asia, inland water bodies include rivers, lakes, floodplains, reservoirs, wetlands, and inland brackishwater water systems, *e.g.* estuaries (**Figure 1.1**).

Inland capture fisheries as defined by FAO (2011), is the extraction of living aquatic organisms from natural or man-made inland waters, but excluding those from aquaculture facilities. While inland fisheries could generally mean the commercial fishing operations done in freshwater bodies surrounded by landmass, some fishing activities like capture fisheries, harvest the fish living naturally in inland water bodies. Fish farming or aquaculture is also another form of inland fisheries, where the aquatic species are raised in tanks, ponds or pens and cages in water bodies, to marketable sizes for human consumption. Specifically, inland capture fisheries refers to all kinds of harvesting of naturally occurring living resources in freshwater environments, while freshwater aquaculture refers to the farming of fish in freshwater environments, *i.e.* commercial production of fish in ponds or enclosures, usually for food. In Southeast Asia, fishing activities in inland waters usually start at the onset of the rainy season when fish migrates from main rivers to other water bodies for feeding or spawning, and end during the middle of the dry season when the fish goes back to main rivers. The phenomenal floodplain areas that are formed during the wet season and the lowland swamps become productive fishing grounds for inland capture fisheries and related activities, where large volumes of fish are harvested.

Figure 1.1 The productive fishing ground: a) The River, b) Floodplain, c) Riparian Vegetation, and d) Swamp Forest

The Southeast Asian region is endowed with enormous areas of natural inland water resources, such as river systems, lakes, floodplains, reservoirs, dams, and wetlands. **Figure 1.2** shows the important rivers and lakes in the region, with Indonesia having more than 256 million ha of inland water bodies, followed by Myanmar with more than 82 million ha, Thailand with more than 66 million ha, and the Philippines with more than 12 million ha. Cambodia has the Tonle Sap Great Lake that could expand from 250,000 ha to more than 1.6 million ha during the wet season (Pongsri *et al*. 2015).

Fisheries in inland waters provide food security, livelihood, cultural and religious identity, recreation, and serve as a source of income for millions of people globally (Welcomme *et al*. 2010; Lynch *et al*. 2016). Inland fisheries have long been a vital component of economic security in sustaining and alleviating the conditions of the poor and disadvantaged communities around the world, their subsistence of which depends on the products from wetlands and other inland resources.

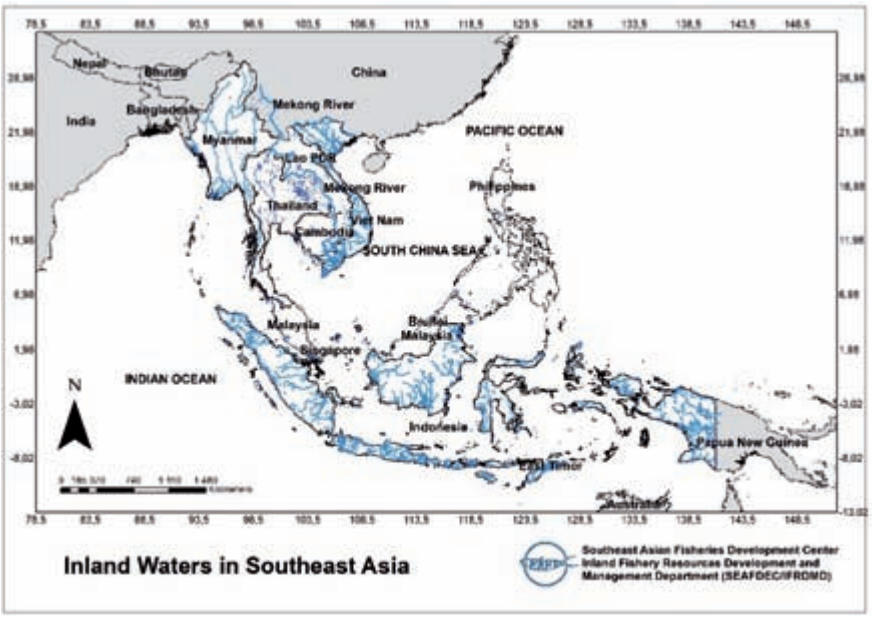


Figure 1.2 Distribution of inland waters in Southeast Asia

Inland waters are hosts to large numbers of aquatic species that have already adapted to the many types of ecosystems. However, most inland water resources have been degraded or even lost mainly as a result of destructive human activities. The pressure exerted on the habitats and the environment in inland waters is also felt by the aquatic communities. Some aquatic species are static and with little movements in a specific habitat while others move between different habitats. Changes in the aquatic environment caused by fishing and non-fishing activities could disrupt the sustainability of the inland water resources. Destructive fishing practices such as the use of poisonous substances and electric shock damages the whole fish community while irresponsible management of aquaculture operations negatively impacts on the quality of the water, which is untreated and oftentimes discharged to the surrounding aquatic environment resulting in eutrophication.

The pressure on habitat and its environment on inland waters will be reacted by aquatic communities. Some species are static and move little for a specific habitat, and others moving between different habitats. The changes of the aquatic environment caused the fishing and non-fishing activities could disrupt the sustainability of the inland water resources. Destructive fishing practices such as using poisonous substances and electric shock damaged the whole fish community as well as inadequate management of aquaculture negatively impacted the water quality. Modification of water bodies (damming or dredging) damaged the spawning ground, changed the fish migration pattern, and harmed fish feed organisms. Competition on utilizing the freshwater resources among several sectors (e.g. development projects) damaged the aquatic ecosystem.

1.2 Inland Waters for Inland Fisheries

The inland fisheries sub-sector is one of the essential socio-economic components for many countries in the Southeast Asian region, and its contributions in rural communities are particularly significant in terms of alleviating poverty, ensuring food security, and sustaining people's nutritional well-being. The sustainability of inland capture fisheries depends much on the quality of the aquatic habitats and ecosystems. Therefore, while aiming for the sustainability of inland fisheries, the fisheries sector should recognize that the inland water ecosystems are also being utilized by other development sectors. It is under such a circumstance that the role of inland fisheries in economic development should be valuated so that its importance as source of food especially for the rural communities is well recognized by planners and policymakers, and its significance in economic development boosted (**Figure 1.3**).

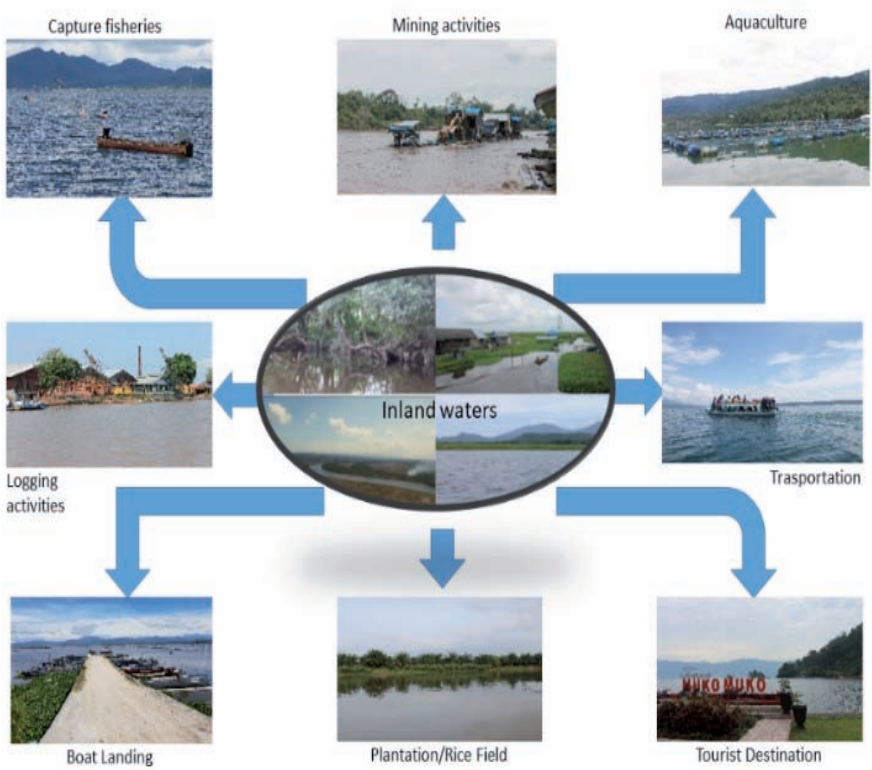


Figure 1.3 Inland waters utilization

Nonetheless, policy makers should be made aware of the impacts of various activities being undertaken by other sectors in inland waters, *e.g.* impacts of alteration of the habitats of aquatic organisms on fishery production. Although many development projects are proposed for enhancing national economies and improving the quality of life of people especially in low-income countries, policy makers should be cautioned that such projects could possibly lose the high productivity potentials and aquatic ecosystem services. Advocacy is necessary to ensure that in every project implemented, the balance between economic development and environmental sustainability is ensured.

In this regard, it has also become necessary that the inland fishery resources should be responsibly managed for sustainability, *e.g.* promotion of management measures that involves all stakeholders,

especially in making management decisions. Adapted from FAO (1997), SEAFDEC (2017) defined fisheries management as "*the integrated process of information gathering, analysis, planning, consultation, decision-making, allocation of resources, and formulation and implementation, with enforcement as necessary, of regulations or rules which govern fisheries activities to ensure continued productivity of the resources and accomplishment of other fisheries objectives*." This implies that the primary purpose of fisheries management is to establish appropriate system of management rules based on defined objectives, as well as a mix of management means to implement the regulations, which are put in place by a system of monitoring, control, and surveillance (Wilson *et al*. 2003). SEAFDEC (2017) added that many types of management measures are applicable for the inland resources in Southeast Asia, taking into account the various ways that water bodies are being utilized, *i.e.* for domestic consumption; industrial production; agricultural production; water barrier construction; and recreational uses (FAO 1997; World Business Council for Sustainable Development 2006). Such measures include co-management, community-based fisheries management, integrated management, government-based management, and the Ecosystem Approach to Fisheries Management (EAFM), where EAFM gives due consideration of the surrounding conditions of the fishery sector. However, there are challenges that hinder the successful promotion of inland fisheries in the region, *e.g.* insufficient data and information, environmental degradation, overexploitation of the fishery resources. These concerns should be addressed for the sustainability of inland fisheries.

Considering that information on the status and trends of inland fisheries is widely recognized as crucial in serving as primary data for keeping the sustainability of development and management of this sub-sector, the SEAFDEC/IFRDMD had started compiling data and information on inland fish and fishery activities in the ASEAN Member States (AMSs), namely: Brunei Darussalam, Cambodia, Indonesia, Lao PDR, Malaysia, Myanmar, Philippines, Singapore, Thailand, and Viet Nam. Exchanging of information on the present status of inland fisheries in the Southeast Asian region as well as seeking practical and precise methods on collection of data on inland fisheries, particularly on catch statistics, fishing gears, management measures, and livelihood, have also been promoted in the AMSs through workshops, meetings, and in-house training sessions.

This book therefore includes the status of inland fisheries in Southeast Asia, the threats to inland water environments and fisheries, and management options for now and in the future that would enhance the economic well-being of the rural communities and promote environment-friendly practices.

CHAPTER 2
INLAND CAPTURE FISHERIES AND ITS STATUS

Fisheries activities in inland waters vary considerably and are adequately related to the specific fishing areas, aquatic species targeted, fishing gear used, and social culture of some places. The inland fisheries sub-sector however, is facing various challenges that should be addressed to be able to implement the appropriate management measures.

Fishing is traditionally an important occupation for many rural people living near inland water bodies, generating significant incomes and providing hereditary employment opportunities to the rural peoples. In utilizing the fishery resources, fishers use many different types of gear and commonly used to catch different fish species as shown in **Figure 2.1**, and the growing trend in the number of fishers entering the fisheries is unlikely to correspond to increases in fishery resource productivity, exacerbated by environmental degradation which has also become a major public concern in inland water bodies. The degradation happened in each country is in different stage. Exemplification in the Siak River, Indonesia, the river gets the waste from the industry such as palm oil processing, pulp and paper processing, rubber processing, docking, transportation and household. **Figure 2.2** shows the color of waters surrounding the rubber processing in Siak River.

The addition of the number of fishers entering the fishing area is likely to be not followed with the increases of fishery resource productivity. Nowadays, inland capture fisheries receive relatively little attention from the governments and scientists, and the problems could even be more complicated than those in marine fisheries. For instance, there is no appropriate landing freshwater fish places compared to those for marine fish. The fishers have landed their fish to the waters body side to sell directly the fish to buyers, who prior to give some money to the fishers in case of the bad season or no fishing season. The main concerns in the inland fisheries sub-sector could be urgently addressed if the responsibility of managing the fisheries is handed over to relevant communities, although fisheries management has always been assumed to be a government responsibility (Gordon 1954).

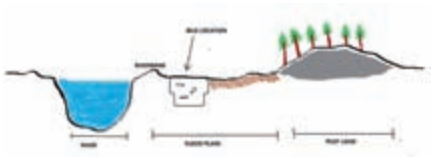
Stow Net in Myanmar

Kind of bamboo traps in Malaysia

Stationary Trawl (Dai) Fishery in Cambodia

Lee Trap Fishery in Lao PDR

Trap in Viet Nam



Beje Trap in Indonesia

Figure 2.1 Commonly fishing gears in AMS

2.1 Portrait of Inland Waters and Its Capture Fisheries

People can fish in inland water bodies whole year round but the amount of fish caught varies from one season to another. Freshwater fishes and other aquatic resources found the inland waters could be categorized as the economically-important fishes, artisanal fishes, threatened fish, or food fish. The life span of each fish is different and determined by the characteristics of the ecosystem and habitats. Exploitation of the fishery resources is also practiced in various ways based on the types of ecosystems. Some pictures showed in **Figure 2.3, 2.4, 2.5, and 2.6**.

Figure 2.2 The waste of rubber processing flows to Siak River

In 2019, Asian Species Action Partnership (ASAP) stated there are 48 freshwater fish in Southeast Asia that are considered to be just one step away from extinction in the wild. A large portion of these are endemic and restricted-range species, such as: Bagangan (*Barbodes clemensi, Mandibularca resinus), Betta Persephone, Betta spilotogena,* Giant Carp, Giant Pangasius, Irrawaddy River Shark, *Hampala lopezi,* Krabi Mouth Brooding Betta, Mekong Giant Catfish, Mekong Giant Salmon Carp, Poso Bungu *(Weberogobius amadi) Schistura leukensis,*

Schistura nasifilis, Sentani Rainbowfish, Siamense Bala-shark, Siamese Tiger Perch (https://www.speciesonthebrink.org/news/freshwater-fish-the-importance-of-updating-conservation-status/).

The range of life for each fish is different and determined by the ecosystem and habitat characteristics. The exploitation of fish is operated in various ways related to the types of ecosystem. The components of inland fisheries are types of inland waters, fish diversity, types of fisher, types of fishing gear, role of gender, and postharvest.

