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Myanmar inland fisheries and aquaculture

A decade in review

Khin Maung Soe, Eric Baran, Ruby Grantham, Xavier Tezzo, Gareth Johnstone

ACIAR MONOGRAPH 209

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ACIAR
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Foreword

Myanmar's fisheries are among the most important globally but remain some of the least documented. Fish provide at least 60% of Myanmar's animal protein consumption. The fisheries sector occupies an important place in Myanmar's economy and culture, and is set to change rapidly as the country enters a period of unprecedented political and economic transition. Building on a unique set of information sources, this book presents a broad view of the current state of knowledge on governance, livelihoods, production and supply chains across two of Myanmar's fishery subsectors: inland capture and aquaculture. The analysis is contextualised with a review of major changes in the country's policy history affecting fisheries. It is argued that Myanmar's fisheries now sit at a crossroad in terms of their governance.

The year 2018 was pivotal for Myanmar's fisheries sector in that state and region inland fisheries laws approved the concept of community-based fisheries management for the first time. This was in part due to the work carried out by WorldFish and partners under the Australian Centre for International Agricultural Research (ACIAR) funded 'Improving fishery management in support of better governance of Myanmar's inland and delta fisheries' (FIS/2015/046) project.

ACIAR has funded sequential inland fisheries and aquaculture research projects in Myanmar, initially designed to improve the capacity for management of Myanmar's inland capture fisheries. This was in addition to the facilitation of fisheries co-management as a cornerstone of rural food security and livelihoods. Continued research is aiming to maximise sustainable small-scale fisheries production in ways that provide equitable benefits to stakeholders in fish-dependent communities in the Ayeyarwady Delta. The current aim is to assess different management practices and evaluate their impacts in securing benefits for small-scale fishers—the benefits being increased fish production and fisher incomes, improved food security and nutrition, and better gender equity.

This work comes at a time when capture fisheries—both fresh water and marine—are in decline. Repeated marine sector studies by the Norwegian fisheries research vessel *Dr Fridtjof Nansen* have shown that marine commercial fish stocks declined by 80% between 1980 and 2018. This in turn puts pressure on inland capture fisheries, with the result that production in these fisheries is also declining, as demonstrated by a WorldFish study funded by the World Bank.

Inland capture fisheries and, increasingly, freshwater aquaculture provide around 65% of fish consumed in Myanmar. However, fish species biodiversity and the availability of nutrient-dense fish (small native fish consumed whole) can only be sustained by improving the management of inland capture fisheries.

Continued research will help to ensure that the fisheries sector remains vibrant, as noted in the vision of the Myanmar Agriculture Development strategy and investment plan for 2018–19 to 2022–23: 'By 2030, Myanmar achieves inclusive, competitive, food and nutrition secure, climate change resilient, and sustainable agricultural system contributing to the socio-economic well-being of farmers and rural people and further development of the national economy'.

This is a very timely and useful review of a very critical sector for the food security and livelihoods of millions of people in Myanmar.

Andrew Campbell
Chief Executive Officer
ACIAR

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Abbreviations

ACIAR	Australian Centre for International Agricultural Research
AD	Ayeyarwady Delta
ASEAN	Association of Southeast Asian Nations
CDZ	Central Dry Zone (of Myanmar)
DoF	Myanmar Department of Fisheries
FAO	Food and Agriculture Organization of the United Nations
MFF	Myanmar Fisheries Federation
MYFish	WorldFish project: 'Improving research and development of Myanmar's inland and coastal fisheries'
NGO	non-government organisation
SEAFDEC	Southeast Asian Fisheries Development Center

Units

cm	centimetre
ha	hectare
kg	kilogram
km	kilometre
km^2	square kilometre
m	metre
m^3/s	cubic metre per second
mm	millimetre
t	tonne

Aquatic animals

Common name	Latin name
African catfish	*Clarias gariepinus*
Bagrid catfish	*Rita rita*
Barramundi	*Lates calcarifer*
Bigeye ilisha	*Ilisha megaloptera*
Bighead	*Hypophthalmichthys nobilis*
Bronze featherback	*Notopterus notopterus*
Catla	*Catla catla*
Climbing perch	*Anabas testudineus*
Common carp	*Cyprinus carpio*
Gourami	Osphronemidae family
Hilsa	*Tenualosa ilisha*
Kelee shad	*Hilsa kelee*
Mola carplet	*Amblypharyngodon mola*
Mrigal	*Cirrhinus cirrhosus*
Mud crab	*Scylla serrata*
Nile tilapia	*Oreochromis niloticus*
Orangefin labeo	*Labeo calbasu*
Pangas catfish	*Pangasius pangasius*
Pool barb	*Puntius sophore*
Rice field fish	*Oryzias uwai*
Rohu	*Labeo rohita*
Salween rita	*Rita sacerdotum*
Shark catfish	*Pangasius conchophilus*
Silond catfish	*Silonia silondia*
Silver barb, Thai barb, tarpian, blue barb	*Barbonymus gonionotus*
Snakeskin gourami	*Trichopodus pectoralis*
Spotted snakehead	*Channa punctata*
Stinging catfish	*Heteropneustes fossilis*
Striped dwarf catfish	*Mystus vittatus*
Striped snakehead	*Channa striata*
Swamp eel	*Synbranchidae family*
Tilapia	*Oreochromis mossambicus, O. niloticus* and *O. aureus*
Walking catfish	*Clarias batrachus*
Wallago catfish	*Wallago attu*

Acknowledgments

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The Fisheries Research Development Network (FRDN) is a multisectoral research network under the supervision of the Department of Fisheries (Research & Development Division) of the Myanmar Ministry of Agriculture, Livestock and Irrigation. The FRDN aims to strengthen the research and development capacity of Myanmar's fishery sector.

WorldFish is an international non-profit research organisation that harnesses the potential of fisheries and aquaculture to reduce hunger and poverty. WorldFish is a member of CGIAR, a global research partnership for a food-secure future.

Partners

CGIAR Research Programme (CRP) FISH

Department of Fisheries, Myanmar

Fisheries Research Development Network

Chapter 1

Background

Myanmar supports a highly productive fisheries sector, which is vital for national food security, income generation and export revenue. Inland fishery resources and aquaculture make an important and expanding contribution to the sector. However, there is a lack of comprehensive and reliable information on Myanmar's fisheries.

This book reviews the current state of knowledge of inland capture fisheries and aquaculture in Myanmar, using data from the past decade. The book aims to highlight challenges and opportunities in Myanmar's fisheries sector, and to contribute to information sharing and capacity building for better management and sustainable use of the country's inland aquatic resources.

The information in this book is predominantly based on a report produced by the MYFish project[1] that reviewed fisheries and aquaculture in the Ayeyarwady Delta (AD) and the Central Dry Zone (CDZ) during 2003–13 (Soe et al. 2015). Other information sources are other MYFish research projects, Fisheries Research Development Network studies, presentations given by national partners and universities at Myanmar fishery symposiums (Lat, Tezzo & Johnstone 2014; MYFish 2013a; Pant et al. 2014), and published literature from the same period, notably Belton et al. (2015). Relevant locally published literature not available in international resource bases was sourced through the Fisheries Information Center.[2]

Country description

Myanmar is home to around 51.5 million people (DoP 2015) belonging to 135 different ethnic groups (MIMU 2016). Two-thirds of the population live in rural areas, and the other third in urban centres, particularly Yangon and Mandalay (MIMU 2016). The proportion of the population living in urban areas increased by about 2.5% annually between 2010 and 2015 (CIA 2016). Myanmar is one of the poorest countries in Asia: in 2010, 37.5% of the population lived below the poverty line, and this proportion was as high as 53.1% in coastal regions (World Bank 2014). In 2016, gross domestic product per capita in Myanmar was US$1,195.50, which is 11.7% of the global average (World Bank 2018). Also in 2016, Myanmar had a Human Development Index value of 0.536, placing it in the low human development category, where it ranked at 148 out of 188 countries and territories (UNDP 2015). Myanmar has the lowest life expectancy, and the second-highest rate of infant and child mortality of countries in the Association of Southeast Asian Nations (ASEAN) (World Bank 2014). Average calorie intake is less than half the World Bank recommendation, and recent studies state that 33–40% of children under the age of 5 are stunted, 25–33% are underweight and 7.9–11% are wasted (LIFT 2013; Thilsted and Bose 2014).

[1] MYFish (Improving research and development of Myanmar's inland and coastal fisheries) was implemented as part of a multidisciplinary research, development and extension program in Myanmar, funded by the Australian Centre for International Agricultural Research, to improve food security and livelihoods for small-scale farmers and fishers in the Ayeyarwady Delta and the Central Dry Zone.

[2] Myanmar's first digital repository for fisheries research, which was initiated in 2015 and is managed by the Department of Fisheries.

Myanmar is the second largest country in South-East Asia, with an area of 676,578 km^2 and a 2,800 km coastline (MIMU 2016). It is bordered by the People's Republic of China, Laos, Thailand, Bangladesh and India. The topography of Myanmar is characterised by central lowlands ringed by steep, rugged highlands, including the Himalayan foothills in the north. This creates seven major topographical regions: the Northern Hills, the Western Hills, the Shan Plateau, the Central Belt, the lower Myanmar Delta, the Rakhine coastal region and the Tanintharyi coastal strip (Oo 2010). These topographical regions encompass eight distinct ecosystem types: forest, mountain, dry and subhumid, estuarine mangrove, inland freshwater, grassland, marine and coastal, and small island. The country is rich in natural resources, including arable land, forests, minerals, natural gas, and freshwater and marine resources (MECF 2011; Oo 2010).

Three distinct seasons characterise Myanmar's climate: cool (November–February), hot (March–May) and rainy (June–October). The rainy season is driven by the south-west monsoon, which is first felt in the south, starting in May, and then in the rest of the country by the beginning of June (Baroang 2013). Coastal regions experience the greatest rainfall (Figure 1), and the central regions are the driest and hottest, with temperatures reaching highs of above 43 °C (Baroang 2013).

It is estimated that Myanmar contains an area of 8.1–8.2 million ha of fresh water, most of which is associated with major rivers, estuaries and lakes (FAO and NACA 2003). The topography of the country, coupled with the flood pulse system, means that, although a significant volume of water passes through the country, access to water is highly variable temporally and spatially (Baroang 2013). Of Myanmar's freshwater resources, 1.2–1.3 million ha are located in permanent wetlands, and the remaining almost 7 million ha are seasonal flood plains (FAO & NACA 2003; Soe 2008), with 80% of river flow occurring during the monsoon (FAO 2011). Myanmar's flood plains are believed to have diminished in recent years as a result of construction of dams and other infrastructure (Aye, Ko & Siriraksophon 2006).

The three major river systems of Myanmar are the Ayeyarwady (Irrawaddy), Salween (Thanlwin) and Sittaung rivers (Figure 2):

- The Ayeyarwady River is 2,150 km long, with a catchment of 413,000 km^2 and an average discharge of 13,000 m^3/s. The discharge of the Ayeyarwady is close to that of the Mekong; the Mekong River is almost double the length of the Ayeyarwady River and has almost double the catchment area. The 1,200 km long Chindwin River is a tributary of the Ayeyarwady.
- The Salween River is 2,800 km long, with a catchment of 158,000 km^2 and average discharge of 4,500 m^3/s.
- The Sittaung River is only 420 km long, with a catchment of 34,400 km^2 and average discharge of 1,500 m^3/s.

Figure 1. Myanmar's rainfall

Source: FAO (2009)

Figure 2. River network in Myanmar

Source: Myanmar Information Management Unit

Other smaller river systems in Myanmar include those in Rakhine State (catchment 58,300 km^2) and Tanintharyi Division (catchment 49,600 km^2), a section of the Mekong River (catchment 26,600 km^2), the Bilin River (catchment 8,400 km^2) and the Bago River (catchment 5,300 km^2) (ADB 2013). Of the 99 wetland sites listed in Myanmar, 85 are located alongside the Ayeyarwady and Chindwin rivers (Figure 3). The Salween and Sittaung basins contain six and five wetland sites, respectively, and the remaining three wetlands are in the Rakhine coastal region (MECF 2011).

Myanmar's large, slow-flowing lowland rivers support a number of important wildlife habitats, including deep pools; sandbanks; sandbars; oxbow lakes; alluvial grasslands; braided, fast-flowing sections with emergent vegetation; and large freshwater lakes (MECF 2011). Oo (2010) refers to three large lakes in Myanmar: Inle Lake in Shan State (15,500 ha), Indawgyi Lake in Kachin State (12,000 ha) and Indaw Lake in Sagaing Division (2,850 ha). However, rapid geospatial analysis suggests that Myanmar's largest lake is Moebyel Lake (also referred to as Pekon Lake), in Shan State to the south of Inle Lake. The diversity of freshwater ecosystems in Myanmar, some of which have been largely lost in other parts of South-East Asia, support a high level of freshwater biodiversity, particularly of finfish (MECF 2011; Oo 2010).

Focus regions

A large proportion of research on natural resources and livelihoods, including that relating to fisheries, has been carried out in the country's two most densely populated regions: the AD and the CDZ (Figure 4). Thus, these two regions are also a focus of this book.

Ayeyarwady Delta

The AD covers approximately 3.2% (22,000 km^2) of Myanmar and boasts the country's highest land productivity. The moderately high rainfall of up to 5,000 mm annually (Baroang 2013) and flat topography are well suited to agriculture (ADB 2013), and abundant water resources support productive fisheries (Baroang 2013). However, roughly two-thirds of households in the AD are landless (LIFT 2015) and, despite the AD's rich agricultural resources, poverty rates (40.4%) are slightly higher than the national average (World Bank 2014). Chronic poverty affects 30% of the AD population, and 80% of fishing households are poor and vulnerable to shocks (MMRD 2014).