Channa striata
Snakehead

Anabas testudineus
Climbing perch

Clarias batrachus
Philippine catfish

Trichogaster pectroralis
Snakeskin gourami

Anguilla bicolor
Indonesian shortfin eel

Chitala lopis
Giant featherback

Figure 2.3 The important economically fish

Mystacoleucus padangensis

Glossogobius giuris
Manggabai

Albulichthys albuloides

Oxyeleotris marmorata
Marble goby

Rasbora argyrotaenia
Silver rasbora

Kryptopterus cryptopterus

Hemibagrius wyckii

Pangasius nasutus

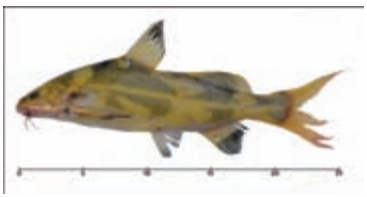
Hampala macrolepidota
Hampala Barb

Tor douronensis
Semah Mahseer

Ompok bimaculatus
Butter catfish

Mastacembelus erythrotaenia
Fire Eel/Spotted Fire Eel

Figure 2.4 The important economically fish as well



Bagroides melanopterus
Harlequin lancer

Balantiochilus melanopterus
Tricolor Sharkminnow

Epalzeorhynchos kalopterus
Flying fox

Kryptopterus minor
Ghost catfish

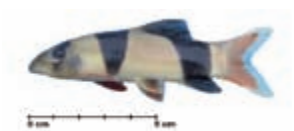
Mastacembelus erythrotaenia
Fire Eel/Spotted Fire Eel

Barbodes schwanofeldi
Tinfoil barb

Leptobarbus hoeveni
Hoven's carp

Kryptopterus limpok
Long barbel sheatfish

Scleropages formosus
Asian bonytongue



Chromobotia macracantus
Clown loach

Figure 2.5 The ornamental fish

Chitala lopis
Giant featherback

Scleropages formosus
Asian bonytongue

Glossolepis incises
Rainbow fish

Telmatherina celebensis
Celebes rainbow

Glossogobius giuris
Tank goby

Giuris margaritacea
Snakehead gudgeon

Neolissochilus sumatranus

Figure 2.6 The threaten fish

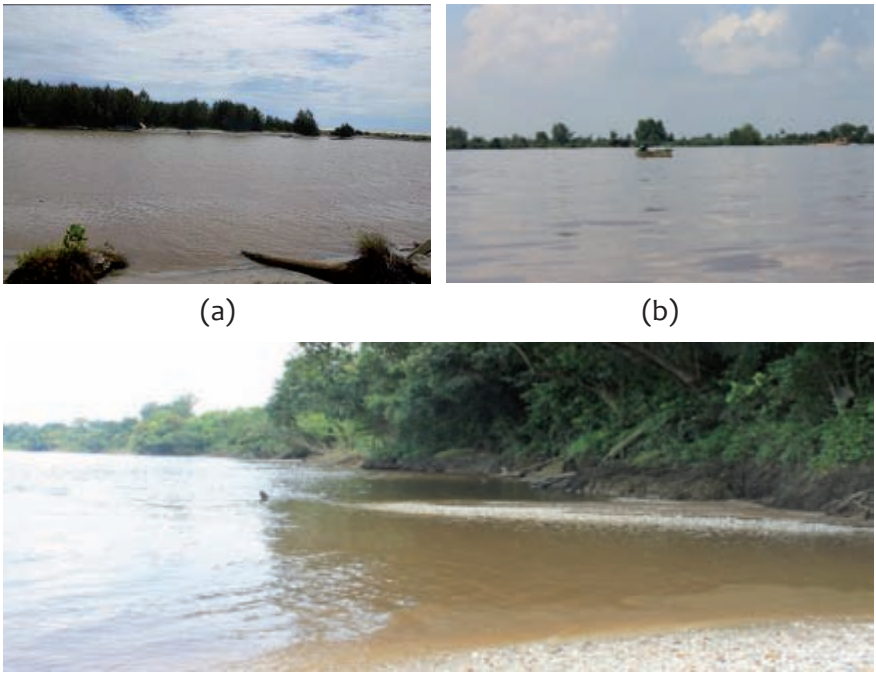
Characteristic of Major Inland Waters

The main types of inland waters serve for fishery activities are as follows.

Rivers

River is the natural flowing of water, usually freshwater in an open linear system, which could be divided into three parts: upstream, midstream, and downstream (**Figure 2.7**). In the upstream of the river, food webs are produced by the organic matter that progressively comes from degradation processes resulting from human activities, and also those of the invertebrates and micro-organisms along the course of the river channel (Vannote *et al*. 1980). The degree of deforestation and agriculture practices in the vicinity of a river, impacts significantly on the food chain in the river's midstream. At the downstream of rivers, the nutrient dynamics comprise the materials deposited from the upstream and midstream of rivers.

In terms of total area of the rivers in Southeast Asia, Pongsri *et al*. (2015) reported that Indonesia's rivers taken altogether have the widest area which total to about 1,899,750 km^2, followed by Myanmar (737,800 km^2), Thailand (511,311 km^2), Malaysia (312,840 km^2), Lao PDR (123,348 km^2), and the Philippines (108,923 km^2). The total river area of Cambodia is the smallest at 1,483 km^2.



(a) (b)

(c)

Figure 2.7 (a) Downstream, (b) midstream, and (c) upstream

Floodplains

A floodplain primarily comprises extensive shallow swampy areas, often associated with an interface of a river as part of a riparian zone, and seasonally varies in terms of area depending on the rainfall, discharge from inflowing streams, and groundwater. Floodplains are usually very productive and support fish populations that have already highly adapted to the demanding environmental conditions of the habitats. One of the most threatened of environments of inland waters is a floodplain since the level of water fluctuates very much and is even used as rice fields in the dry season. Although not a permanent area, floodplains account for over half of total wetland areas in Southeast Asia and support high levels of fisheries production, with the population of fish that usually increases during the wet season (Nguyen Khoa *et al.* 2005; Hortle *et al*. 2008). During the water flooded the swamp

area, some fish migrate for feeding and starting to spawn by putting and keeping the eggs among the branches of plants. The fish usually migrate to the swamp area are the blackfish group such as snakeheads, climbing perch, kissing gourami, and catfish.

In Southeast Asia, Indonesia has the biggest area of floodplains totaling to about 33,281,155 ha, followed by Thailand (12,851,984 ha), Myanmar (6,000,000 ha), Malaysia (2,979,918 ha), Cambodia (727,382.10 ha), and Lao PDR (156,000 ha).

The unique of Tonle Sap Great Lake in Cambodia is the system expands and contracts seasonally in response to rainfall and the flow of the Mekong, thereby acting as a storage which regulates flooding (**Figure 2.8**). When the level of the Mekong rises, water runs north-west 'up' the Tonle Sap towards the lake, which may increase from its dry-season (Dec-June) depth of 1-2 m up to about 10 m at the peak of the flood. The lake's area expands from 2,500-3,000 km^2 in the dry season to 10-14,000 km^2 during the flood season, when it covers about 5-8% of the land area of Cambodia (Hortle *et al*. 2004).

(a) (b)

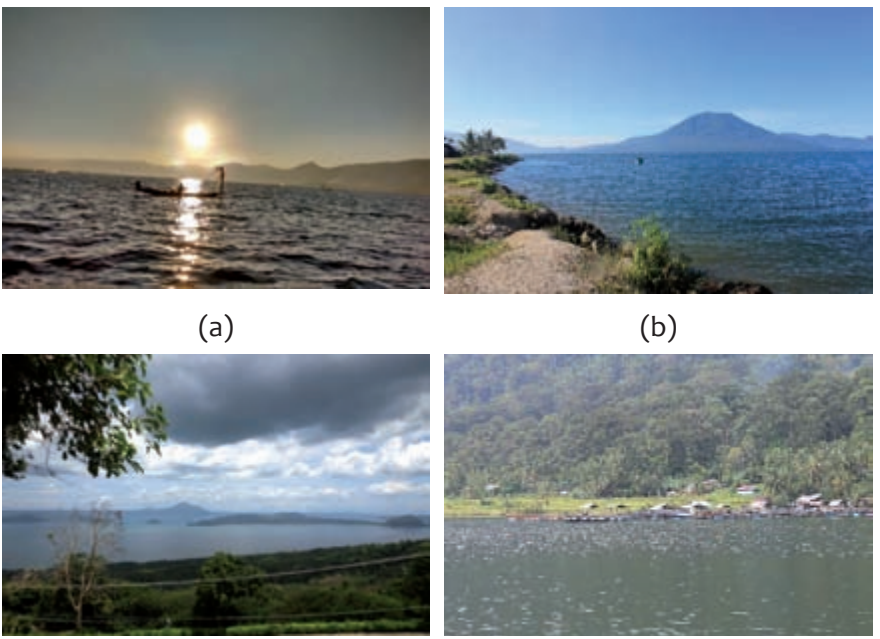
Figure 2.8 Tonle Sap Great Lake in Cambodia during the flooded (a) and dry season (b)

Lakes

A lake is an area filled with water, surrounded by land, apart from any river or other outlets. Lake water body is stable relative than rivers, since it is a closed system and lie on the ground (**Figure 2.9**). Lakes could be natural or man-made. Natural lakes are generally found in

mountainous areas or along the courses of mature rivers. Man-made lakes have been constructed for agriculture purposes, *e.g.* irrigation, or for generation of hydroelectric power and domestic water supply, or for recreational purposes. and certainly, play an important role for fishery activities. In fact, lakes are multi-purposes usefull to support human being. This condition may arise often some conflicts of interest. Lakes are classified naturally according to the richness of their nutrients, from the oligotrophic lakes being the lowest in nutrients and the least productive to eutrophic lakes being high in nutrients and highly productive.

The total lake area in Indonesia is the biggest in Southeast Asia with about 1,800,000 ha, followed by Cambodia (334,186.79 ha), Philippines (87,168.40 ha), and Malaysia having the smallest lake area at 109,489 ha.



(a) (b)

(c) (d)

Figure 2.9 Some views of lakes (a) Inle Lake in Myanmar, (b) Ranau Lake in Indonesia, (c) Taal Lake in Philippines, (d) Maninjau Lake in Indonesia with the floating net cages

Reservoirs

A reservoir is an artificial lake, also known as man-made reservoir, which can be formed by building a dam across a valley, or by excavating the land or by surrounding a piece of land with dyke sand diverting part of a river to flow into the reservoir. The water that accumulated and kept in the reservoir could then be used for irrigation, hydro-power generation or used as water source for domestic and industrial activities. Reservoirs are also constructed to effectively control unexpected floods. A reservoir is filled by precipitation, rainwater runoff or from a constant flow of a river. Sediments from rivers or surface runoff can significantly reduce the storage volume of a man-made reservoir (FAO 1992). Some resevoirs found in the ASEAN Member States (AMSs) include those in Myanmar with the biggest reservoir area of about 1,800,000 ha, followed by Thailand (645,350.62 ha), Indonesia (500,000 ha), Lao PDR (130,309.78 ha), Philippines (19,000 ha), and Cambodia (11,684.47 ha).

Characteristics of Fish Diversity and Fishing Gears

Fish Diversity

Freshwater fish which are restricted to inland waters cannot move quickly between different areas, therefore, inland waters are characterized by high endemicity. Researches regarding the fish diversity identification has already been done in SEAFDEC Member Countries.

There are about 103 freshwater fish species in Brunei Darussalam of which 100 are native and 3 species were introduced. There are 23 of endemic fish with 15 belonging to the family Balitoridae.

More than 500 fish species are found in Cambodia freshwaters, but for any particular fishery most of the catch usually comprises 10 species or less such as *Cirrhinus lobatus/alamensis* (small river carp/Riel), *Channa micropeltes* (Giant Snakehead/Chdao), *Cyclochellichthys anoplos* (Solder river barb/Chhkok), *Labiobarbus* spp. (River Barbs/Ach nok), *Osteochillus*

spp. (Shark minnows/Kroh), *Circhinus microlepis* (Small scale carp/Pruoi). *Pangasius* spp. (River catfish/Pis), *Barborrymus gontonotus* (Tear os/Chhpin prak), *Pateubuca typus* (Pelagic river carp/Siak russey) and *Channa striata* (Striped snakehead/Roh).

In Lao PDR, more than 481 fish species have been identified, including 22 exotic species, and more species are being discovered regularly. More than 10 exotic fish species have been introduced into Lao PDR through various sources, mostly not formally recorded, include: *Cyprinus carpio* (common carp or pa nai), *Carassius auratus* (gold fish or pa phek in the north), *Hypophthalmichthys molitrix* (silver carp or pa ked lap), *Ctenopharyngodon idella* (grass carp or pa kin gna), *Hypophthalmichthys nobilis* (bighead carp or pa houa nhai), *Oreochromis nilotica* (Nile tilapia or pa ninh), *Labeo rohita* (rohu), *Cirrhinus mrigala* (mrigal), *Catla catla* (catla) and *Clarias gariepinus* (African catfish or pa douk phanh) (Phonvisay 2013).

Indonesia is endowed with diverse freshwater fish species, which more than 1,300 species inhabit the Sundaland (about 798 species), Wallacea (68 species) and Sahulland (about 58 species) zones of the country, moreover of the total of about 924 species, 275 species (30%) are endemic species. About 19 introduced species recorded include: *Aequidens pulcher* (Blue Acara), *Aequidens latifrons* (Platinum Acara), *Aristichthys nobilis* (Bighead carp), *Betta splendens* (Siamese fighting fish), *Carassius auratus auratus* (Goldfish), *Clarias gariepinus* (North African catfish), *Ctenopharyngodon idella* (Grass carp/Tonggan), *Cyprinus carpio carpio* (Common carp/Ikan mas), *Oreochromis niloticus niloticus* (Nile tilapia/Nila), *Oreochromis mossambicus* (Mozambique tilapia/Jahir), *Poecilia sphenops* (Molly), *Poecilia reticulata* (Guppy), *Poecilia latipinna* (Sailfin molly), *Pterygoplichthys disjunctivus* (Vermiculated sailfin catfish), *Pterygoplichthys pardalis* (Amazon sailfin catfish), *Trichogastes pectoralis* (Snakeshin gourami/Lampor), *Tinca tinca* (Tench), *Xiphophorus maculatus* (Southern platy fish), *Xiphophorus helleri* (Green swordtail/Suwadakar) (https://fish.mongabay.com/data/Indonesia.htm#hH8Ve2erorul50s3.99).

Meanwhile, the freshwater fish of Malaysia listed 641 species, 621 native species, 16 introduced species, 4 endemic species and 16 species still in questionable/misidentification. The endemic species are *Wallago maculatus, Phallostethus dunckeri, Parsphronemus nagyi, and Clarias batu.* While the introduce species are *Barbodes gonionotus* (Java barb/Lalawak), *Betta splendens* (Siamese fighting fish/Belaga), *Carassius auratus auratus* (Goldfish), *Catla catla* (Catla/Pla kra ho), *Cirrhinus chinensis* (Chines mud/Kap Lumpur), *Ciirhinus cirrhosis* (Mrigal/ Mrigal), *Clarias gariepinus* (North African catfish), *Clarias macrocephalus* (Bighead catfish), *Cyprinus carpio carpio* (Common carp/Leeko), *Etropus suratensis* (Green chromide). *Gambusia affinis* (Mosquito fish), *Hypostomus plecostomus* (Suckermouth catfish), *Micropterus salmoides* (Largemouth bass), *Oreochromis niloticus niloticus* (Nile tilapia), *Oreochromis mossambicus* (Mozambique tilapia/Tilapia), *Poecilia reticulata* (Guppy), *Pterygoplichthys pardalis* (Amazon sailfin catfish), *Trichogastes pectoralis* (Snakeshin gourami) (https://fish.mongabay.com/data/ Malaysia.htm).

A total of 449 fish species have been identified from rivers and lake of Myanmar. Those are consisted of 365 native species and 54 endemic fish, 12 introduce species, and still questionable/ misidentification for remaining. The introduce species are *Aristichthys nobilis* (Bighead carp), *Barbodes gonionotus* (Java barb), *Clarias gariepinus* (African catfish), *Clarias macrocephalus* (Bighead catfish), *Ctenopharyngodon idella* (Grass Carp), *Cyprinus carpio carpio* (Common carp), *Gambusia affinis* (Mosquito fish), *Hypophthalmichthys molitrix* (Silver carp), *Pangasinodon hypophthalmus* (Sutchi catfish), *Osphronemus goramy* (Giant gournami), *Oreochromis niloticus niloticus* (Nile tilapia), *Oreochromis mossambicus* (Mozambique tilapia), *Trichogaster pectoralis (*Snakeskin gourami/ Bubble nest builder) (https://fish.mongabay.com/data/Myanmar.htm).

The Philippines noted their freshwater fish resources host about 358 species grouped onto 120 endemics, 59 introduces, and 102 threatened species. Some invasive species of Philippines can be processed to fish meal, dried fish skin, and handicrafts. Some of those fish are utilised as

a source of income and livelihood from local fishery, such as: *Gambusia affinis* (Mosquito fish), *Channa striata* (Snakehead), *Cyprinus carpio* (Common carp), *Oreochromis mossambicus* (Mossambique tilapia), *Oreochromis niloticus* (Nile tilapia), *Carassius* spp. (Crucian carp), *Cristaria plicata* (Freshwater mussel), *Liposarcus disjunctivus* (Janitor fish), *Liposarcus pardalis* (Janitor fish), *Clarias batrachus* (Thai catfish/ Walking catfish), *Pomacea cananiculata* (Golden apple snail), *Parachromis managuensis* (Guapote tigre/Jaguar guapote), *Barbodes gonionotus* (Java barb/Tawes), *Pygocentrus nattereri* (Red piranha), *Clarias gariepinus* (African catfish), *Channa micropeltes* (Giant snakehead), *Arapaima gigas* (Arapaima), *Piaractus brachypomus* (Red-bellied pacu) (http://www.fftc.agnet.org/htmlarea_file/activities/ 20110826121346/ paper-729213301.pdf).

Further, Thailand determined about 836 species of freshwater fish which consist of 17 endemic species, 23 introduced species and 756 native species. The endemic species are: *Badis siamensis, Cryptotora thamicola, Devario maetaengensis, Ellopstoma mystax* (Enigmatic loach), *Epalzeorhynchos bicolor, Homaloptera sexmaculata, Lobocheilos nigrovittatus, Lobocheilos thavili, Nemacheilus troglocataractus* (Blind cave loach), *Platytropius siamensis, Propuntius speleops, Pterocryptis buccata* (Cave sheatfish), *Schistura jarutanini, Schistura oedipus, Schistura reidi, Schistura spilota, Trigonostigma somphongsi.*

The freshwater fish fauna of Singapore consists of 135 species of which 73 were regarded as native species, with 56 being introduce species and six being identification (https://fish.mongabay.com/ data/Singapore. htm)

Viet Nam has 632 species which consist of 587 native species and 17 introduce species. The intoduce species are *Aristichthys nobilis* (Bighead carp), *Aspidoparia morar, Carassius auratus auratus* (Goldfish), *Catla catla* (Catla), *Ciirhinus cirrhosis* (Mrigal), *Clarias gariepinus* (North African catfish), *Ctenopharyngodon idella* (Grass Carp), *Cyprinus carpio carpio* (Common carp), *Gambusia affinis* (Mosquito fish), *Hypophthalmichthys molitrix* (Silver carp), *Hypostomus plecostomus* (Suckermouth catfish),

Labeo rohita (Rohu/Cá Trôi Ân Độ, Rôhu), Micropterus dolomieu (Smallmouth bass), *Oreochromis niloticus niloticus* (Nile tilapia/Ca Ro phi van), *Oreochromis mossambicus* (Mozambique tilapia/Ca Ro Phi den), *Pangasius pangasius* (Yellowtail catfish/Cá ba sa), *Poecilia latipinna* (Sailfin molly) (https://fish.mongabay.com/ data/VietNam.htm).

Previous decade, people prefer to eat marine fish, but currently, many people tend to likely eat freshwater fish. It could be seen that it is easy to find the "pecel lele" restaurant in Indonesia. Lele is the clarias catfish that grows up from aquaculture with many advantages such as: rapid growth, containing high protein, and cheap price. Besides that, the tilapia issues development is very massive. This way could support the need of human beeing for fish consumption if conventional fish decreases.

The water condition in the whole stretch of river determines the different types of fishes. Welcomme (1985) stated that the condition towards the mouth of a river could differ from the rest of the parts of the river as saline waters penetrate many kilometers upstream, particularly in lowland rivers. Three groups of fishes inhabit in this transitional zone: (a) freshwater stenohaline species which enter the area during the flood and retreat upstream at low water according to the penetration of saline waters; (b) marine stenohaline species which follow the influx of marine waters into the river for feeding; and (c) euryhaline species which move a little but could adapt to the changing salinities of the water. Several aquatic species migrate between the river system and the sea either for breeding or feeding, and are called anadromous or catadromous species. Anadromous species completes its breeding cycle in freshwater, for example the salmonids, while catadromous species essentially lives in freshwater habitats but breed at sea, for example the anguillid eels (**Figure 2.10**).

Welcomme (1985) also stated that there are three distinct groups of freshwater species that migrate between rivers and floodplains. These are:

a. The "blackfish" species, whose migrations are between dry and wet season habitat and these species are more normally confined to the swamp. During the dry season, the blackfish stay in the deep pool as their habitat.

b. The "greyfish" species undertake moderate movements within the river, then spawn in the floodplain. The major migrations disperse in the floodplain as favored breeding places in the dry season.

c. The "white fish" species undertake an upstream migration during the dry season or early in the wet season. Such migrations are usually linked to both the reproduction and the need to escape the adverse conditions of the downstream river channels and lakes in which water levels where the dissolved oxygen concentrations may become dangerously lowered for sensitive species.

Types of Fishing Gears

Fishing gears used in inland fisheries are traditionally developed from small-scale fishing activities. The most widely used gear is stationary pots, stow net, lift net, gillnet, line, scoop net, bamboo trap, and cast net (**Figure 2.11**).

Figure 2.10 The anguillid eels

These gears are quite selective and straightforward to use. The use of fishing gears in inland waters often called "selective fishing gears" has to be permitted by authorities. A selective gear is a fishing gear designed to select target species including the sizes of fish. The selectivity of gears can reduce or exclude the capture of unwanted sizes of fish and incidental catch. It should be noted that multi-species and multi-size fishes inhabit the inland waters so that the application of gear cannot only select the appropriate size of fish to be caught. However, most fishers do not clearly define their target species, but their experience and knowledge of various environmental factors such as seasonal fish migration patterns, spawning seasons, and high-water level, while fishing lead them to get more fish or avoid catching specific species of fish.

In terms of fishing gear operation, there are two basic categories of fishing gears, namely the passive gears and active gears (**Figure 2.12**). Passive gears are stationary gears that are not to be dragged, pulled or towed to capture fish, and include among others, hook and lines, traps, wires, and gill nets among others that could effectively fish by themselves. The catch is recovered by merely removing the gear from the water after a certain period of time. No energy is expended in towing, pulling or dragging the gear out of the water. While active gears have to be moved, dragged, or towed to capture fish, and require engine-propelled boats to operate and thus, usually involve additional investments (Eyo and Akpati 1995).

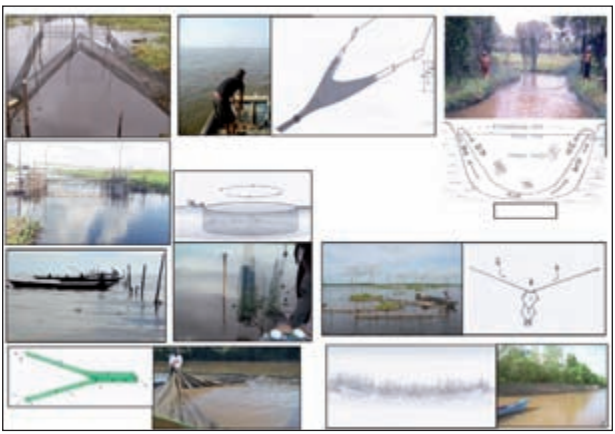
Characteristics of Fishers and Trading

Type of Fishers

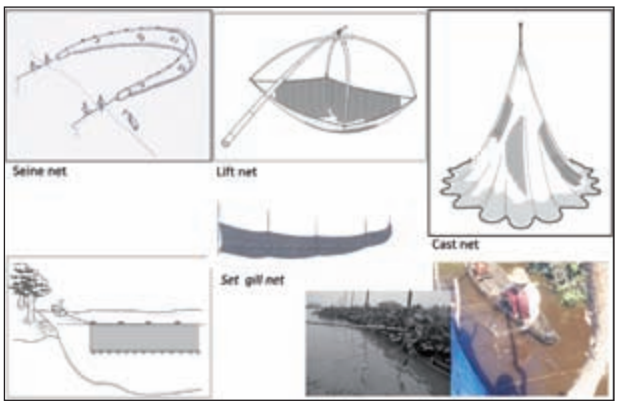
There are two types of fishers with respect to the fishing gears used. These are the individual fishers (**Figure 2.13**) and grouped fishers (**Figure 2.14**). The individual fishers work individually using simple fishing gears, usually inhabitants native to an area and do not need a license for the fishing activity. Usually, the fishers do fishing by himself, but in some case, they go to fish with their family. The grouped fishers work as a team of 3 to 10 people using more complex fishing gears, and may not necessarily include the inhabitants native to a place only but also the migrant fishers. Usually, they need an appointment before working together. The laters usually occurred in some countries, such as in Indonesia and Lao PDR. The migrate people comes from the intern country for example from village to other villages. In order to fish in a certain water body, the grouped fishers should have obtain permit to to fish, from the local government units. The license could be obtained through auctions conducted by the district government. Individual fishers could still fish in the auctioned area by paying certain a cost as rental, to the winner of the auction.

The levels of fisheries based on the practices adopted in utilizing the inland waters, are classified into two, namely: small-scale fisheries and middle-scale fisheries. Small-scale fisheries are generally meant to provide important source of food, employment, and income, and usually require only small capital investment, use low technology gear and vessels (often non-motorized), and catch fish for subsistence or for sale in local markets only.

(a)



(b)



(c)

Figure 2.11
(a) Pot Traps;
(b) Trap nets; and
(c) Gill nets

Figure 2.12 Passive gears (stow net) and active gears (cast net)

Figure 2.13 Individual fishers

Although some fishers often work part-time or seasonal, they play a key component in the livelihoods of millions of people, especially in the rural areas. Small-scale fishers are known to inhabit the areas along freshwater lakes, rivers, and reservoirs, and are dependent on fisheries activities daily. Although some fishers might be relatively well-off, majority of these fishers live in rural (often remote) areas, with poor standards of living, and are unable to meet their operating constraints. Middle-scale fisheries could be operated only in the open access area of the inland fishery domains using middle-scale fishing gears. In case of Cambodia, there are group of fishers categorized as middle-scale fishing, their fishing operation is only in the open access area.

Figure 2.14 The fishers in Group

Women's Role in Inland Fisheries

Women play multi-dimensional roles in the households that are often undefined or undervalued. It is for these reasons that gender issues in fisheries received attention in the global fisheries arena. The gender issues in fisheries across Southeast Asia have been evolving since the late 1980s. Although the Gender in Aquaculture and Fisheries Section (GAFS) of the Asian Fisheries Society (AFS) was officially founded in January 2017, the AFS has been active in promoting the importance of gender dimension in fisheries and aquaculture early on.

In the Southeast Asian region, women and men utilize different spaces and have differential access to resources because of the norms and values attached to certain places. In fisheries, the contributions of women are either overlooked or considered less valuable compared to those of men. Women are often assumed to play more traditional and supporting roles with lesser economic values attached to their activities. Women participate in the households' fishing activities that take place along the waters which are in the vicinity of their house because they want to stay close to their house. When not fishing, the women dominate in activities that support fishing, such as preparing food for their families, especially for their husbands when they go fishing, repairing fishing equipment (**Figure 2.15**), and sorting the landed fish catch of their husbands. Women also participate in the economic activities, usually in the processing and marketing of the fish catch (**Figure 2.16**).

Post-Harvest and Fish Trade

Freshwater fish products from the inland waters constitute a significant part of the rural peoples' diet. Most of the fish catch are consumed immediately although some portions of the catch are sold in local markets. The surplus of the fish catch is preserved in variety of ways according to cultural preference and the prevailing local conditions. Commonly, fishers' families are engaged in fermenting (the primary process), pickling, drying, and smoking of fish (**Figure 2.17**).

Figure 2.15 Woman's roles in repairing the fishing gear and sorting fish

Figure 2.16 Woman's roles on fish marketing

In the rural areas, where fresh fishes are not always available, preserved fish products are generally more valuable. In the Southeast Asian region, fermented fish is a significant staple product, particularly during times of the year when fish catch is low, or at the peak of agricultural labor requirements that reduce peoples' time available for fishing.

In processing the fish catch, the women are the main players. In spite of the women's key role in processing and marketing fish, both fresh and preserved fish products, still such economic activities are under-valued in the society.

Figure 2.17 Traditional fish product

Markets are the central points where sellers and buyers meet. Insufficient support from local governments, especially providing better market facilities in the rural areas, often forces women to restrict their activities in the market. Thus, women would prefer marketing on a limited scale or directly selling their catch to middlemen even if the price is often quite low.

2.2 The Challenge to Manage the Inland Fisheries

The challenges in implementing some management approaches to inland fisheries include the multiple uses of inland waters and difficulties in acquiring accurate information on the status of the inland fishery resources. These challenges that impede the promotion of sustainable fisheries management are discussed below:

Fishing Gears Used

According to Megwalu *et al.* (2018), the majority of the fishing gears used, either passive or active, has damaging effects to the environment. Illegal fishing practices in small-scale fisheries also impede the sustainable development of the inland fisheries, *e.g.* the use of dynamite and other explosives, and poison to kill the fish; the use of small mesh-size fishing nets and other destructive gears, and irresponsible methods and techniques; as well as the use of traps and weirs. These practices have been the root of certain problems associated with decreasing diversity, as well as the economic, institutional and social nature of inland fisheries. Since the inland waters are open access for small-scale fisheries, economic problems occur when the number of fishers increase and compete for the exploitation of the vulnerable resources. Social concerns take place because of low education and general poverty of the fishers, *e.g.* limited funds to buy appopriate or legal types of fishing gears. From the government side, there is no legislation governing small-scale fisheries, and the lack of capability and capacity of fisheries administrations to effectively monitor, control, manage, and to advocate the advantages of using legal fishing gears and related activities. The biological consequences of using the unconventional fishing gears include destruction of the natural habitats and ecosystems that sustain the fish populations; capture of juvenile and immature fishes before allowing them to grow to commercial sizes depriving fishers of more economic benefits; and damaged or loss of fish stocks, especially of the most commercially-important and target species.

Lack of data and information

The catch statistics of inland fisheries are fragmented and discontinuous, and causes alarming condition in small-scale fisheries where large numbers of fishers are involved including occasional fishers, and where catches are unrecorded as these are brought directly to the local markets. Moreover, the catches comprised multi-species of fish that go immediately to various channels without proper recording, while large portions of the catches brought home for household domestic consumption.

In order to achieve the sustainability of the inland fish resources, it needs to understand the importance of catch statistic (especially on inland capture fishes). Statistic data would help the decision makers in taking the fisheries management policy measures.

The data needed initially come from a wide variety of sources. The existing subsistence fisheries may furnish some written or oral records of species available, fishing grounds, seasonal fluctuations and types of gear which are effective. Data collection can be done by hiring enumerators. To monitor the present situation of fish stock through the trend of CPUE, it needs to collect the data not only the catch but important also the fishing effort.

Environmental Pressure

A human exploitation of fish resources can cause environmental degradation (**Figure 2.2**), such as the influence on the aquatic environment in the form of pollution that has worst effects on aquatic life. Most of the loss of freshwater biodiversity originates to failure in understanding the linkages between development activities and their impact upon freshwater ecosystems. The first pollution of aquatic comes from sevaral sources, such as: agriculture (run-off of fertilizers and pesticides), domestic sewage, and industrial waste. Furthermore, the need for water to fulfil irrigation and domestic purposes will

continuously reduce water availability for fisheries, especially during dry seasons. Also, an increasing demand for energy, including hydropower would likely lead to further damming of rivers.

The other environment pressure affecting inland waters is the climate change phenomena, which changing a of environment condition variability includes increasing of temperature, strong rainfall, and high river runoff charge.

Fish Stocking Activities

Fish restocking in inland waters is done by releasing billion of hatchery bred species to increase fish population in the next future. The fish the caught by people are important as protein source for people living in rural areas, and also to conserve actually fish resources sustainability (**Figure 2.18**).

Most countries report that they conduct fish release to respond to degraded natural fish populations in some degrees. Fish release is an attempt to fix a problem to control fish exploitation as a result of habitat change or overexploitation of fish, or just to increase the fish stocks in general. The release of fish into the wild will increase stock abundance, and thereby harvest levels would be to increase. Fish restocking activity should be used local fishes, in order to fish be easy to adapt with the aquatic environment. Fish release activity in some countries tends to be as ceremonial to celebrate feast day in the country. Sometimes there is a confused word with introduced fish activity, for which the stocked fish are perceived to affect negatively the wild fish through competition or predation.

Figure 2.18 Restocking activities in Serau River, Lipis, Pahang, Malaysia

Inadequate Governance Systems

States should develop and publish policies and regulations for implementing the fisheries management. Procedures for allocation of fisheries management should be consistent with broader social, economic, and environmental objectives. Local communities use traditionally the inland waters for fishing should be received the attention from authority. Policies should take into account the interest of everyone which could be affected in the fishery management should be included in the consultation, participation and decision-making processes. Such systems should ensure that the allocation of management does not hurt the people in term of their livelihoods, by depriving them of their legitimate access to fish resources.

CHAPTER 3

THREAT TO INLAND WATERS ENVIRONMENT AND FISHERIES

Inland water systems that include rivers, lakes, swamps, floodplains, small streams, ponds, and reservoirs, have a variety of biological, physical, and chemical characteristics. Inland waters are an ecosystem that easily becomes endangered and highly vulnerable to degradation. The aquatic organisms in inland waters are dependent on each other. While the consumption of fish is increasing with the increasing population of the world, the supply of wild-caught fish is put under pressure.

The inland waters of the Southeast Asian region are known for having one of the highest diversities and broadest geographical coverages in the world. Despite this natural endowment, there is a need to harmonize the use of land and aquatic habitats as they influence each other and vice versa. The inland water ecosystems are ecologically dynamic, although inland waters do not have artificial conceptual boundaries or ecosystem perspective. For example, in rivers with seasonally flooded areas, the water may be high during the rainy season, flooding or submerging the land, while in the dry season there may be no water and the rivers remain dry.