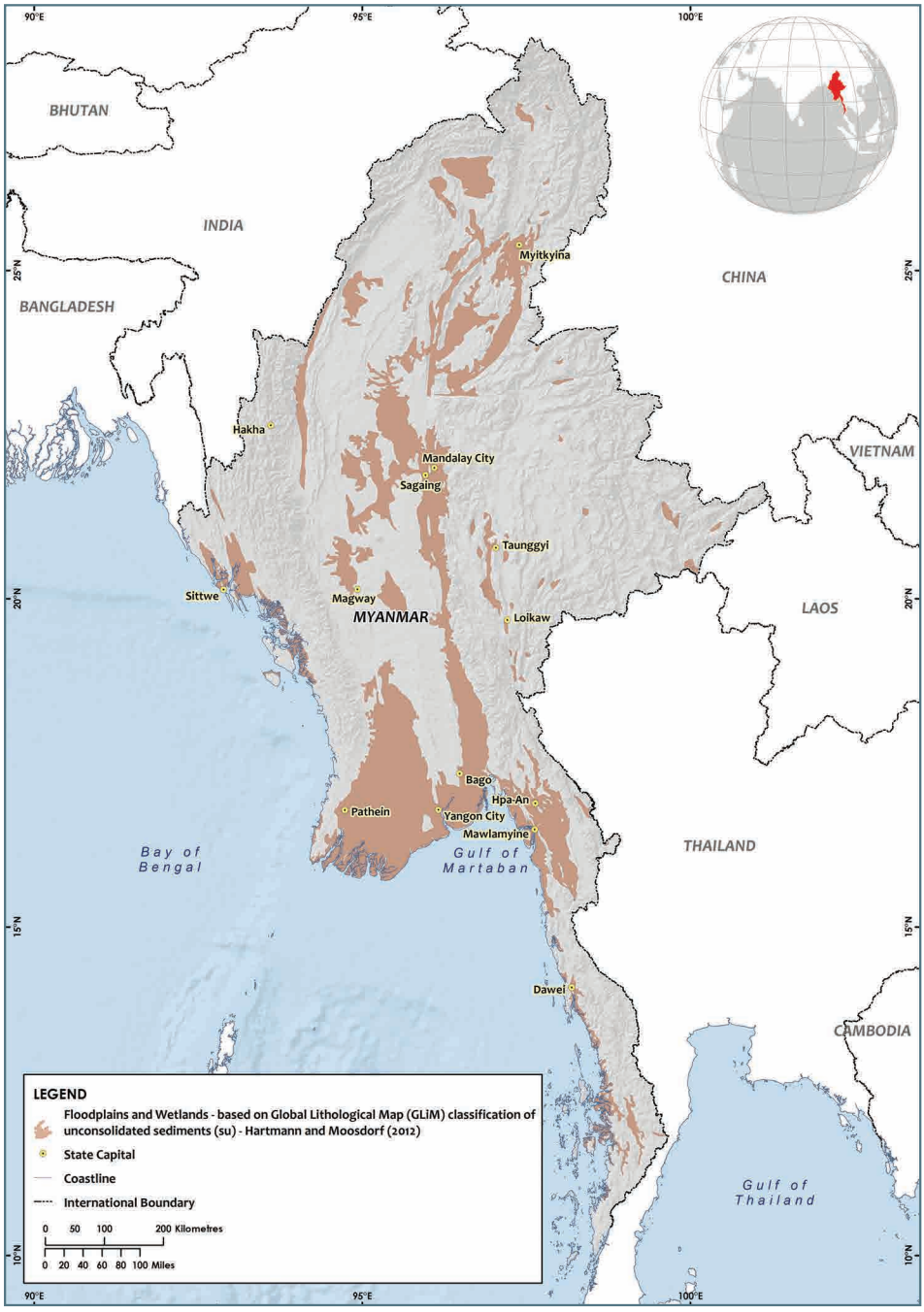

Figure 3. Flood plains and wetlands in Myanmar, derived from a geological map of unconsolidated sediments

Source: Jason Benedict, WorldFish. Data: Global lithology map, Institut für Geologie, Hamburg University, Germany

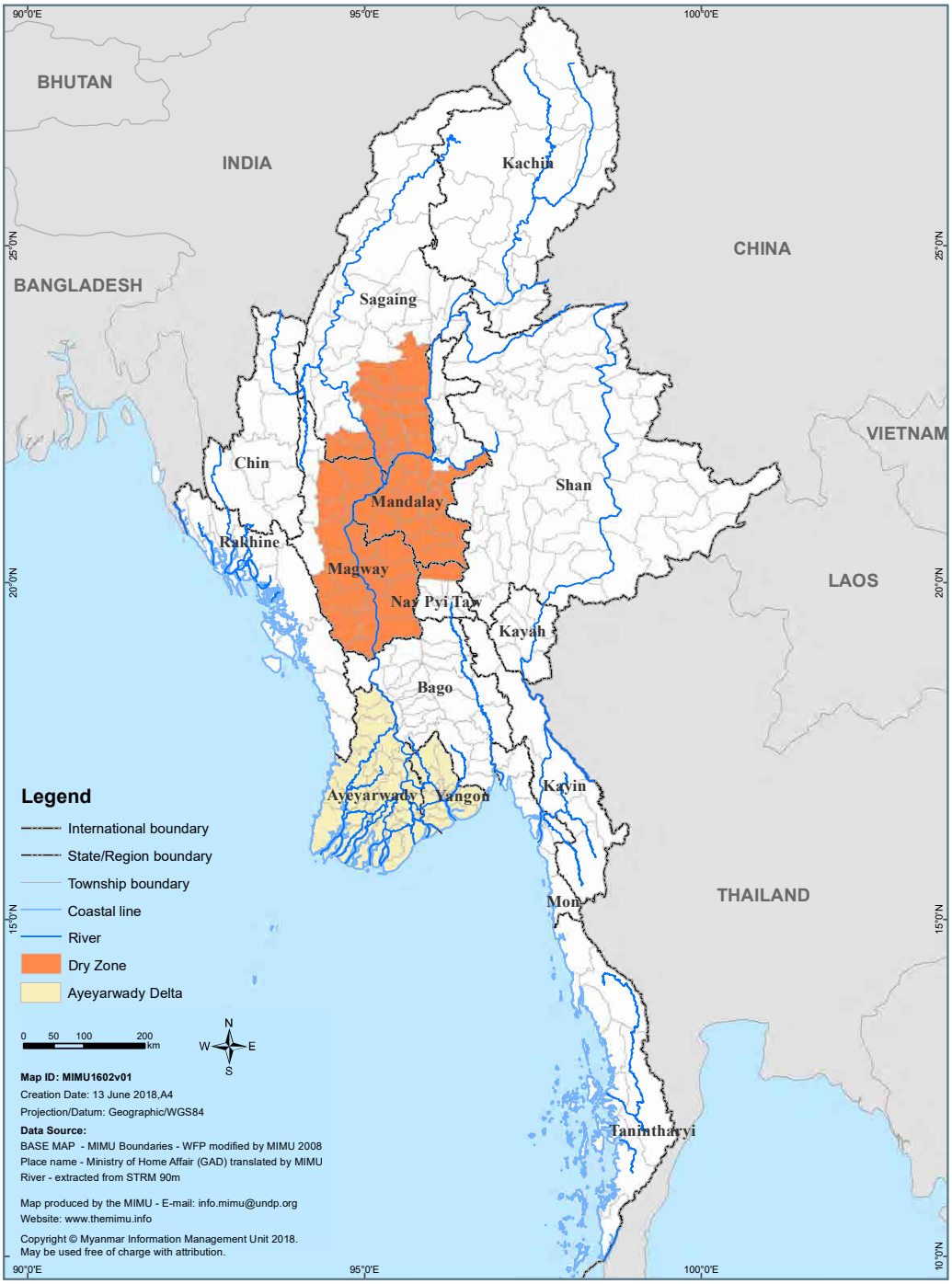

Figure 4. Ayeyarwady Delta and Central Dry Zone regions of Myanmar
Source: Myanmar Information Management Unit

The region contains two deep rivers—the Pathein[3] (6–14 m deep) and the Ayeyarwady (5–24 m deep)—and a number of other shallow rivers (2–3 m deep). Three main ecological zones can be identified in the AD in relation to elevation, distance to the sea and salinity (Figures 5–7):

- *Floodplain zone*—characterised by fresh water or very low salinity and the presence of freshwater fish species.
- *Estuarine zone*—characterised by multiple waterways and degraded mangroves in a patchwork of rice fields, trees and villages. Waterways are temporary and brackish, and typically contain estuarine species.
- *Coastal front*—a part of the coastal zone including the Ayeyarwady plume; it is characterised by flat land, quasi-permanent brackish water, salty soils and almost no vegetation except very degraded mangroves. Fishing activities target the coastal and marine resources.

[3] The Pathein River is also called the Nagwun River.

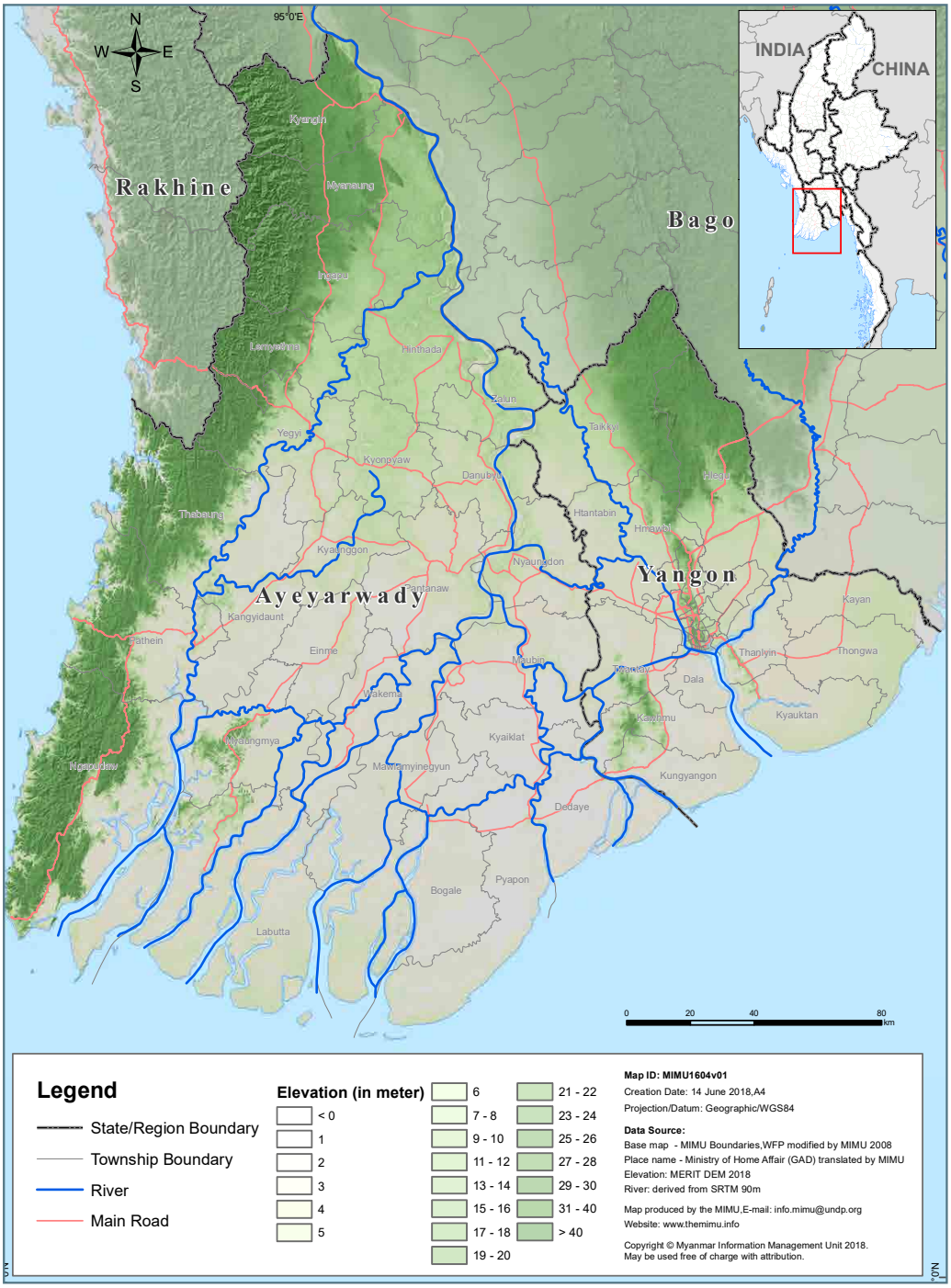

Figure 5. Ayeyarwady Delta region of Myanmar

Source: Myanmar Information Management Unit

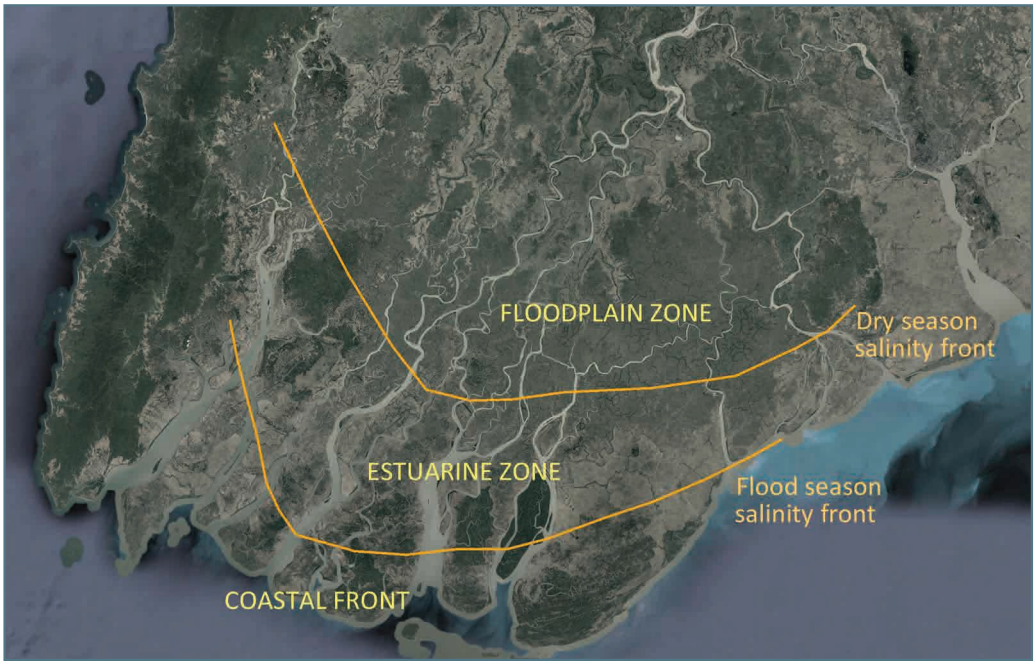

Figure 6. Salinity zones in the Ayeyarwady Delta
Source: Johnstone et al. (2012)

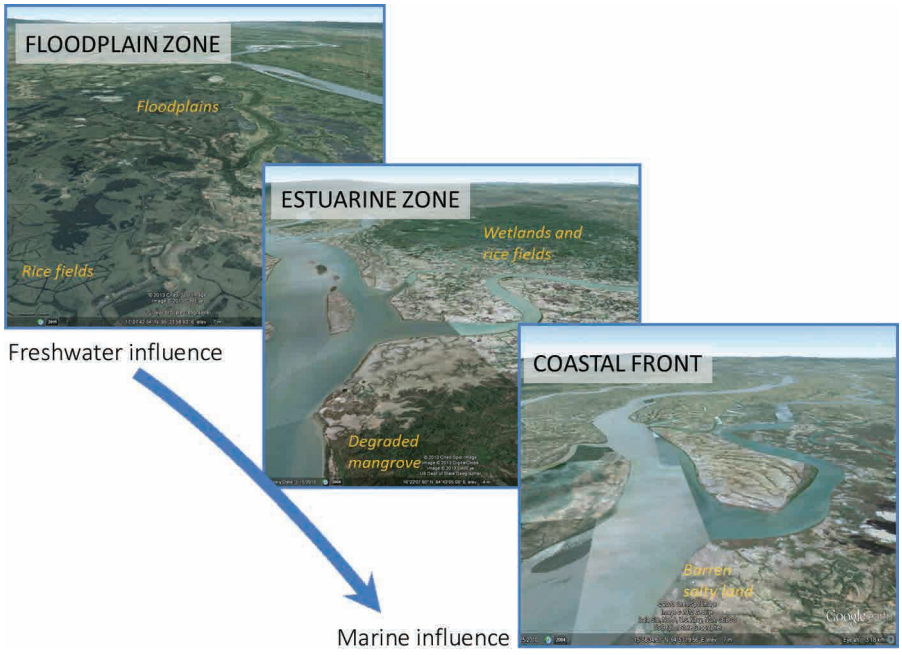

Figure 7. Google Earth view of the main landscape forms in the Ayeyarwady Delta
Source: Adapted from Johnstone et al. (2012)

Central Dry Zone

The CDZ encompasses 13% (88,500 km^2) of Myanmar's land area, and covers large parts of the Magway, Mandalay and lower Sagaing divisions in the central plains of Myanmar (Poe 2011). The region is bordered by a mountainous zone to the west and highlands to the east. The CDZ is home to 34% of the population (McCartney et al. 2013) and has the lowest rate of poverty (29.5%) in the country (World Bank 2014). However, livelihoods in the CDZ, including agriculture and fisheries, face the constant threat of drought due to irregular and scarce rainfall. The CDZ receives only 600 mm of rainfall per year (Baroang 2013), and rainfall has shown a downward trend in past decades (Poe 2011). The El Niño – Southern Oscillation is believed to contribute to the interannual variability, and frequent incidences of below-average rainfall and drier-than-normal conditions from July to September (Baroang 2013).