In everyday practice, inland waters are used as source of water supply and for water transportation. Moreover, man-made reservoirs are used to generate hydropower and dams are good source of fish. While fishing activities usually do not pay much primary attention to inland water resources, even if inland fisheries have always been dubbed as protein source provider for the rural people and one of the significant contributors to national economies, the inland fisheries subsector has been sustaining the livelihoods of peoples in rural communities.

The statistics data and records during the past 20 years have shown that fisheries production from inland waters had been substantially increasing, although at a slow annual average rate of increase of about 4% (Pongsri *et al*. 2015; SEAFDEC 2017). Nonetheless, the utilization of inland fishery resources needs to be monitored to ensure their sustainability and that the aquatic diversity is maintained.

Considering that inland waters, as an ecosystem could easily become endangered and are highly vulnerable, and where the aquatic organisms are dependent on each other, changes in the aquatic ecosystem would affect the organisms present in the waters. Moreover, nowadays, the consumption of fish is growing as the world's population expands. This has put the supply of wild-caught fish under pressure. In most cases, changes in the inland waters ecosystem are caused by natural or human factors. Thus, it is necessary to identify the various threats in the inland waters environment to address the multi-faceted problems over the inland waters.

Threat is the amount of damage from something done directly or indirectly. Therefore, the threats to inland waters, on its environment and fishery activities are significant and are likely to escalate as more water is used to meet human needs while the impacts of land-based activities further degrade the well-being of inland waters. Nevertheless, the main direct drivers of change in inland water environments could include habitat change, pollution, over-exploitation, introduction of invasive alien species, and climate change among others.

3.1 Natural Factors

In the upstream, river tends to flow fast because the slope of the land is steep, while, in lowland areas, the river tends to flow slowly because the slope of the land is more or less flat. The downstream areas become wider when a lot of rainfall is received, and the river will flood the flat areas that could extend into tens of kilometers. Increased intensity of agriculture and deforestation, and activities related to improving the runoffs with pesticide contamination could cause erosions and sedimentation of rivers. Several studies had been conducted to determine the relationship between vegetation and the hydrological cycle, the results of which showed that vegetation has direct influence on controlling erosion, water quality, and aquatic diversity present in the waters. The rising of water level related to changes in the precipitation, causes the soil to become warmer due to decreased water content. The increasing water temperature is one of the natural phenomena known as global climate change.

Deforestation

Forests with its vegetation cover can prevent the occurrence of shallow landslides (Bruijnzeel 1990). That is the same as saying that deforestation could enhance erosion, although the downstream areas cannot always be ascribed to the changing of upstream land use practices. Erosion contributes bulk of the sediments and the effects of erosion on the sediments would be felt in the downstream areas. In the region with high rainfall rates and unstable geological conditions, soil erosion would impact on the flow of sediments leading to accumulations of physical and chemical pollutants. Freshwater aquaculture and agricultural activities can add substantial nutrient loading to waters, increasing the nutrient contents of the surface and groundwater. On the other hand, application of pesticides in agricultural activities poses much danger to the water resources, since pesticide compounds are designed to be toxic and persistent, and could easily go with the flow of the water (**Figure 3.1**).

Climate Change

Climate change affects the inland waters and directly or indirectly on the biota. The significant expected impacts to inland waters include warming of the rivers, which in turn can affect the chemical and biological processes in the waters, reduce the amount of dissolved oxygen in deep waters, and affect the growth rates, reproduction, and distribution of organisms and aquatic species in the waters (Gitay *et al.* 2001). Climate change also affects the sea level to rise and salt water could intrude into floodplains and swamps (**Figure 3.2**). Plant species which could not tolerate increases in salinity or inundation could be eliminated, while salt-tolerant mangrove species could expand from nearby coastal habitats.

Figure 3.1 Agricultural activities (palm plantation, rice field and traditional plantation) and freshwater aquaculture could pose the danger to inland waters

Changes in the vegetation will affect both resident and migratory animals, especially if these cause major changes in the availability of staging, feeding, or breeding grounds for particular species (Boyd and Madsen 1997; Zockler and Lysenko 2000). Reduced rainfall and flooding across large areas will disturb the habitats that are episodically wet and fresh or drier and saline (Roshier *et al*. 2001).

Climate change also affects the wetland carbon sink because the potentials of absorbing more carbon into the carbon sink could be disrupted. The hydrology and vegetative community of a wetland could also change because of climate change, resulting in more extended and more frequent droughts altering the carbon balance in peatlands (Gitay *et al.* 2001).

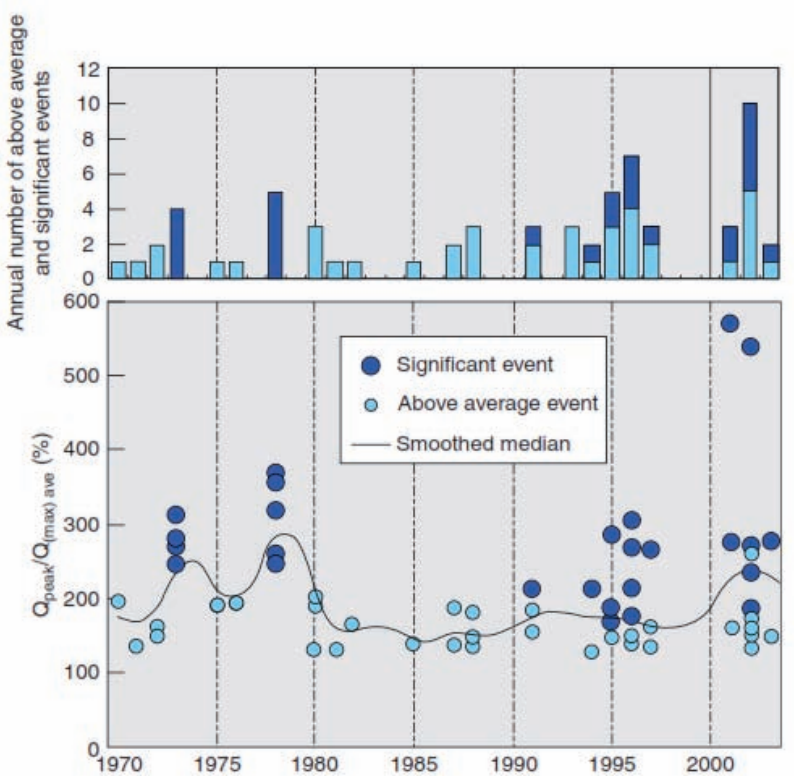


Figure 3.2 Regional incidence of "significant flood events" between 1970 and 2003, where a significant flood event is one with more than one standard deviation above the mean annual maximum flood peak (Adamson *et al*. 2009)

Recently, the impacts of climate change had been more pronounced, such as increasing incidences of floods and river erosions that affect the use and value of rivers for recreation, conservation, fisheries, water supply, and transportation (Ashmore and Church, 2001). Therefore, the extent of changes in inland waters as a consequence of climate change should not be addressed in isolation from the other drivers of change (Gitay *et al*. 2001; van Dam *et al*. 2002).

3.2 Anthropogenic Factor

An anthropogenic factor occurs when there is increase in human populations, which consequently affects the growing need for food resources, resulting in increases in the level of exploitation of the food sources including fish (Schindler 2001). The need for protein and food sources, especially from fish, encourages excessive exploitation activities to the extent of depleting the existing resources. Furthermore, the fulfillment of other requirements such as transportation, shelter, electricity or energy, and recreation, adds to the broad transition of the resource functions of land and waters. Construction of dams for irrigation and electricity generation, land reclamation for settlement and transportation, and reconstruction of natural recreation areas for tourism (**Figure 3.3**) are also part and parcel of the anthropogenic factors. As a result, the interests of development are more real-valued than the fisheries sector so that the well-being of the fishery resources tends to be overlooked.

Overfishing

Increase in the human population in an area induces an increase in the need for food sources, which could be met mainly from the availability of natural resources including fishery resources. Fulfillment of fish consumption needs has often been a point of discussions in many fora because the needs and demands are always increasing, but the existing resources tend to decrease and experience certain degradations. Inland fisheries are different from marine fisheries because in the former, the conditions of the land and environment significantly influence their existence. The increasing demand for fish has led to certain level of overexploitation of the fishery resources, and the need for fish is no longer selective in terms of consumption of particular fish species as other fishes not consumed before including by-catch are also being exploited (Welcomme *et al*. 2010). Using various types of fishing gear

is also practiced to obtain the desired amount of catch, with variety of fishing gear used to adapt to seasonal changes so that fish production remains high following the purpose of exploitation (Aroef *et al*. 2019).

In some areas, the smaller and shorter-lived species become the main component of the catch, because of the decreases in catch of the predatory species. The situation may look good for a while, however, smaller fish are often much less valuable, which could ultimately result in further recruitment failures. Furthermore, overfishing of larger fish in a population may eventually change the gene pool towards smaller-sized fish (Fenberg and Roy 2008; Van Wijk *et al*. 2013). This problem is generally overlooked and not addressed in many fisheries management plans.

Figure 3.3 Dams and hydroplants construction, water transportation, and establishment of tourism destinations could affect the well-being of inland water resources

Unfriendly Fishing Gears

Fishing that utilizes poisonous compounds and destructive gears, is harmful to the fishery resources and damages the water environment (**Figure 3.4**). Moreover, the unexpected behavior and quality of the catch could endanger the fishers and other persons such as the consumers. These fishing activities also tend to kill the essential aquatic organisms and reduce the sustainability and productivity of the fishery resources. Otherwise, regulations on the minimum mesh sizes must be heeded to minimize the mortality of undersized or juvenile fishes, although the mesh size regulations have not yet been reported to have significant impacts on the juveniles' survival to maturity. Another unfriendly fishing gear is the practice of disrupting the flow of water and catching the fish during their migration from upstream to downstream for spawning in the deep sea (**Figure 3.5**).

An important factor that looms the inland fisheries is the effective and efficient enforcement of legislations in each country (**see Chapter 4**). The globally large numbers of illegal fishing activities is caused by weak institutional and governance arrangements on illegal fishing and use of destructive fishing practices (Agnew *et al.* 2009). In most inland waters, the fisheries management of multi-species and multi-gear becomes particularly challenging.

Figure 3.4 Fishing with the use of electricity (above) and small mesh size of gillnet (below) could contribute to the degradation of the aquatic organisms in particular, and the fishery resources in general

Figure 3.5 "Waya Masapi", a fishing gear for anguillid eels in Poso Lake, Indonesia, cuts the flow of lake water threatening fish migration from upstream to downstream during their spawning in the oceans

Pollutant Matters

Pollutants and wastes contribute to the decreases in the environment's function in inland waters, especially with increasing human activities. Several lake and river systems can be particularly damaged by the increase of siltation and pollution coming from mine tailings and agricultural wastes. At present, the biggest issue in the world is plastic wastes irresponsibly thrown everywhere and finally coming down to the waters (**Figure 3.6**). This kind of wastes is difficult to decompose in nature because the materials used come from organic polymers that cannot be degraded quickly.

Figure 3.6 Plastic wastes in inland waters take much longer time to decompose

The expansion of plantation and agricultural areas that use toxic active ingredients in massive quantities is dangerous and the wastes that directly flow to the rivers could not be controlled. Meanwhile, the development and expansion of coal mining ventures and the production of crude oil and gas in many Southeast Asian countries, such as Indonesia, Thailand, and Viet Nam have been intensified. It is well established that pollution from sources such as mining and agriculture have had devastating impacts on the biota of inland waters. Threats of water quality degradation are usually most severe in areas where water is scarce due to the reduced capacity for waste dilution. Meybeck (2003) provides an overview of water pollution problems in inland waters from industrialized countries, and the emerging problems from agriculture run-offs that are increasing everywhere in developing countries. Urban and industrial pollution sources are also increasing faster than the related wastewater treatments, while nutrient enrichment resulting from the use of high protein feeds to spur the growth of cultivated fish is also on the rise. Also, air pollution coming from factories and vehicles increases carbon emissions, and contribute to the amount

of CO_2 discharged to the air. Consequently, this condition affects the fish that consumes the phytoplankton and zooplankton, and other microorganisms that have been polluted (Tanaka *et al*. 2015).

Land-use Changing

Projects on agro-industry, wood and paper production, mining, chemical and power plants, tourism, and infrastructure development, could have various effects on the inland waters environment (**Figure 3.7**).

Figure 3.7 Mining activities (sand, gold, and logging) affect the inland waters environment

As mentioned above, pollutions caused by agriculture, plantation, and mining activities are already discussed above. Generation of electricity from hydropower dams has increased enormously in recent years. Consequently, large hydropower projects will cause flooding of vast land areas, and projects on the development of dams threaten the rich

biodiversity and ecosystems by constraining the adjustments of the range of warm temperatures of the waters. Furthermore, dams also interfere with fish migrations by stopping them from reaching their habitats for spawning and as a consequence, also harm the livelihoods of local people from the inundation of agricultural and residential lands (Kano *et al*. 2016).

3.3 Biological Factors

The introduction of some alien invasive species has contributed to species extinction in some freshwater systems (Tockner and Stanford, 2002). The problems caused by introduction of invasive species had posed a big global concern (Mooney and Hobbs 2000). Fish introducing activities done over the last 150 years in tropical Asia (carps and tilapias, for instance) are usually conducted to enhance fish production and recreational fisheries or to control pests such as mosquitoes and aquatic weeds (Revenga and Kura 2003).

Nonetheless, the spread of exotic species in inland waters has been increasing with the development of aquaculture as mentioned by FAO (1999). Many fish species have been spread beyond their native ranges, often as an important component of aquaculture. This species have overgrown and reached maximum population densities within a period of few months, and then later, the species flourished and became serious problems (Williamson 1996; Manchester and Bullock, 2000). Not only fish species, but also plants spread quickly to rivers and lakes, clogging the waterways and infrastructures, reducing the penetration of light and occurrence of oxygen in freshwater systems, and causing changes in the water chemistry and species assemblages. Water hyacinth is an example of a widespread of alien water plant species that causes considerable economic and ecological damages in inland water systems around the world (Gopal 1987) including in many Southeast Asian countries (**Figure 3.8**).

Figure 3.8 Plants like water hyacinth can spread quickly clogging the inland water systems

The existence of water hyacinths and other aquatic plants has been a major concern in Rawapening Lake, Indonesia, becoming a serious problem for more than 50 years (Kenneth 1980; Hidayati 2018). Nutrient input from water catchment area and fish feed residues are suspected to lead to eutrophication, a condition that induces uncontrolled growth of aquatic plants. In dry season, aquatic plants cover almost 70% of the lake area. This problem should be handled properly due to the wide range of lake functions such as utilization of the water resources, fish farming, operationalization of power plants, flood control, irrigation, and many other important uses and activities (Hidayati 2018).

The impacts of introduced species on the native fish and ecosystems have not been well documented, although Fernando (1991) reported that in some cases introduced fish were not found to have caused severe damage to indigenous species. In recent decades, tilapia species have been established and become a substantial contributor to inland fisheries to fulfill human needs for fish consumption, indicating a significant shift in the composition and structure of biological communities in those systems.

Actually, introduction of alien species can increase the production and value of inland ecosystems, but they can also have profound and severe impacts on the ecosystem (Bartley 2006). Another risk from fish

aquaculture is in the event when some fish escape from fish farms to the waters. The escaped fish usually grow up rapidly, about twice that of the native fish species' growth, resulting in the native species either getting extinct or inhabiting only in small populations (Kolding *et al.* 2008).

3.4 Other Factors

Various activities done by other sectors in inland waters would often create competition on the utilization of the inland water resources. Many development projects proposed for enhancing the economy and quality of life for people living in low-income countries, could lessen or lose the high productivity potentials and aquatic ecosystem services of the inland waters. For establishing the basis of proper management, data and information on these aspects would be necessary to come up with a complete report.

Conflict of Interests

The need for water to support fish and fisheries can conflict with the needs of other sectors, in particular, agriculture, in both water quality and flow requirements for sustaining the aquatic habitats. Decisions on water management frequently do not take into account the impact on fish and fisheries, and on the rural livelihoods of the populations that depend on them. In part, this is because inland fisheries are significantly undervalued in the water management plans at local, national, and basin-wide levels. In the local scene, specific provisions governing access to rice field fisheries have been introduced by local wisdom (Figure 3.9), where two separate regimes of access are recognized depending on whether the area where the rice fields are located is flooded or not.