Seasonal water availability is reflected in the flows of the region's rivers. Most flow occurs during the wet season, and many rivers dry up during the hot season (McCartney et al. 2013). The Ayeyarwady River and its tributaries constitute the main river system of the CDZ, flowing from the north-east to the south of the region. Figure 8 illustrates the river systems of the CDZ.

Across the CDZ, vegetation cover is sparse, and the soil is characterised by severe erosion and low fertility. The region also experiences salinity due to saline subsoils, high evapotranspiration rates and restricted outward drainage of groundwater (ACIAR 2014). Deforestation may have compounded this problem.

In the CDZ, rohu and mrigal account for the greatest proportion of aquaculture production; other common species include other Indian carps and Chinese carps, Nile tilapia and wild fishes. More than half of fish farmers in the CDZ practise polyculture, with species combinations determined by seed availability (MYFish, in press).

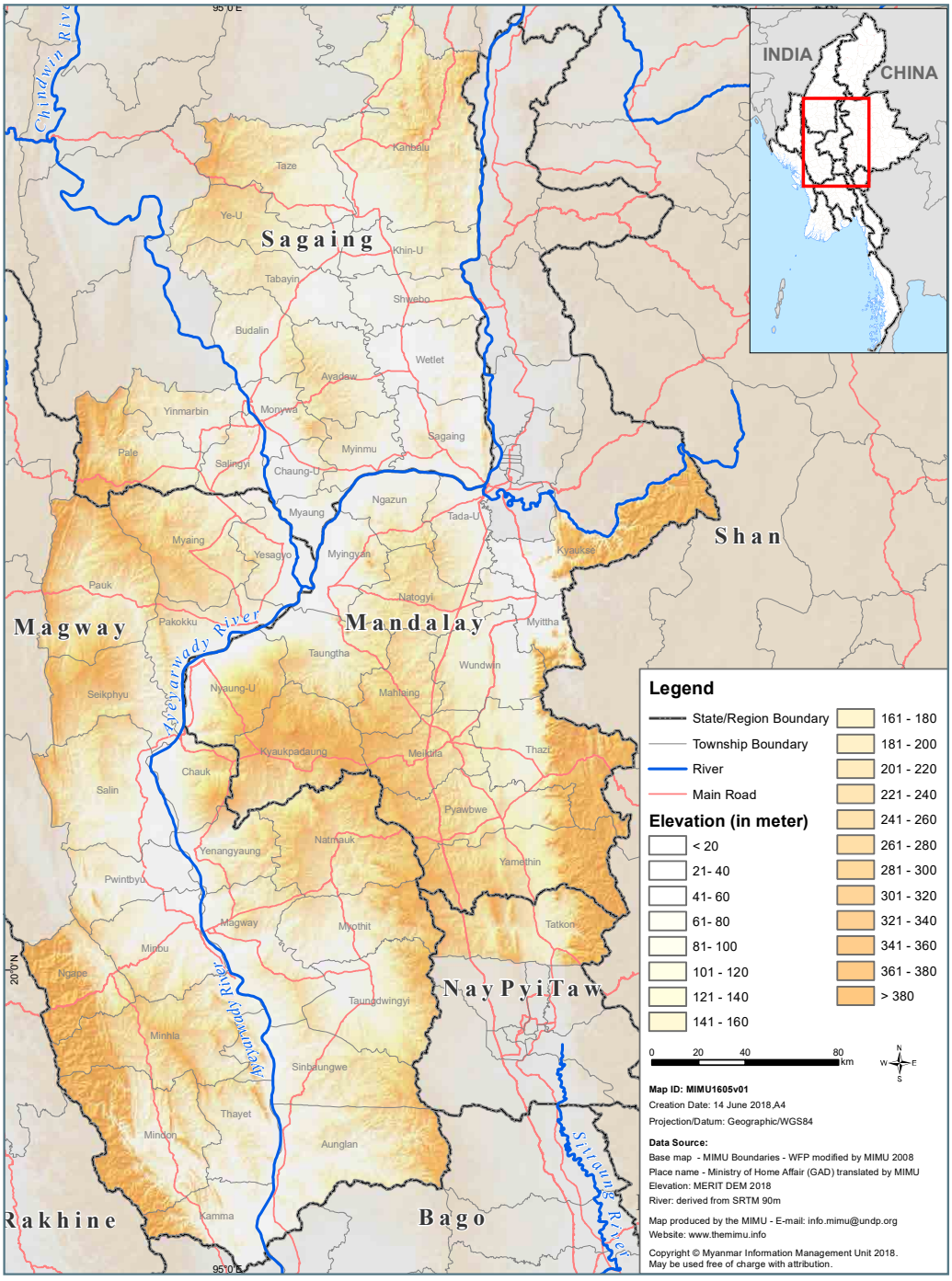

Figure 8. Central Dry Zone region of Myanmar

Source: Myanmar Information Management Unit

Inland fishery systems

Most freshwater fishing[4] in Myanmar takes place in the country's river systems, and associated streams and flood plains. There is also some evidence of fishing activities in reservoirs, although this is currently limited by legislation (see 'Reservoirs and fisheries' in Chapter 5). Freshwater fishing is technically possible year-round (Figure 9) but yields are higher in June–September during the rainy season when fish are abundant, spawning occurs and yearling fish have grown to full size (Figure 10).

A variety of fishing gear is used in Myanmar (Figure 11). Aye, Ko and Siriraksophon (2006) have broadly classified the gear as:

- gillnets—drift gillnets, set gillnets and trammel nets
- hook and line—longline, hand line, and pole and line
- traps—fish traps, bamboo stake filter traps, stow nets and drop-door traps
- surrounding nets—small, large and net fences
- cast nets—small and large
- lift nets—portable lift nets, stick-held dip nets and Chinese dip nets
- push nets—with or without bags
- others—Inle baskets, eel clamps, plunge baskets or cover pots (with or without tamarind wood sacred line), bush bundle baskets, small bag nets, beam trawls, multipronged burble spears (a rod with grouped spikes at the end) to capture large fish and seven-barbed spears to capture dolphins.

The various gears have been adapted for different types of fishing grounds. For example, stow nets are suitable for main rivers and river channels, whereas filter traps are more adapted for seasonal wetlands (Wah et al. 2016). Larger gears, such as bamboo stake filter traps and bag nets, are used in the most productive areas—typically leaseholds and tender lots. Smaller gears, such as small gillnets and fish traps, are typically used in open fishing areas and individually licensed by the Department of Fisheries (DoF); in the AD, new legislation permits the use of these gears for free. According to Oo (2010), non-motorised, traditional wooden crafts are often used for fishing in artisanal open-water fisheries.

[4] The terms 'inland fisheries' and 'freshwater fisheries' are used interchangeably in this book.