Figure 3.9 Local wisdom in floodplain areas, indicating areas where fishing is not allowed (right) and deep pools for fish culture during the dry season (left)

Under the general regulation, any person wishing to fish in a rice field is required to seek permission from the field owner or the holder of land use right over that field. In the event of a flood, any person may fish in submerged rice fields without permission from the field owner, but if the water level covers only the deep pool, only the owner can catch the fish.

Insufficient Data and Information

Data and information are the basis for proper management, and thus, should be properly monitored and collected. It is common in tropical watersheds that fish landings could go completely unreported and the amount of catch is oftentimes estimated from unreliable information sources. This clearly contributes to the severely incorrect production data from inland capture fisheries. In many cases, the amount of catch reported is only an underestimation because the contributions of many fisheries on smaller tributaries and water bodies are generally overlooked (Coates 2002).

A problem on data collection is that the statistical system is very much production oriented. There appears to be limited information collected on the participation of stakeholders in fisheries including

those involved in catching, processing, and marketing (Welcomme 2011). The majority of inland fisheries activities is not licensed, operated at a semi-commercial or subsistence level, and widely dispersed along the numerous waterbodies (FAO 2010). There are often no centralized landing ports or major markets where data can be easily collected, and a large part of the catch is bartered locally or consumed domestically by the fishers' households. Moreover, the catch size and composition, gears used, and numbers of fishers vary significantly during the different seasons. These forms of challenges make the data collection not only time-consuming but also costly.

Furthermore, the amount of landings is often recorded for some indicative fisheries, but is subsequently extrapolated up to the national level, with large errors occurring especially when the numbers of gears, fishers, and households involved are unreliable (FAO 2010), making the overall quality of the data weak (Ernst and Young 2011).

Alternative approaches to data collection are needed to improve the situation. These could include the conduct of traditional catch and effort surveys, as well as efforts in addressing the issues, such as through population census, consumption studies, market surveys, and habitat classification.

3.5 Challenges

There are two broad challenges in fisheries production; *i.e*. sustained and increased production. In supporting the present level of fisheries production, it is necessary to maintain or restore the aquatic environment, including its diversity, and improve management of capture fisheries and other ecosystem services through the provision of target-directed environmental flows. To increase the present stages of fisheries production, wider adoption of methods for enhancing and intensifying production could be promoted.

Figure 3.10 Building partnerships between Government and fishers/ Fishers' Groups to address the concerns on the sustainable utilization of the inland water resources

The methods could include proper adoption of stocking densities and good aquaculture practices, as well as appropriate management adequate enough for suitable habitats and arrangements. Both challenges can be surmounted by building partnerships between fisheries and other interested groups concerned with water management and to be facilitated by the Government (**Figure 3.10**). Those engaged especially in water management for agriculture and fisheries, should strengthen their collaboration in searching for more efficient ways of obtaining the overall benefits of water uses that would raise food security and reduce poverty.

CHAPTER 4

DESIRED CONDITION FOR KEEPING THE SUSTAINABILITY OF FISH RESOURCES

Fishery resources are renewable natural resources that could be sustainably utilized through rational and responsible exploitation. Enforcement of regulations by governments to fisheries activities is necessary to ensure the continued productivity of the resources in particular, and accomplish the sustainable fisheries objectives in general. Promoting the sustainable management of the fishery resources should take into consideration the availability and affordability of the fish and fishery products obtained from the fishery resources, and should also aim for the enhanced socio-economic well-being of the fisheries households, and should be environment-friendly.

As renewable natural resources, fishery resources could be exploited through rational and responsible means to ensure their sustainability. The desired ways and means of ensuring the sustainability of the fishery resources should be based on sound fisheries management options, which should be established considering the resources available, now and in the future, when people need fishes in excellent condition and at affordable prices. Such management options should also aim to enhance the economic well-being of the fishers and fisheries communities, and should be environment-friendly.

The inland fisheries sub-sector is one of the most important economic groups that tap the inland water ecosystems for development. Despite its importance to rural communities, especially in the least-developed countries, this sub-sector has been given little attention in planning and policy formulations. As a result, management of inland fisheries is insufficient and inadequate resulting in the increasing threat of the fisheries to the inland water resources, exacerbated by the irresponsible utilization of the resources by non-fishery users (Welcomme *et al*. 2014). Aside from the inland fisheries and aquaculture sub-sectors, the inland water resources are much used for varied purposes, as source of water for domestic uses, hydropower generation, and irrigation, as well as serving as natural track for water transportation (*e.g*. rivers, canals) and sites for recreational activities (*e.g*. rivers, lakes, dams).

Inland waters of Southeast Asia are among the longest and most productive waters for wild-capture inland fisheries in the world (Welcomme *et al*. 2015). FAO (1988) defined capture fisheries as an activity that refers to all kinds of harvesting of naturally occurring living resources in freshwater environments whereas aquaculture is the farming of aquatic organisms, including fish, mollusks, crustaceans, and aquatic plants. Farming implies some forms of intervention in the rearing process to enhance production, such as regular stocking, feeding, protection from predators, and so on. Farming also implies individual or corporate ownership of the stock being cultivated.

Management of inland fisheries has always been extremely complicated owing to the spatially dispersed nature of the fisheries activities, the large numbers of persons involved in such activities, and the distance of the fisheries operations, installations and facilities from major urban centers. As a result, fisheries regulations are often not effectively enforced or when enforced, success in the implementation might be insufficient and inefficient because such regulations had been established by central authorities and promoted in a top-down manner, without taking into account the needs and priorities of the inland fishers and fisheries communities, and disregarding the very nature of the inland water resources. Moreover, the drivers of change mostly come from outside the fisheries sector, and might be unaware of the fact that the productivity of many fish populations could be affected by the environmental impacts of the irresponsible activities of the other users of the aquatic resource (Welcomme *et al*. 2014).

4.1 Ten Steps of Inland Fisheries Management

As an umbrella in managing inland fisheries, Rome Declaration on Inland Fisheries Management has been established in 2015 and can be used as a platform of inland fisheries management in Asia. The declaration mentions ten steps of inland fisheries management as follows (Taylor *et al*. 2016):

1. Improve the Assessment of Biological Production to Enable Science-Based Management

It is widely acknowledged that inland fisheries have been facing with lack data, all from local to global ecosystems. In this regards, standardizing assessment method for inland fisheries is very essential in accordance with the spirit of sciences-based inland fisheries management. (Taylor *et al*. 2016) also suggested that to implement the data collection for

inland fisheries we need at least activities such as (1) develop, promote and support standardized methods for assessment of inland fisheries harvest and aquaculture products; (2) support the development of novel approach in collect inland fisheries data; (3) incorporate inland fisheries and aquaculture into ongoing national house hold census to support inter-sectoral decision making process; (3) increase support for efforts to increase capacity of fishery resources officers to collect information and data; (4) establishment of set of minimum data requirement that would be practical for countries to collect data.

2. Correctly Value Inland Aquatic Ecosystem

Especially in Asia, it is often that the ecological, social and economic value of inland fisheries are still heavily unknown (Taylor *et al*. 2016). In this regard, application of total economic value of inland fisheries can be included in the assessment of inland fisheries in the countries. Additionally, the application of Voluntary Guidelines of Securing Small Scale Fisheries (SSF) in inland fisheries should be widely conducted (Taylor *et al*. 2016).

3. Promote Nutritional Value of Inland Fisheries

The inland fisheries can be considered as one of main sources of nutrition, especially for the poor food-insecure regions (Taylor *et al*. 2016). In this regard, it is important to maintain and improve the accessibility or availability of nutrient-rich fish coming from inland fisheries in area with traditionally high fish consumption.

4. Develop and Improve Science-Based Approaches Fisheries Management

The management arrangement can result in excessive fishing pressure, decreased catch per unit effort, and conflicts between fishers, as well as changes in the productivity of fishery resources (Taylor *et al*. 2016).

In this regard, it is important to start an Ecosystem Approach to Inland Fisheries and develop the database system for better sharing of data and information of inland fisheries.

5. Improve Communication among Freshwater

Many misconceptions exist on the needs and desires of fishing communities happened due the policy-makers, stakeholders and the general public could not access the information on the importance of the inland fishery and aquaculture sectors (Taylor *et al*. 2016). Hereof, using appropriate and accessible communication channels to disseminate information will raise the awareness of inland fisheries' values, alter human behavior, and influence relevant policy and management.

6. Improve Governance Especially for Shared Water Bodies

Many national, international, and transboundary inland water bodies do not have a governance structure that holistically addresses the use and development of the water and its fishery resources. The results in decisions made in one area were often adversely affecting aquatic resources, food security, and livelihoods in another (Taylor *et al*. 2016). On this subject, building up the capacity of existing institutions and including the agreed decision on national government policies is important to do.

7. Develop Collaborative Approaches to Cross-Sectoral Integration in Developmental Agendas

Water-resource development and management discussions very often marginalize or overlook inland fisheries (Taylor *et al.* 2016). In this connection, policymakers should be made aware of the impacts of various activities being undertaken by other sectors in inland waters

although many development projects are proposed for enhancing national economies and improving the quality of life of people, constantly mindful of consolidating the inland fisheries into the post-2015 sustainable development goals.

8. Respect Equity and Rights of Stakeholders

Lack of recognition of the cultural values, beliefs, knowledge, social organization, and diverse livelihood practices of indigenous people, inland fishers, fish workers, and their communities has often resulted in policies that exclude these groups and increase their vulnerability to changes affecting their fisheries (Taylor *et al.* 2016). Recommend the local scene; the local wisdom introduces the specific provisions governing access to fisheries, where the separate regimes of access are recognized.

9. Make Aquaculture an Important Ally

Aquaculture can complement capture fisheries, through stocking programs, by providing alternative livelihoods for fishers leaving the capture fisheries sector, and by providing alternative food resources. On the other hand, Aquaculture can also negatively affect capture fisheries, by introducing the invasive species and diseases, competing of water resources, pollution, and restrictions accessing to traditional fishing grounds (Taylor *et al.* 2016). In this regard, it is important to start an Ecosystem Approach to Fisheries and Aquaculture Management and considering the use of native species in aquaculture development.

10. Develop an Action Plan for Global Inland Fisheries

The challenges in fisheries production are to sustain and increase production by providing healthy inland aquatic ecosystems. Without immediate action, it will be jeopardized, risking social, economic, and political conflict and injustice (Taylor *et al.* 2016). The challenges can be

surmounted by building partnerships that facilitated by the Government between fisheries and the international community, governments, Civil Society Organizations, indigenous peoples groups, and private industry, and include all sectors using freshwater aquatic resources.

4.2 Policies, Regulations, and Institutions

One of the most critical challenges that confront the inland fisheries sub-sector in many countries is the competition for the use of waters and the aquatic habitats. The conflict occurs when the need for water in terms of quantity and quality, to support fisheries and sustain the aquatic habitats, coincides with the needs of the other sectors, in particular agriculture. Decisions on water management frequently do not take into account the impact of shared water utilization on fish and fisheries and on the rural livelihoods of the populations dependent on the water resources. In part, this could be because inland fisheries are significantly undervalued in water management at local, national, and basin levels (Dugan 2007). This is despite the regulations established by many countries to control, guide and monitor the optimal use of the ecosystem services, as well as the environmental and water productivity approaches to allocate sufficient amount of water for sustaining the fish and fisheries.

Nevertheless, there are several countries that have not yet developed their national policies tailored to inland fisheries since in most cases inland fisheries are placed under the policy frameworks that evolve around the coastal and marine fishery resources. It is therefore necessary that countries should establish the policy frameworks aimed at implementing the contexts specific to inland fisheries. An essential attribute of a useful inland fishery policy framework is an ecosystem approach to fisheries, which includes fisheries considerations and related environmental concerns in integrated planning, particularly for water use (Dugan 2007).

For achieving the desired condition on keeping the sustainability of fish resources, certain actions should be done. Several countries in Southeast Asia have established regulations and policies, published by local and central governments. The regulations and policies that have been compiled from the ASEAN Member States are shown as follows.

Regulations in the AMSs: A brief review

Brunei Darussalam

With the approval of His Majesty the Sultan and Yang Di-Pertuan of Brunei Darussalam, the Constitution of Brunei Darussalam 2009 includes under **Article 8313 - Part XI** a provision dealing with the inland fisheries sector for the purpose of:

a) promoting and regulating aquaculture in riverine waters and in particular, to provide for the leasing and licensing of lakes, swamps, mining pools and other pools, land and other areas for the cultivation of fish; to prescribe standards for the construction and operation of aquaculture establishments including the size and depth of ponds; and to measure for the prevention of fish diseases and controls over any particular species of fish which may be produced by cultivation;

b) regulating or prohibiting any method of fishing in riverine waters or the use or possession of certain types of traps or nets, and to prescribe minimum mesh sizes for fishing nets;

c) prescribing the minimum weights and sizes of fish which may be caught in riverine waters for sale or for the purpose of processing, consumption or sports, or to prohibit fishing for any prescribed species of fish;

d) designating the persons, by name or office, to be licensing officers and to prescribe the powers to be exercised by such officers and by any officer authorized by the Director in writing in that behalf with respect to inland fisheries;

e) for the purpose of conserving fish in riverine waters, to regulate and control the construction of any slides, dams or other obstruction, or the removal of sand or gravel or other alteration to the natural environment or habitat of fish; and

f) designating, prescribing, promoting, providing or regulating any other matter for the proper conservation, development, management and regulation of inland fisheries.

Cambodia

The Government of Cambodia through Fisheries Administration (FiA) of the Ministry of Agriculture, Forestry and Fisheries (MAFF) regulates inland fisheries exploitation through the Law on Fisheries (Preah Reach Kram NS/RKM/506/011 - year 2007) with the following provisions:

a) **Article 10:** The inland fishery domain is the water bodies that extend from the marine waters to the inland border of the Kingdom of Cambodia.

b) **Article 16:** Cambodia has the closed season for middle-scale fishing defined as follows:

   1. From 01 June to 30 September for the inland fishery domains located north of Tonle Chaktomok parallel (Latitude: 110 33' 259"N).
   2. From 01 July to 31 October for the inland fishery domains located south of Tonle Chaktomok parallel (Latitude: 11°33' 259"N).

c) **Articles 39-44**: arrangement for the Inland Fishery Exploitation, type of fishers (small-scale, middle-scale and large-scale fisher)

At the local community level, the Community Fisheries take part in the sustainable management, conservation, development and use of the fishery resources.

Fishing effort is primarily controlled through licensing. Fishing licenses are either auctioned by the Government to the highest bidder for exclusive exploitation for two-year period (Deap, Degen and van Zalinge 2003) or are allocated by the FiA for research purposes. During

the period 1938-1939, a total of 108 dai units were permitted to fish in 23 rows (Chevey and Le Poulain, 1940), but by 1962-1963 the number had been reduced to 61 units in 15 rows (Fily and D'Aubenton 1995). The mid-1980s saw an increase to 86 units followed by a decline to present-day numbers. In Tonle Sap, there are currently 64 dais in 15 rows. Fishing effort (mortality) is also controlled through the enforcement of a closed season between 1 April and 30 September. The closed season, which corresponds to the spawning period for the majority of target species, is also a technical measure designed to protect the reproductive potential of the resources.

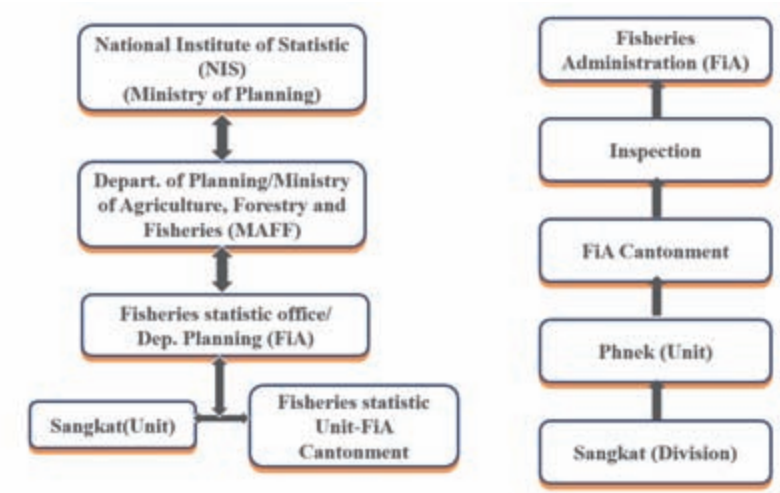


Figure 4.1 Fisheries Statistic and Information Data Collection System and Reporting

Regular monitoring by the FiA (formerly the Department of Fisheries) using logbooks began in the 1980s, supplemented by *ad hoc* surveys as described by Nguyen and Nguyen (1991). However, monitoring using the logbook was regarded as unreliable because some fishers under-reported their catch as this has an influence in the license costs. Sub-national fisheries officers/FiA Cantonment officers who are responsible for fisheries statistic were trained by fisheries statistic officer from central level on how to collect data, data entry and report writing (**Figure 4.1**).

Since 1994, catch and effort variables as well as length-frequency data have been sampled daily by the FiA using direct observation (enumerator) method with the support of the Fisheries Programme of the Mekong River Commission (MRC) providing species-wise estimates of the: (i) total annual catch; (ii) indices of abundance and biomass (CPUE), (iii) mean weight; and (iv) population size (age) structure.

Indonesia

Indonesia applies relevant regulations in homogenous communities and small ecosystems within their jurisdictions, which is widely practiced in Sumatera and Kalimantan. Considering that most of the current regulations at national levels only emphasized on marine fisheries, some district governments enacted laws related to inland fisheries for inland waters within their jurisdictions. Fisheries Law No. 31/2004 of Indonesia and revised as No. 45/2009 is the basic fisheries legislation, which stipulates provisions on utilization of the fishery resources, either for fish catching or fish breeding in the Indonesian waters, to ensure their preservation and the protection of the environment. The Ministry of Marine Affairs and Fisheries (MMAF) shall determine the provisions for regulating the fishing gear, allowable catch, fish breeding, prevention of pollution, protected fish, etc. (**Art. 7**). All individuals and companies carrying out fishing business shall be licensed, except for small fishermen and small fish breeders. The Government shall establish a court of fishery affairs authorized to examine, hear and rule criminal cases in fishery affairs.

Furthermore, in the legal plan, Fisheries Law No. 31/2004 clearly mentions that fisheries management is done under a partnership principle, as indicated in **Article 2**: *The fisheries management is done according to the benefit base, justice base, partnership base, even distribution base, integrity base, openness base, efficiency base, and continuous conservation base*. More specifically, the fisheries management should also consider the customary laws and local wisdom as provided for in the Fisheries Law No. 31/2004, **Article 6** in particular: *The fisheries*

management for fish capture and fish cultivation has to consider the customary law and/or local wisdom and also the society that partakes. These legal provisions clearly show the justice and partnership benefit, based on the local wisdom and customary law which become basis for the implementation of fisheries co-management in Indonesia (**Figure 4.2**).

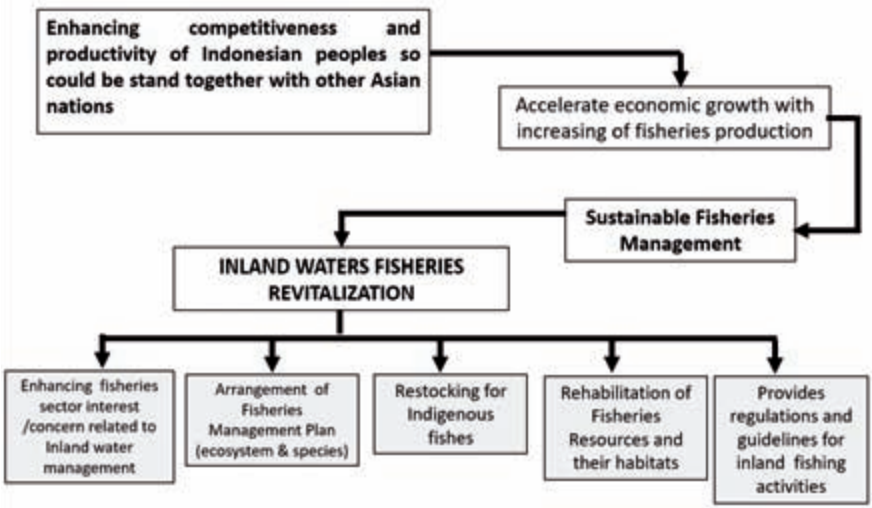


Figure 4.2 Policy and program for inland fisheries management in Indonesia (2015-2019)

There are also regulations declared by local government. For example, South Sumatra Regional Regulation No. 6 of 1978 and Decree of the Governor of the Head of Level I of South Sumatra No. 705/KPTS/II/82 concerning the auction of lebak lebung (also known as deep swamp) that contains the obligations of the leaders and winners of the lebak lebung auction to preserve the water resources and prohibit fishing with explosives, poison and others. Moreover, Ogan Komering Ilir District Regulation No. 18 of 2010 is also concerned with the management of lebak lebung. **Article 1 Item 5** is on lebak lebung and rivers as the areas that consist of lebak lebung, teluk (also known as bay), swamp, and rivers which are periodically or continuously flooded and are natural places or refuge for fish seeds or other aquatic biotas.

Indonesia had collected the data for inland capture fisheries since 1974 when Fisheries Directorate-General (under Ministry of Agriculture) established a national fisheries statistics system with assistance from FAO. In 2014, there are 320 districts (from 514) and 27 Provinces (from 33), collect and report their inland capture fisheries activities (**Figure 4.3**).

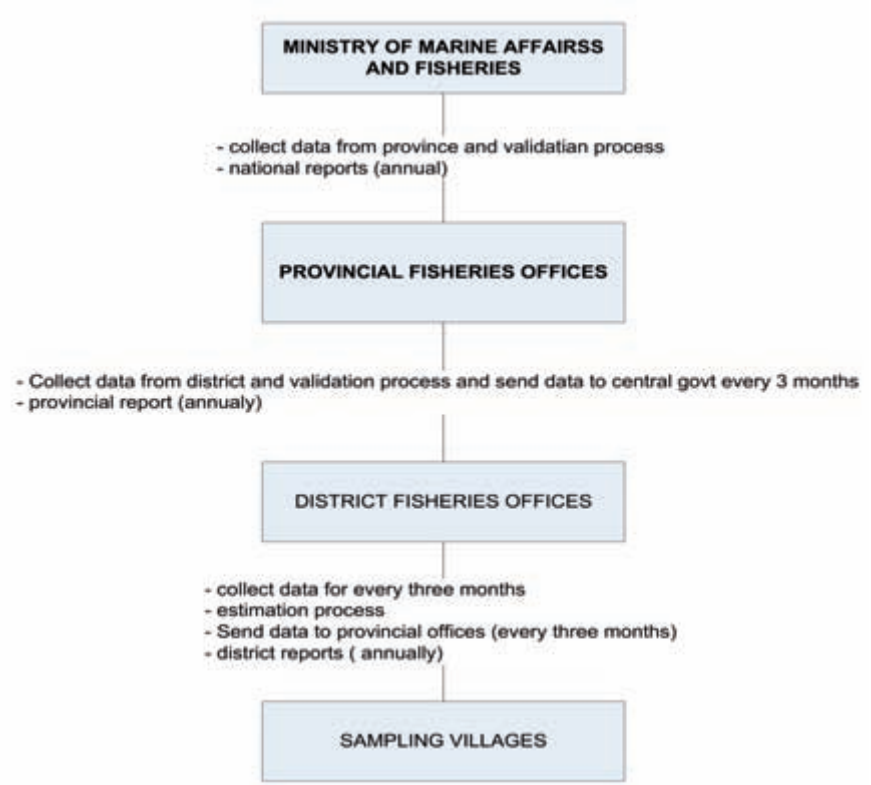


Figure 4.3 National fisheries statistics system of Indonesia

Lao PDR

In the new fishery law which was endorsed in Lao PDR in July 2009, **No. 03/NA** brings fisheries management within one cohesive framework. The fisheries law identified the principles, regulations and measures governing organizations, implementation, management, and fisheries inspection of aquaculture to promote conservation, protection,

development and sustainable utilization of aquatic resources and to ensure the food security for the Lao people. As part of the environment protection for national economic development, a measure is being taken by the Government to conserve the fishery resources as follows: establishing the closed season and conservation, regulation of the fishing nets, and the establishment of the annual plans. Under Part IX: Fish Release Day, Symbols and Stamps, **Article 69** on the National Fish Release Day provides that the Government has designated the 13th of July every year as National Fish Releasing Day for conservation, protection and development of abundant aquatic organisms.

The national strategy for fisheries management and development from present to 2020 (**Figure 4.4**) is the government's highest priority.

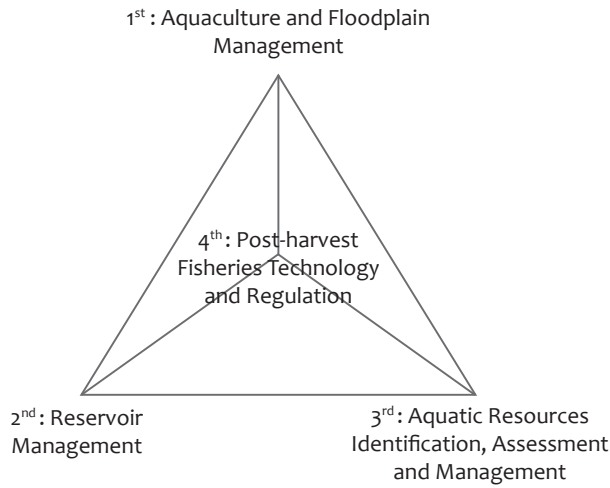


Figure 4.4 National Strategy for Fisheries Management and Development from present to 2020

The policy is to obtain food self-sufficiency both in agriculture and fish products to overcome poverty in rural areas and to improve the nutritional level as well as economic status. National agricultural and fisheries development policies will center around:

1. Meeting food security (especially the fish protein intake of the population averaging 18 kg/caput/year and projected by the year 2020 about 23 kg/caput/year;

2. Ensuring the provision of fishery products as commercial commodities for the local market and future export;
3. Supporting the rural development in the perspective of poverty alleviation and income-generating opportunity and a complementary source of cash;
4. Contributing to the gradual reduction of slash and burn shifting cultivation by integrating fish culture into the upland farming systems;
5. Adding to the sustainable use, appropriate management and protection of aquatic resources including aquatic bio-diversity;
6. Upgrading and establishing appropriate basic infrastructure required for further aquatic resources research, management and development for the country;
7. Strengthening, upgrading, and performing the technical support services in Research, Extension, Management and Development od the sub-sector such as Living Aquatic Resources Research Institute, Inland Fisheries Development Center, Aquatic Animal Health Diagnostic Network.

Malaysia

Among the legislations in Malaysia that are relevant to environmental protection and preservation, and on aquaculture development, are those included in the Fisheries Act 1985, Environmental Quality Act 1974, Environment Protection Enactment 2002, Sabah Inland Fisheries and Aquaculture Enactment 2003, and the Natural Resources and Environment (Amendment) Ordinance 2005. The Fisheries Act 1985 (FA85) focuses on relevant fisheries matters pertaining to development and management, and there are also provisions that are indirectly relevant to the preservation of the environment (Vun and Witus 2016).

A local fisheries management system is known as tagal, which prohibits anyone from catching fish in the river that has been designated by the community itself until such time (usually one year) that harvest of the fish resources is permitted. In 2002, a system of smart partnership between the community and Department of Fisheries Sabah (DOFS)

to support the protection, conservation and management of fishery resources in the rivers of Sabah. Creating a model tagal in Penampang, in collaboration with local communities, promoting the tagal system to other areas, monitoring the tagal, conduct research, and assist in terms of equipment and basic infrastructure. To develop further the tagal system, creating the sport fishing, tourist attractions and directly increase the income of local community resources.

During the 10th MP (2011-2015), the Department of Fisheries Sabah has been allocated more than RM2 million to support efforts to develop a statewide tagal system. Currently, there are 536 rivers of the area involving the 221 rivers in 20 districts throughout the state having the system the tagal that was created jointly by the local community with the DOFS. Efforts to develop the tagal system will be continued in the 11th MP (2016-2020) to achieve the target of 700 tagal system under the National Agro-Food Policy by 2020.

Myanmar

The Department of Fisheries (DOF) of Myanmar has extended the lease period of leasable fisheries for up to nine years to promote improved long-term management (3 years x 3 lease terms). The management systems of leasable fisheries are normally handled by the DOF, mainly through the auctions which are conducted in conjunction with the townships and regional authorities. Act "9" of the Fisheries Manual 1905 is concerned about regulating the leasable fisheries. The Freshwater Fisheries Law for Indawgyi Region in Kachin State has been renewed in 1905, 1991, and 2013.

Myanmar has been practiced the right-based fisheries management under the Freshwater Fisheries Law (1991) till 2011. Due to the politic and administration reforms of Myanmar, the Department of Fisheries has transferred the management power to Local Government on 16-4-2011. All local government has enacted the Regional or State Freshwater Fisheries Laws for fisheries management at present. These laws are practiced based on the particular and current situation of each state and region.

In terms of management, fisheries activities in Myanmar are grouped into three (3) parts following the rules of the Government of Myanmar. These are: leasable fisheries, tendered fisheries, and open fisheries. In leasable fisheries, management is carried out by the auction winners who automatically become the temporary owner of the auction-acquired fishery area but still the owner must follow the government regulations, including observance of the fishing season, closed fishing season, and conduct of restocking activities of fish seeds in an effort to increase the number of fish in the managed area. Outside the fishing season, the Government regulation states that the May-August period is declared as closed season. During this period, in which the fish is spawning, no fishing is allowed but restocking of fish seeds into the waters is encouraged. The types of fish stocked are generally the economically-valuable local fish species and could also include the fast-growing fish species such as Tilapia, Rohu, and Carps to dam, reservoirs, and rivers annually. There were 65.8 million numbers of fish fry released into the dam, reservoirs, and rivers in 2018.

The Philippines

The primary fisheries policies of the Philippines are provided for in the following:

a) Philippine Environment Code (1988) which provides the foundation for all measures dealing with the Philippines' natural environment, encompassing the management of air quality, water, land use, natural resources and wastes.

b) Philippine Fisheries Code (1998) that provides for the development, management, conservation and utilization of fisheries and aquatic resources.

c) Fisheries Administrative Order No 196 (2000) also known as FAO 2000, provides the detailed guidelines on the creation and implementation of the Fisheries and Aquatic Resources Management Councils (FARMCs).

Fisheries Code of 1998 of Philippines states that food security is the overriding consideration in the use, management, development, conservation, and protection of fisheries in order to address the food needs of the population. With this premise, the Philippine Government launched in the early 2000s the program known as "Agrikulturang MakaMASA," which means agriculture for the masses. Its fisheries component the "Agrikulturang MakaMASA – Fisheries" is aimed at developing and managing the country's fisheries for food security, contribute to the socio-economic upliftment of subsistence fisherfolk nationwide, and promote environmental protection for sustained aquatic productivity over a long-term period. With the implementation of the Philippines Fisheries Code of 1998, fishery law enforcement nationwide had been strengthened in close coordination with local government units and national law enforcement agencies. Generally, the main problems in the effective implementation are: lack of appropriate equipment, operating funds and trained manpower.

Regarding the data collection of inland fisheries, National Stock Assessment Program (NSAP) is the title of the Philippines' national information-gathering program for capture fisheries (in both marine and inland), started in June 1997. The objectives of NSAP are to develop and institutionalize the capability of the region on resource assessment, resource management, and development, and generate reliable data as the basis in the formulation of policies for the management and conservation of the country's marine and inland resources to attain sustainable development and exploitation. NSAP was designed to have more reliable data on the fisheries status in the Philippines and to come up with science-based policy recommendations for conservation and management of fishery resources in the country. The member of managing NSAP consists of the enumerators; data managers and analysts; NSAP regional team leaders; and policymakers. Training of the enumerators (data collection method of catch and effort data, fish identification) is also conducted in this program — survey methods used by NSAP survey landing sites. Enumerators take the samples at least

10% of the landed boats by gear. The final step of NSAP was to input the information on the database. NSAP Database System (NSAP DB) was also established to store the catch statistics and related information continuously with a standardized format. This database was designed for aiming efficient means of storing, managing, and retrieving data for analytical purposes (**Figure 4.5**).