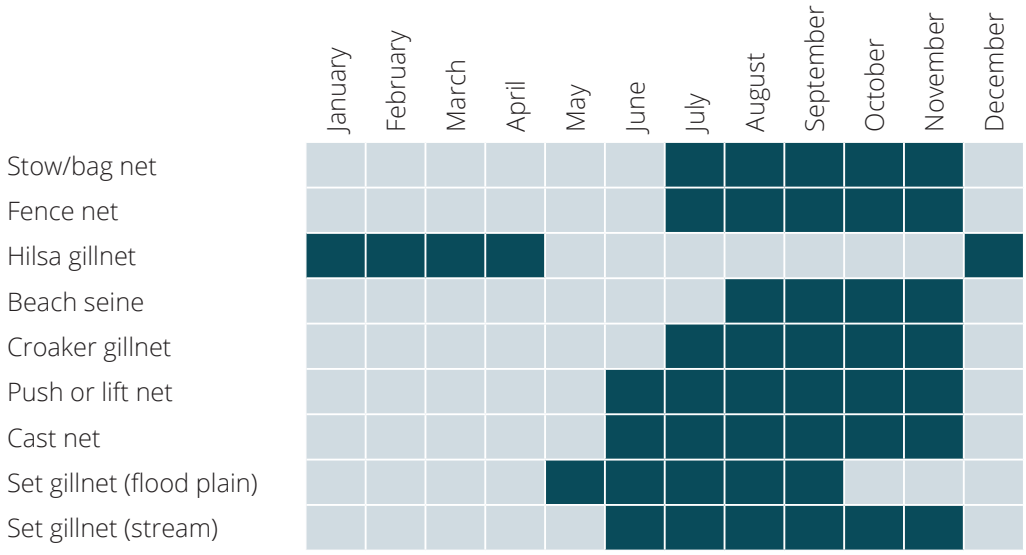

Figure 9. Monthly use of fishing nets. Dark shading indicates usage. The general closed season is May, June and July.

Source: Duan (2008)

One of the most important commercial and subsistence fisheries in Myanmar is the hilsa fishery. Hilsa is a major migratory fishery resource in the Gulf of Bengal, and stocks are shared between multiple countries (Baran et al. 2015). Hilsa migrate upstream through Myanmar's river systems to breeding sites, and are found in particularly high abundance near river mouths and in larger estuaries (Baran et al. 2015). In the AD, almost all fishers target hilsa; commercial fishers use boats to fish in the rivers and coastal waters (roughly one-third of commercial hilsa fishers are migrant fishers), while subsistence fishers use bag nets and blockage techniques from the river banks to harvest hilsa, along with other small fish and shrimp (MMRD 2015).

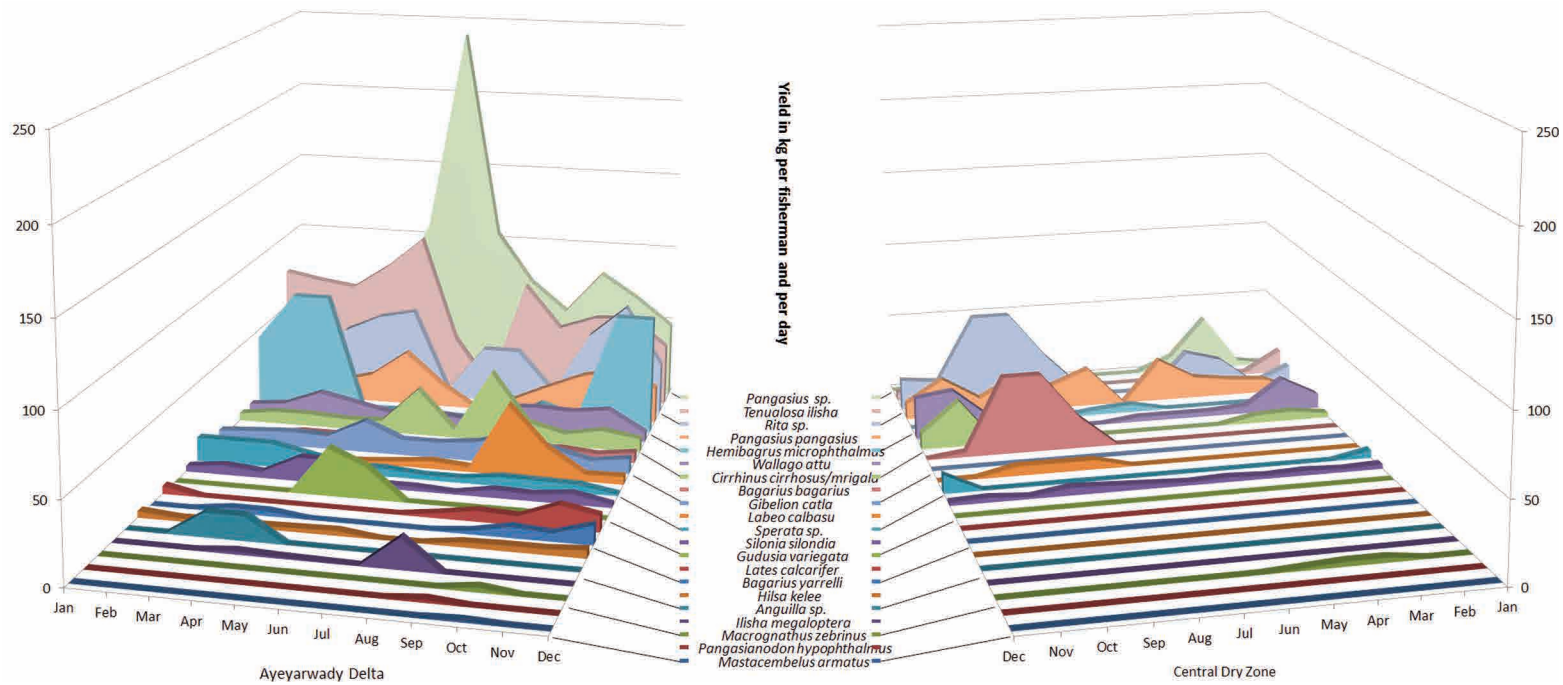

Figure 10. Monthly catches of various species in the Ayeyarwady Delta and the Central Dry Zone
Source: Baran et al. (2017)