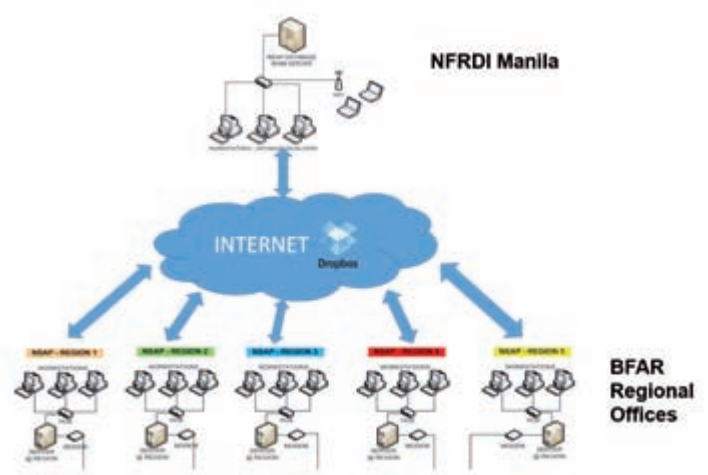


Figure 4.5 Flow chart of gathering data by (Bureau of Fisheries and Aquatic Resources), Philippines (image source: NSAP)

Singapore

The protection and conservation of fisheries, and to make provision for the control of fishing, the control of the marketing and distribution of fish, for measures pertaining to the general welfare and improvement of the fishing industry in Singapore and for purposes incidental has regulated in fisheries act (Chapter 111), Original Enactment: Act 14 of 1966 and revised in 2002.

Since limited land resources, Singapore can be developed not only to supplement Singapore's fresh-fish consumption, but also to utilize the limited land and water resources for maximum yield and economic returns efficiently. Aquaculture can play an important role in Singapore in the implementation of national policies on food production. The

activities will maintain the present status of local food production, thereby minimizing the over-dependence on external food supply (FAO 1976).

Thailand

Fisheries management in Thailand has started since B.E. 2444 (1901) when tax and tariff were collected from fishing activities to ensure sustainable fish supply for local consumption. During the reign of King Rama VII, the Department of Aquatic Animal Conservation was established on 21 September B.E. 2469 (1926). It was renamed as the Department of Fisheries since 1 January B.E. 2497 (1954).

Inland Fisheries Management under the Royal Ordinance on Fisheries B.E. 2558 (2015), Chapter 2 Fisheries Management provides policies on fisheries management by way of promoting the participation of all stakeholders in the management and conservation of aquatic animal resources. The highlights of The Royal Ordinance on Fisheries B.E. 2558 (2015) came into force on 15 November 2015, with focused on:

1. Encourage the incorporation and registration of the local fishing community.
2. The registered local fishing community has rights to proposed fisheries management measures for and eligible to be selected as the provincial fisheries.
3. Local fishing community members have been selected as an eligible, competent helper.
4. The Provincial Fisheries Committee will be determined Measures to manage fishing Development issues or fishing in the area by made following local conditions and circumstances more.

Thailand has a very extensive stocking program, mostly concentrated on reservoirs and rice-fields as well as in rivers and swamps. The NGO's and local communities are becoming increasingly more influential under the stocking programs where attention is being focused on social justice, livelihoods, biodiversity, and the environment. Co-management is promoted, as an approach to promote environmental rehabilitation.

Also mentioned in Section 56, is a provision that "no person shall catch aquatic animals in an aquatic species sanctuary except for the purposes of academic advancement or for the purposes of nurturing the aquatic animal breeds for which permission in writing has been granted by the Director-General of the Department of Fisheries. Moreover, under Section 71, the Minister or the provincial fisheries committee shall have the power to issue notifications regarding the fishing gears according to their types, fishing methods, fishing areas, and other conditions that are prohibited from engaging in fishing operations in the country's fishing grounds.

Viet Nam

In Viet Nam, the Government's fisheries policies are defined in laws, decrees, ordinances, circulars and regulations, the latter of which are often developed at provincial level. Provinces are the lowest level at which regulations can be drafted, consistent with the relevant national legislations. Since 1996, the Government has emphasized on the development of the country's market economy under the Doi Moi (renovation) Policy. A new Fisheries Law was drafted by the Ministry of Fisheries (MOFI) of Viet Nam with help from Norwegian Development Agency (NORAD) and FAO, and passed by the National Assembly in November 2003. The Fisheries Law went into effect on July 1, 2004 (Anonymous 2005).

In the case of capture fisheries, focus is on marine activities and based along the 29 coastal provinces of Viet Nam, which clearly receives the most attention and given much detailed consideration. However, aside from its marine water resources, Viet Nam has a dense river network, including nine major river basins as well as a substantial inland water surface area of (open access) its lakes and lagoons. Very little is actually known about the levels of production from these inland water resources, the profits generated, and the characteristics of those fishing activities in such inland common water resources. This could be due in part to the nature of the subsector, where data are limited as the catch is simply not reported in any systematic way. As such, just one (relatively

modest) national production number of approximately 200,000 metric tons from the country's inland water resources is published every year. Inland capture fishing is the least understood fisheries activity in Viet Nam (Anonymous 2010). In accordance with the Law of Fisheries 2003, Decree No 103/2013/ND-CP was issued by the Government of Viet Nam on 12 September 2013 stimulating the handling of administrative violations in fisheries activities. Nonetheless, for the sustainable development of the country's fisheries, the Government of Viet Nam adopted the FAO Code of Conduct for Responsible Fisheries (CCRF) 1995, especially the CCRF which defines the principles for sustainable fisheries management. In this regard, the Government of Viet Nam enacted Decision 153/QD-TTg dated 17 August 2004, promulgating a strategy for sustainable development in Viet Nam also known as Viet Nam Agenda 21 (Phuong 2010).

4.3 Management Measure

The main goal of inland fisheries management is to improve the well-being of all the people engaged directly or indirectly in the fisheries sector, especially those in the rural areas. The decided management should commit for poverty alleviation, the welfare of future generations, and environmental conservation.

However, it is also understood that, in many cases, the primary driver of the fish assemblages is not how the fishery is managed but rather the state of the environment as acted upon by other human uses. This means that mechanisms are needed to improve both management of fisheries through forms of co-management and collaboration at the national and international level between and among the agencies responsible for the control of the aquatic resources in general (Welcomme *et al.* 2014).

In the context of inland fisheries management, there are 5 challenges which are very important to be considered: (1) Identifying and quantifying the spectrum and types of ecosystem services of the aquatic waters, including fisheries; (2) quantifying the ecological, economics

and social values of ecosystem services of the inland and marine fisheries; (3) assessing the fish stock of aquatic waters; (4) determining the functional and structural connectivity within ecological system of the inland and marine fisheries; and (5) seeing the inland and marine waters as a social-ecological system (SES) unit (Suuronen 2014).

Measuring the management of fisheries, more particularly inland fisheries, could be carried out in two ways: (1) using traditional knowledge as the benchmark, and (2) compiling sufficient statistical data. Traditional knowledge refers to the knowledge, innovations, and practices of indigenous and local communities around the world. Developed from experience gained over the centuries and adapted to the local culture and environment, traditional knowledge is transmitted orally from generation to generation. It tends to be collectively owned and takes the form of stories, songs, folklore, proverbs, cultural values, beliefs, rituals, community laws, local languages, and agricultural practices, including the development of plant species and animal breeds. Sometimes it is referred to as an oral tradition for it is practiced, sung, danced, painted, carved, chanted, and performed down through millennia. Traditional knowledge is mainly practical, particularly in such fields as agriculture, fisheries, health, horticulture, forestry, and environmental management in general (Adrianto *et al*. 2009; https:// www.cbd.int/traditional/intro. shtml).

Another tool that could be used to facilitate the development planning and management of fisheries in general, is fishery statistics which comprise the data and information that describe the current and past status of the fisheries, showing the trends in the development of the fisheries sector that can be used for policy, planning and management. Statistics refers to both the methods applied to collect data and the (partially) analyzed data themselves.

During the "Workshop to Review Activities and Methodologies for Promotion of Inland Fisheries" organized by the SEAFDEC Inland Fishery Resources Development and Management Department (IFRDMD) in Palembang, Indonesia on 8-10 August 2016, information

from the Southeast Asian countries on how much attention is given by governments on the compilation of fisheries catch statistics was reported. The results showed that most countries in the region have established their respective catch statistics on inland fisheries, which is updated annually. In most countries, their respective government agencies take on the responsibility of compiling the catch statistics. Therefore, collection of fishery statistical data should be supported by the governments.

Nevertheless, in many Southeast Asian countries, the collection of the fishery statistical items and data set could differ, as such activities always take into account their respective priority needs, objectives and requirements. In most cases, inland fishery statistics are generally very poor, and as a result information on the actual contribution of the sector to food security is not generally known. Considering that inland fisheries employ millions of people directly or indirectly, the state of the fish stocks of inland waters is still not known because of the low level of research across the rivers, floodplains, reservoirs and lakes. The use of fishery statistics is not only for national purposes but also for regional and international actions where comparable analysis of fisheries status and trends could be deduced and used for planning and management in a broader scope (Pornpatimakorn and Ananpongsuk 2013).

Without applying statistics, the raw data collected could not be changed into something that the managers, planners and policy makers could understand, let alone the data trends. Indeed, statistical analysis can be very complex, but for most purposes the statistical tools required for fisheries are rather straightforward and easy to understand.

Considering that seasonality is an important characteristics of inland capture fisheries, this should be taken into consideration when collecting and analyzing the statistics at national level. Moreover, statistics on inland capture fisheries production by species by fishing gears is very useful for management even if the current framework still does not accommodate the compilation of inland capture fisheries production by species by fishing gear, and thus should be collected.

Fishing activities in reservoirs and even rivers or in the main river channels are quite obvious, including in fixed fishing grounds, thus for better monitoring and reporting of data and information, fisheries data should also be collected in landing sites, and the adoption of some forms of license systems could also be promoted to improve fishery statistics compilation. In general, the amount of subsistence fishing is far more significant in inland waters, especially where floodplain fisheries (including rice-fish 'culture') exist or the seasonality of fishing activities (intensity) and involvement of them is of greater importance. This is especially true for the highly productive floodplain fisheries that still form a significant contribution to the fisheries sector in Cambodia, Viet Nam and Myanmar, and to a lesser extent in Lao PDR, where fishing operations are spread out over a vast area, without fixed landing sites. Because the water-land interface available for fishing activities in inland areas is enormous, especially where extensive floodplains exist, the amount of people involved in inland fisheries is far higher than in coastal fisheries.

Compared with coastal fisheries, the commercial inland fisheries consist mainly of small-scale one-person fishing operations, while the catch from this commercial sector is only a small part of the total fishing production. Due to the inherent dynamics of inland waters, the heavy dependence on floodplains in river fisheries, either directly (floodplain fisheries) or indirectly (much of the catches, *i.e.* biological production, in rivers and reservoirs is actually produced on the floodplains), there may be considerable fluctuations in production from one year to another, but are mostly unrelated to the fishing pressure. The complex relationships between habitats, fish, and flooding create a far more complex fisheries system in inland areas than in coastal fisheries. Participation, gear use, and catches fluctuate between seasons and years, depending on the influence of economic factors. Although this generally holds true for both inland and coastal fisheries, many more people are involved in inland fisheries in a far larger area.

Inland fisheries are far more complex, dynamic and more challenging to monitor and care has to be taken not to merely transpose marine methodologies and concepts to inland fisheries, as has been done so often in the past. This places specific requirements on the data that have to be met, and this has implications for the data collection system. Although stock assessment works well in marine environments, and can also be applied to lakes and reservoirs without too many problems, it needs a trial to be used in riverine habitats, especially rivers with extensive floodplains, where the fish migrates during the low or high-water level. Therefore, some of the variables that are routinely collected, *e.g.* length-weight composition of the catch may be particularly useful for most inland fisheries.

CHAPTER 5
REMARKS

This chapter gives a brief assessment of what happens in inland waters, including its fisheries, and for what needs should be identified and observed in the future, with respect to the current conditions.

Inland fisheries in Southeast Asia are characterized by the huge aquatic diversity based on various range of ecosystems, the great variety of gears used, the culturally complex society engaged, and the problems in collecting and compiling the fishery statistics. Inland fisheries are dynamic since there are other sectors also doing various activities in the same inland waters often causing changes in the habitats of the aquatic organisms that could impact on the fishery production. Inland fisheries are also influenced by nature, the occurrence of rainy and dry seasons that cause water level fluctuations leading to biodiversity alteration and adjustments in the fishery activities.

In many Southeast Asian countries, specifically in Cambodia, Indonesia, Myanmar, Lao PDR, Thailand, and Viet Nam, where there is wide distribution of inland waters, inland fisheries could be the main livelihood of the fisher households, although in most cases, the fishers also have other jobs such as farming or tending the rice fields. Despite such situations, the role of inland fisheries for improving the socio-economic of local people is often underestimated. As mentioned by Platteau (1989), the inland fisheries have been perceived as 'backward, informal and marginal' economic activities.

Generally, the people who inhabit the areas surrounding the inland waters are living under the poverty line, making them less capable of getting enough access to utilizing the fishery resources. Aside from inadequate catching ability to produce fish, because of limited capital to procure fishing gears, their catch is directly sold to middlemen who had previously loaned them some money-making poor fishers becoming much poorer. One of the most promising solutions for the sustainability of small-scale fisheries would be for the governments to provide support to fishers in terms of fishing gears and to conduct capacity building on catch management as well as to provide capital grants.

An integrated system of farming should be developed in and around the fishing areas such as fish-cum-agri-culture. This could be one way of increasing the fish stock through natural recruitment as fish

supply could be sourced from the fish culture or promotion of culture-based fisheries and restocking using seeds produced from the culture activities. Agriculture activities could also provide the nutrition needs of the fishers.

The major threats to inland waters come from human activities and environmental degradation. Dam development could be one of the artificial obstacles of fish migration and fisheries activities. Converting of inland water sites into agricultural areas, *e.g.* palm plantation or recreational destinations or industrial areas could impact on the fishery resources threatening the survival of freshwater fishes, a consequence of the underlying causes of the decline of fisheries activities and production (**see Chapter 1 and Chapter 3**).

Although SEAFDEC has published the statistics on inland capture fisheries in Southeast Asia since 2008, the information is far from complete as data collection had always been a difficult task to undertake considering that inland fisheries use various types of fishing gears, involve large numbers of small-scale and part-time fishers, endure high seasonality, and comprise complex fishing activities. Moreover, inland fishery resources have diverse species composition, fish landing sites for the catch are inadequate, and significant portion of the catch goes directly for household consumption. The statistics reporting system for inland capture fisheries make use of enumerators, but because of their limited numbers, all fishers and landing sites could not be covered. The insufficiency of the statistics on inland fisheries production is one of the big challenges that hinder the sustainability of inland capture fisheries. As a result, some of the nominal catch statistics have been considered unreliable and could not be used unless they are reconciled with other sources of information (Coates 2002), because where the errors and biases are considered constant, the statistics are used to establish the trends (Lymer and Funge-Smith 2009). Therefore, it is necessary to improve the data collection systems and methods that could be applied to various conditions and background of inland capture fisheries in the region. The data to be collected could include among

others, fish production in quantity, species composition of the catch, operational time spent in fishing, and the kinds of fishing gears used. These data and information are necessary so that the contribution of inland fisheries to the economies of the countries could be visualized, and the sustainability of inland fisheries is ensured.

Regulations on inland fishery resources should include provisions that concern a wide variety of matters, including the use of responsible fishing gears, allowable mesh size of fishing gears, methods of fishing, prohibited fishing areas, closed and open seasons in inland water bodies, sustainable trading of fish catch, and the restrictions on fishing. The responsibility of managing the inland waters which should consider the impacts of the fisheries on the environment and other aquatic components, not only lies on the fishery authorities but also with some other relevant sectors. Fisheries interests are peripheral to policy-making and as such, are allocated the appropriate processes in most countries. Keeping the sustainability of biodiversity and habitats could be achieved by developing conservation zones and formulating the inland fisheries management plans. The value of the aquatic ecosystems lies in the sustained net benefits derived from the ecological services and food supply, direct and indirect human consumption, energy, as well as the aesthetic and recreational interests. Frequently, inland fisheries have been accorded lower priority in policy-making because of the perception that the alternative users of the water resources contribute more to society's welfare. Conservation of inland aquatic resources should be viewed within the multi-purpose use of inland waters. The principal constraints on fisheries management emanate from human activities, other than the fishing activities. The government, at all levels from central to local authorities, should set up mechanisms to conserve the aquatic diversity compatible with the sustainable use of the inland waters and for the whole range of its economic and social purposes.

Conservation and management decisions for inland fisheries should be based on the best scientific evidence and available data, taking into account local knowledge in managing the resources and their

habitats. Countries should make it a priority to undertake research and data collection on improving the scientific and technical expertise of fisheries including their interaction with the ecosystem. In overcoming the concerns regarding the transboundary of the ecosystems, the concerned countries should promote bilateral and multilateral co-operation in research. A better understanding of the significance of inland fisheries resource would influence the direction of the general development policies for inland water resources.

EDITORIAL TEAM

Prof Dr Ngurah N Wiadnyana

Born in a coastal village in Padangbai, Bali on 31 December 1959, Dr. Wiadnyana, after graduating from high school in 1979 continued his education at the Bogor Agricultural Institute and obtained a "Sarjana" of Fisheries majoring in Water Resources Management in 1983 from the Faculty of Fisheries. He obtained the Diplôme d'Etude Approfondie (DEA) degree in Biological Oceanography from the Université Pierre et Marie Curie (Paris VI), France in 1987. He then obtained a doctorate degree in Biological Oceanography from the same university in 1991. He successfully reached the highest functional position as Senior Research Scientist in 2002 and inaugurated as Research Professor in January 2006. He has written more than 100 scientific publications by himself and with colleagues that were published in international and national journals, international and national proceedings, and several books and parts of books. He taught and guided S-1, S-2 and S-3 students at several universities, including the University of Pattimura, Bogor Agricultural Institute, University of Indonesia, University of PGRI Palembang, and USNI Jakarta. Aside from being a researcher, he was charged as echelon 3 (Head of Division and Head of a Research Institute) from 2000 to 2012 and as Director of the Center for the Assessment and Application of Marine and Fisheries Technology, Agency for Marine and Fisheries Research and Development in 2012-2014. Currently, he is active as a researcher and Chair of the

Research Group on Habitat Rahabilitation and Aquatic Environment at the Research Center for Fisheries, Agency for Marine and Fisheries Research and Human Resources, the Ministry of Marine Affairs and Fisheries.

Dr Luky Adrianto

Dr Adrianto has been working for more than 20 years in the field of coastal and marine resources management, including fisheries. He is also active and take the leading position in teaching at undergraduate and graduate levels of fisheries sciences at IPB University since 2004 to the present. His research works are mainly in the field of fisheries social-ecological system including social-ecological metabolism, fisheries ecological footprint, coastal and ocean governance, ecosystem approach to fisheries management, and governance with funding from national and international sources. From 2005-2013, he was appointed as Deputy Director at the Center for Coastal and Marine Resources Studies IPB, where he led and managed the research activities, knowledge management in ICM planning and implementation, and assumed position as Director from 2013 to 2015. At the national policy level, he had also been appointed as Co-Chair for the National Working Group on Ecosystem Approach to Fisheries Management (EAFM), Indonesia (2014-2017).

His publications have appeared in number of international journals such as *Marine Policy, Environmental Impact Assessment Review, Environment, Development and Sustainability, Tourism Perspective, Marine Pollution Bulleting, etc.* as well as in some reputable journals on related studies in Indonesia. In 2010, he published FAO's Technical Book on Mainstreaming Fisheries Co-Management in Indonesia and with funding from by ICSF, he published book *Local Construction of Fisheries Management in Indonesia*. His other publications include *Coral Governance in Indonesia* (2015), and *Mainstreaming Marine Conservation Governance for Sustainable Fisheries in Indonesia* (in press 2019).

From the academic viewpoint, he is now Dean of Faculty of Fisheries and Marine Sciences, IPB University, Indonesia (2015-2020), and during the same period, he has been elected as the President of Indonesian University Networks for Fisheries and Marine Sciences (2015-2020).

Ms Virgilia T Sulit

After graduating with a Bachelor's degree major in Mathematics from the Mindanao State University in southern Philippines, Mrs. Sulit served as Instructor in Mathematics at the same University. She then continued her graduate studies and obtained her M.Sc. in Statistics from the University of Bombay (now Mumbai) in India and later, Diploma in Project Development and Management from the Philippine Executive Academy of the University of the Philippines, Manila campus. She had undertaken various training courses in technical writing and editing, and in development communications from various institutions in the Philippines. She had worked with the Aquaculture Department of the Southeast Asian Fisheries Development Center (SEAFDEC) in Iloilo, Philippines where she assumed many positions that included Head of Human Resource Management, Extension Officer, Information Management Officer, and many more. She has written many institutional articles and books, written and edited Proceedings, and other technical and institutional reports. Currently, she works at SEAFDEC Secretariat in Bangkok, Thailand as Managing Editor of the SEAFDEC Special Publication *Fish for the People*.

Dr Arif Wibowo

Completed his postdoctoral fellowship at Leibniz Center for Tropical Marine Ecology (ZMT), Bremen, Germany (2013), and in 2014, at Biology Department, University of Turku, Finland, through Erasmus Mundus Postdoctoral Research Fellowship Program. He acquired his Doctoral in Program Study Aquatic Resources Management, School of Graduated Study, Bogor Agricultural University (2011) and obtained his M.Sc and B.Sc. in Major Environmental Science, School of Graduated Study, Gadjah Mada University, Yogyakarta (2003) and Major Plant Breeding, Faculty of Agriculture, Gadjah Mada University, Yogyakarta (2001), respectively. So far published many papers in peer-reviewed international journals as first author or co-author. He has received travel grants as participant on Open Science Meeting and Master Classes, the Joint Working Group for Scientific Cooperation between Indonesia and the Netherlands (JWC) in Jakarta and Bogor – Indonesia (2011); the winner of Du Pont Indonesia writing competition and awarded Du Pont scholarship (1998) and the third winner of HAYATI AWARD as the best scientific paper from Department of Biology, Faculty of Mathematics and Natural Sciences, Bogor Agricultural University (2010). Now, he is the Chief of SEAFDEC Inland Fishery Resources Development and Management Department (IFRDMD) and Head of Research Institute for Inland Fisheries and Extension, Ministry of Marine Affairs and Fisheries, Republic of Indonesia.

Dr Dina Muthmainnah

Has been a Researcher at the Research Institute for Inland Fisheries and Extension of the Ministry of Marine Affairs and Fisheries in Palembang, Indonesia since 1998. Currently, she assumes the position as Researcher at SEAFDEC/IFRDMD and takes the responsibility as Project Leader for the publication of the scientific book "Promotion of Responsible Utilization of Inland Fisheries in Southeast Asia" for 2017 to 2019. She completed her Doctoral Degree in Environment Waters Management at University of Sriwijaya, Indonesia in 2013. She wrote many scientific papers that were published in a number of national and international proceedings and journals, namely Jurnal Kebijakan Perikanan Indonesia, Indonesian Fisheries Research Journal, Journal of Biodiversity and Environmental Sciences, and so on, and also semi-popular articles published in newspapers and magazines. She also presented several scientific papers in many fora, and served as Keynote Speaker in some International Classes and Seminars. She actively attends several meetings, workshops and conferences, related to her area of expertise.

Dr Safran Makmur

Has been a Researcher at the Research Institute for Inland Fisheries and Extension of the Ministry of Marine Affairs and Fisheries in Palembang, Indonesia since 1999. He is currently involved as Researcher of SEAFDEC/IFRDMD and was the Project Leader for the "*Promotion of Responsible Utilization of Inland Fisheries in Southeast Asia*" in 2015. He completed his Doctoral Degree from the University of Brawijaya, Indonesia in 2015. His scientific articles were published in several national and international proceedings and journals.

Mr Aroef Hukmanan

Is a young researcher at SEAFDEC/IFRDMD and at the Research Institute for Inland Fisheries and Extension of the Ministry of Marine Affairs and Fisheries in Palembang, Indonesia. His carrer as researcher started in 2009. He has experience in conducting many studies in estuaries and floodplains especially in Indonesia. As Researcher at SEAFDEC/IFRDMD, he has been involved with the Project *Promotion of Responsible Utilization of Inland Fisheries in Southeast Asia* from 2015 until now. His scientific papers have been published in Jurnal Penelitian Perikanan Indonesia, and Indonesia Fisheries Research.

Ms Sevi Sawestri

Is a Researcher at SEAFDEC/IFRDMD and at the Research Institute for Inland Fisheries and Extension of the Ministry of Marine Affairs and Fisheries in Palembang, Indonesia. She was the Project Leader for the research project *Promotion of Responsible Utilization of Inland Fisheries in Southeast Asia* in 2016. She completed her Magister Program of Animal Bioscience at Bogor Agricultural University, Indonsia in 2010. She has been working in several fish and environmental resources research. Her scientific papers have been published in several national and international proceedings and journals. For her capacity enhancement, she has participated in several trainings and internships. In 2015, she was given the opportunity to join the SEAFDEC Regional Fisheries Policy Network (RFPN) representing the Ministry of Marine Affairs and Fisheries (MMAF) Indonesia, and stationed at the SEAFDEC Secretariat in Bangkok, Thailand.

Mr Freddy Supriyadi

Is a Researcher at the Research Institute for Inland Fisheries and Extension of the Ministry of Marine Affairs and Fisheries in Palembang, Indonesia, and SEAFDEC/IFRDMD. He was involved with the research *Enhancement of Sustainability of Catadromous Eel Resources in Southeast Asia* in 2016 *and Promotion of Responsible Utilization of Inland Fisheries in Southeast Asia* in 2017-2018. Currently, he is persuing graduate studies for Magister Program at Bogor Agricultural University, Indonesia with major study in hydroacoustics and Geographic Information System.

Mr Khoirul Fatah

Has been a Researcher at the Research Institute for Inland Fisheries and Extension of the Ministry of Marine Affairs and Fisheries in Palembang, Indonesia since 1998. Currently, he is a Researcher at SEAFDEC/IFRDMD, and involved with the research project *Promotion of Responsible Utilization of Inland Fsheries in Southeast Asia* from 2017. He obtained his Bachelor's Degree in Chemical Engineering from the University of Sriwijaya, Indonesia in 2002. His scientific publications appeared in several national and international proceedings and journals.

ABBREVIATIONS AND ACRONYMS

AMSs	ASEAN Member States
Art	article
ASEAN	Association of Southeast Asian Nations
AFS	Asian Fisheries Society
B.E.	Buddhist Era (Thailand)
CBD	Convention on Biological Diversity
CCRF	Code of Conduct for Responsible Fisheries
CO_2	Carbon dioxide
CPUE	Catch Per-Unit of Effort
DDT	Dichloro Diphenyl Trichloroethane
DOF	Department of Fisheries
FA	Fisheries Act
FAO	Food and Agriculture Organization
FARMCs	Fisheries and Aquatic Resources Management Councils
FiA	Fisheries Administration
GAFS	Gender in Aquaculture and Fisheries Section
GVP	Gross Value Production
ha	hectare
Html	hypertext Markup Language

IFRDMD	Inland Fishery Resources Development and Management Department
Int	International
Lao PDR	Lao People's Democratic Republic
MRC	Mekong River Commission
MAFF	Ministry of Agriculture, Forestry, and Fisheries
MMAF	Ministry of Marine Affairs and Fisheries
MOFI	Ministry of Fisheries
N	nitrogen
N	north
NGO	non-governmental organization
NORAD	Norwegian Development Agency
P	phosphate
SEAFDEC	Southeast Asian Fisheries Development Center
USSR	Union of Soviet Socialist Republics
UV	ultraviolet

GLOSSARY

Abundance	the number of individuals of a particular taxon in a certain area or volume of sediment.
Aquatic	(a) living entirely or primarily in or on water. (b) growing in or on water. (c) living near or frequenting water
Aquaculture	the cultivation of aquatic and plants, especially fish, shellfish, and seaweed, in natural or controlled freshwater or marine environments.
Auction	a publicly held sale at which property of goods are sold to the highest bidder.
Basin	a partially enclosed, sheltered area along a shore, often partly man-made or dredged to a greater depth.
Biodiversity	diversity among and within plant and animal species in an environment.
Biomass	the amount of living matter in a given habitat, expresses either as the weight of organisms per unit area or as the volume of organisms per unit volume of habitat.

Coastal	of, relating to, bordering on, or located near a coastal.
Co-management	a process of management in which government shares power with resource users, with each given specific rights and responsibilities relating to information and decision-making.
Conservation	official supervision of rivers, forest, and other natural resources in order to preserve and protect them through prudent management.
Crustaceans	any aquatic arthropod typically having the body covered with a hard shell or crust, including the shrimps, and crabs.
Dam	a barrier to obstruct the flow of water, especially one of earth, masonry, etc., built across a stream or river.
Economic	pertaining to the production, distribution, and use of income, wealth, and commodities.
Ecosystem	a system, or a group of interconnected elements, formed by the interaction of a community of organisms with their environment.
Environment:	the air, water, minerals, organisms, and all other external factors surrounding and affecting a given organism at any time.
Exploitation	use or utilization, especially for profit; selfish utilization.

Fishing gear	the equipment used for fishing, e.g. baitboat, gillnet, handline, harpoon, haul seine, longline, widwater trawl, purse seine, rod-and-reel, trap, and trawler. Each of these gears can have multiple configurations.
Fishing net	a large net used for catching fish.
Floodplains	flat land bordering a river and made up of alluvium (sand, silt, and clay) deposited during floods. When a river overflows, the floodplain is covered with water.
Food security	a situation that exists when people lack secure access to sufficient amounts of safe and nutritious food for normal growth and development and an active and healty life (FAO).
Habitat	the natural environment of an organism; place that is natural for the life and growth of an organism.
Homogenous	of uniform structure or composition throughout.
Hydropower	energy derived from flowing water. The basic principle of hydropower is using water to drive turbines.
Irrigation	the artificial application of water to land to assist in the production of crops.
Lake	a body of fresh or salt water of considerable size, surrounded by land.

Length-Frequency	data of the length of focal fish species which can be measured: standard length (SL), fork length (FL), and/or total length (TL).
Livelihood	a means of supporting one's existence, especially financially or vocationally; living.
Management	the act or manner of managing; handling, direction, or control.
Middlemen	a person who plays an economic role intermediate between produce and retailer or consumer.
Nutritional	the act or process of nourishing or of being nourished.
Policy	action or procedure conforming to or considered with reference to prudence or expediency.
Rehabilitation	to restore to a condition of good health, ability to work, or the like.
Reservoir	a natural or artificial place where water is collected and stored for use, especially water for supplying a community, irrigating land, furnishing power, etc.
Restocking	to stock again.
River	a natural stream of water of fairly large size flowing in a definite course or channel or series of diverging and converging channels.

Socio	living or disposed to live in companionship with others or in a community, rather than in isolation.
Spawning Ground	a place where fish go to lay eggs.
Stakeholder	a person or group that has an investment, share, or interest in something, as a business or industry.
Statistics	the science that deals with the collection, classification, analysis, and interpretation of numerical facts or data, and that, by use of mathematical theories of probability, imposes order and regularity on aggregates of more or less disparate elements.
Stocking	The practice of putting artificially reared young fish into a sea, lake or river. These are subsequently caught, preferably at a larger size.
Surveillance	activities undertaken by the fishery enforcement system to ensure compliance with fishery regulations.
Sustainability	(1) Ability to persist in the long-term. (2) Characteristic of resources that are managed so that the natural capital stock is non-declining through time, while production opportunities are maintained for the future.
Swamp	a tract of wet, spongy land, often having a growth of certain types of trees and other vegetation, but unfit for cultivation.

Trap	*fish trap*-a device for catching fish that consists of a net or other structure which diverts the fish into an enclosure so arranged that egress is more difficult than ingress.
Wetland	land where saturation with water is the dominant factor determining the nature of soil development and the types of plant and animal communities living in the soil and on its surface. The single feature that most wetlands share is soil or substrate that is at least periodically saturated with or covered by water. The water creates severe physiological problems for all plants and animals except those that are adapted for live in water or in saturated soil.

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THE FEATURES OF INLAND FISHERIES IN SOUTHEAST ASIA

Numerous bodies of inland waters are widely spread in Southeast Asia where fisheries production is important sources of people's animal protein. The capture fisheries sector, utilizing the inland waters, provides employment opportunities and revenues to millions of peoples in the rural areas.

Inland fisheries activities are varied considerably and adequately, related to the specific fishing areas, aquatic species targeted, fishing gear used, and social culture. The inland fisheries sub-sector, however, is facing various challenges that should be addressed to implement the appropriate management measures.

Inland water systems, including rivers, lakes, swamps, floodplains, small streams, ponds, and reservoirs, have a variety of biological, physical, and chemical characteristics. Inland waters are an ecosystem that easily becomes to be endangered and highly vulnerable to degradation. The aquatic organisms of inland waters are dependent on each other. Nowadays, the consumption of fish increases with the increasing population of the world; the supply of wild-caught fish could be put under pressure.

As renewable natural resources, fisheries resources should be utilized continuously through rational and responsible exploitation. Enforcement of regulations published by governments to control fisheries activities is necessary implemented to ensure the continued fish productivity in particular, and accomplish the sustainable fisheries objectives in general. Promoting the sustainable management of the fishery resources should be taken into consideration for the availability and affordability of the fish products obtained from the fishery activities, and should also be aimed for the enhancing the socio-economic well-being of the fisheries households in Southeast Asia Regions.

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