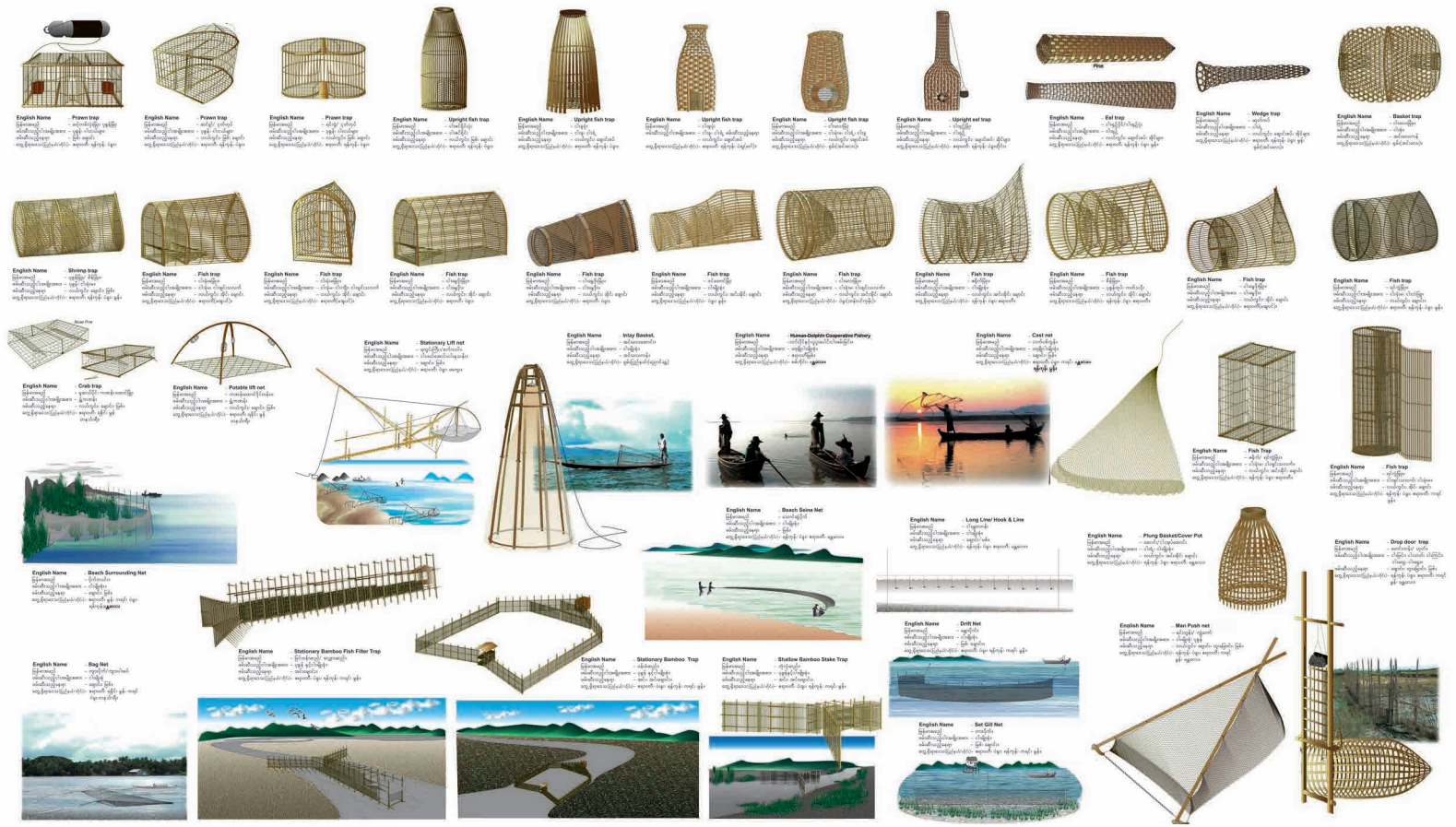

Figure 11. Inland fishing gear of Myanmar

Source: U Ko, Department of Fisheries

Aquaculture systems

Freshwater systems account for a large majority of aquaculture production in Myanmar (Belton et al. 2015), most of which (90%) takes place in the AD. Roughly half of the 90,000 ha dedicated to freshwater fish farming is located in the AD (Gregory 2013; LEI Wageningen UR 2012; MYFish 2013a). Commercial aquaculture, in particular, is concentrated within 50 km of Yangon to benefit from trade and transport infrastructure (Belton et al. 2015). Rohu carp is estimated to account for 70% of all farmed fish in Myanmar (Belton et al. 2015); multiple studies express concern about the dominance of, and potential overdependence on, rohu (Belton et al. 2015; DoF 2011a; FAO & NACA 2003; SEAFDEC 2012).

In 2004, it was reported that most aquaculture ponds were medium to large sized (UNDP 2004), but a later study (Belton et al. 2015) drew a more complex picture of a 'dualistic' sector. Using satellite images, the study found that large to very large farms (including several vertically integrated companies) account for well over half the total pond area, but that small and medium-sized commercial farms are more numerous than had been previously thought—more than 200,000 small backyard ponds were identified in the southern AD (Belton et al. 2015). These homestead ponds were originally dug for domestic water supply but are increasingly used for growing fish, mostly for family consumption (Belton et al. 2015).

In the CDZ, most aquaculture is found in the better-irrigated lowlands, particularly in the northern part of the region around Mandalay and Shwebo. In the Magway Region, reduced water availability necessitates a short production cycle, and cultured fish are therefore mostly fast-growing carp species such as rohu, mrigal, catla and bighead (Johnstone et al. 2013).

Trap ponds are used in both capture and culture fisheries in Myanmar. A study in the Bago Region suggests that trap ponds are widespread. Monsoon flooding supplies wild fish to paddy fields and ponds originally intended for household drinking water (Oo and McKay 2018). These fish then become trapped as the floodwaters recede, and fishers actively manage the fish, typically feeding them with rice bran, and sometimes even retaining broodstock for the following year (Oo & McKay 2018). Trap pond management practices appear to be quite similar between villages as a result of knowledge sharing (Oo & McKay 2018).

Biodiversity

The freshwater fish fauna of Myanmar is among the least known in South-East Asia; sources provide different and sometimes contradictory figures. A FishBase query (www.fishbase.org) in April 2018 showed that 511 freshwater fish species have been scientifically documented as being present in Myanmar, of which 439 were native, 58 were endemic and 14 were introduced; the presence of another 13 species was uncertain. Alternatively, the 2017 'State of the Ayeyarwady Basin assessment' (Zöckler & Kottelat 2017) suggests that:

- the Ayeyarwady Basin alone is home to 388 fish species, of which 311 are found in Myanmar
- 193 of the 388 species are endemic to the basin
- 100 of the species are only known to exist in Myanmar.

These records suggest that endemism in Myanmar is higher than in neighbouring countries; 22 endemic species have been reported in Thailand, 2 in Laos, 1 in Bangladesh and none in Cambodia or Vietnam. Fish endemism in Myanmar is believed to be particularly high in forested streams and rivers in the upper catchments of the country (MECF 2011), and in inland natural lakes (Oo 2010; Vidthayanon, Termvidchakorn & Pe 2005).

Large and migratory species of commercial significance—such as catfishes (wallago and several *Pangasius* species) that have become rare in most tropical rivers, including the Mekong—are still considered common in Myanmar (Johnstone et al. 2013). Research undertaken by the Bay of Bengal Large Marine Ecosystem project, WorldFish and DoF used local ecological knowledge to assess catches, and identify migration patterns and breeding sites for a number of species[5] in the Ayeyarwady, Chindwin, Pathein and Toe rivers in the AD and the CDZ (Baran et al. 2015; Ko et al. 2016). The study rated the ecological importance of different areas according to the number of species breeding, the area of the breeding ground and the commercial importance of the breeding species. Of the 42 breeding sites identified, 10 were used by multiple species and/or constituted the main breeding site of one or several species. Hinthada township was rated as the most ecologically important site; it had large spawning sites for nine species, most of which were commercially important, including the largest breeding site for hilsa.

The largest fish species in Myanmar is the giant pangas catfish, which has a maximum recorded length of 3 m and weight of 248 kg. The smallest species is the rice field fish, which is only 1.6 cm long. The longest-living fish in the system is the Salween rita, which has been recorded as living for 58 years (FAO 2014).

[5] Catla, mrigal, kelee shad, bigeye ilisha, orangefin labeo, barramundi, shark catfish, pangas catfish, bagrid catfish, silond catfish and wallago catfish

Chapter 2

Role of fisheries and aquaculture

Livelihoods

The fisheries sector plays a vital role in the culture and socioeconomic life of Myanmar (ADB 2013; Oo 2002). It is considered the second major contributor, after agriculture, to income generation, employment creation and livelihoods (DoF 2015; Schmidt & Soe 2014). Per acre, fish farming generates about twice as much employment as paddy farming (Belton et al. 2015). According to national statistics employment data for the period 2008–14, fisheries and aquaculture provided full-time employment for more than 800,000 people and part-time employment for a further 2.4 million (DoF 2015) (Figure 12). During that period, roughly three times more people worked in fisheries part-time than full-time,[6] and inland fisheries provided slightly more full-time and part-time jobs (1.6 million) than marine fisheries (1.4 million). However, these figures are likely to be significant underestimates because occupation statistics do not account for households that engage in fishing as a subsistence activity; a study in Cambodia revealed that 58% of households that engaged in fishing activities did not report fishing as an occupation (Nasielski et al. 2016). The fisheries sector is estimated to provide income for 12–15 million people in Myanmar (McCartney & Khaing 2014). A baseline survey found that fisheries, through casual labour and the sale of fish, was the most important source of income for 25% of landless households in Myanmar (LIFT 2012).

Reliance on capture fisheries and aquaculture for livelihoods varies between agroecological zones in Myanmar. A baseline study (LIFT 2012) revealed that, in delta and coastal areas, casual fisheries labour had been a source of income for 41% of households and the most important source of income for 19% of households during the previous 12 months. Selling fish products was the most important source of income for 12% of households. In dry areas, 1% of households had engaged in casual fisheries labour, and 0.8% had sold fish products in the previous 12 months; these activities were considered the most important source of income by only 0.4% of households. A household survey in 2013 found that 23.5% of AD households regarded the sale of fresh wild fish, prawns, crabs and shellfish to be one of their five main sources of income, and 54% considered the fisheries sector, including direct and wage labour, as an important source of income (LIFT 2013). Some AD households and communities depend almost exclusively on fisheries for income; a survey of hilsa fishers found that the average proportion of household income from hilsa catch was 77% in freshwater areas and 97% in brackish and saline areas (MMRD 2015).

[6] Department of Fisheries statistics distinguish between full-time, part-time, occasional and unspecified employment; here, we group occasional and unspecified under part-time.

Figure 12. Number of people involved in aquaculture and capture fisheries (2008–14 average)

Source: DoF (2015)

Employment of women

In 2014, Myanmar was ranked 85 out of 155 countries for gender equality, with a Gender Inequality Index value of 0.413, which is slightly above the average for countries in east Asia and the Pacific (UNDP 2015). An increasing proportion of Myanmar women contribute to household income through economic activity of their own (Friedrich-Ebert-Stiftung Foundation 2009), but women are generally relegated to the lower ranks of workers in both the formal and the informal sectors. They also usually work longer hours and have less leisure time than men. Fishing and aquaculture are male-dominated activities, but women are also active in the sector, mainly in post-harvest activities. Women are key actors in Myanmar's fishery value chains through their dominant role in marketing fish (FAO & NACA 2003; Friedrich-Ebert-Stiftung Foundation 2009) and processing fish (Johnstone et al. 2012; Schmidt & Soe 2014; WorldFish et al. 2014). There is evidence that women engage in some harvesting activities—for instance, a number of small-scale fishers around Inle Lake are women. Venkatesh (2015) reported that women were active fishers in the Gulf of Mottama, particularly in inland water bodies, where they fish with their husbands, other women or alone, from boats or by wading in the shallows. Women are also involved in routine seeding and feeding operations of small-scale aquaculture ponds and hatcheries (FAO & NACA 2003).

However, the profile of women throughout fishery value chains is limited by structural inequalities and social norms. More gender-disaggregated data are needed to assess the constraints and opportunities faced by women in small-scale fisheries (Aregu et al. 2017).

Food

The national diet of Myanmar is based on rice and fish (WorldFish et al. 2014). Fish accounts for 60% of animal protein consumed (Wilson and Wai 2013) and 90% of animal protein available in local markets (FAO & NACA 2003). In 2010, approximately 14% of monthly household food expenditure was on fish and fish products, second only to the 19% spent on rice (Belton et al. 2015). High fish consumption reflects the relative affordability of fish—the price of fresh fish is on average 35% lower than the price of other meat (Belton et al. 2015).

Subsistence fishing makes an important contribution to diets and nutrition in rural Myanmar. A survey of 150 households from six villages in Labutta and Bogalay townships in the AD showed that 54% of fishing households consumed half their catches and 13.5% consumed their entire catch (MMRD 2014). In lowland areas of the CDZ, most families collect aquatic products on a seasonal basis to complete their daily nutritional intake (Johnstone et al. 2013). As emphasised by Belton et al. (2015), 'ensuring adequate availability of and access to fish supplies is critical to ensuring food and nutrition security' in Myanmar. However, rising prices of seafood are threatening the availability of traditional fishery resources for local consumption. For example, mud crab, which used to be an important part of the diet of coastal communities, has become so valuable that almost every crab captured is now exported (Marius 2013).

Myanmar people prefer to consume freshwater species, even in coastal areas (DoF 2011a; Oo 2002; Thilsted & Bose 2014). The main inland fish species consumed are shown in Table 1. Processed fish, including dried and fermented fish, is a staple component of the daily diet of most people (Oo 2010) and accounts for 34% of fish consumed (Belton et al. 2015). Processed fish is particularly important in the dry season when availability of fresh fish is limited (Thilsted & Bose 2014).

Table 1. Main inland fish species consumed in Myanmar

Fish size	English name	Local name
Small	Climbing perch	Nga pyaema
	Mola carplet	Nga bae phyu
	Pool barb	Nga khone ma mee ni
	Spotted snakehead	Nga pa naw
	Striped dwarf catfish	Nga zin yine
Medium	Bronze featherback	Nga phae khone
	Walking catfish	Nga khu
	Stinging catfish	Nga gyee
	Striped snakehead	Nga yant kar
	Tilapia	Tilapia
Large	Rohu	Ng myit chin

Source: Thilsted & Bose (2014)

At the regional and national scales, rates and patterns of household fish consumption are poorly documented (WorldFish et al. 2014), and various figures can be found in the literature. The Ministry of Planning and Economic Development quoted fish consumption as 15.1 kg per person per year based on a 2001 household survey (Soe 2008), whereas the Ministry of Livestock and Fisheries reported consumption of fish as 28.5 kg per person in 2001–02 (Burgos, Otte & Roland-Holst 2009). Oo (2010) and SEAFDEC (2012) both reported fish consumption to be roughly 43 kg per person per year in 2008–09. Calculating annual fish production less exports divided by the population, the Food and Agriculture Organization of the United Nations (FAO) estimated annual fish consumption to be 22.7 kg per person; this figure could be closer to 26–34 kg if likely unreported fishing is accounted for (FAO & NACA 2003). However, a similar calculation by DoF of fish landings minus non-food use and exports, divided by the population, estimated fish consumption as 61 kg per person per year (DoF 2015).

Analysis of national household consumption surveys suggests that households consume an average of 21.1 kg of fish products per year, which equates to 46.5 kg of fresh fish once the volume of fresh fish used in processed fish products is accounted for (Needham & Funge-Smith 2014). This study also found that average annual household consumption of fish products varied between states, ranging from 6.4 kg in Northern Shan State to 67.7 kg in Kayin State, and that the most commonly consumed fish were mrigal, striped snakehead and rohu (Needham & Funge-Smith 2014). Using data collected in the Integrated Household Living Conditions Assessment conducted in 2010 by the Ministry of National Planning and Economic Development and the United Nations Development Programme, Belton et al. (2015) provided a conservative estimate of average annual fish consumption in Myanmar as 18.9 kg per person, ranging from 8.5 kg in eastern Myanmar to 19.4–25.1 kg in southern Myanmar. Regional variation in fish consumption was also documented in a survey that found that 83% of coastal and AD households had consumed fish and/or seafood the previous day, compared with only 27% in the CDZ (LIFT 2013).

Chapter 3

Economy, value chains, export and trade

Value chains

Myanmar has five main freshwater fish supply chains:

- rural fresh fish
- processed fish
- urban fresh fish
- export
- animal feed.

The latter two are relatively data-poor, and account for only a small proportion of production.

The *rural fresh fish supply chain* is typically served by capture fisheries (Belton et al. 2015) and includes subsistence fishing. This value chain usually involves small catch volumes and low profit margins, but plays a crucial role in the food security of the poorest consumers and fishing communities.

The *processed fish supply chain* is essential for the food security of upland areas in Myanmar where processed fish (mainly dried fish, fish paste and fish sauce) is often the only source of fish. Most of the processing is from marine catch, but there is evidence of processing of freshwater fish at a smaller scale.

The *urban fresh fish supply chain* is a relatively new but fast-growing chain driven by traders who have the financial resources, infrastructure and market information to play a direct role in transactions beyond the local level. This value chain is increasingly dominated by aquaculture production. A large proportion of supply passes through wholesale fish markets in Yangon (San Pya and Shwe Padauk) before being redistributed through local wet markets. Because of the catches it handles and the income it generates, Venkatesh (2015) considers the urban fresh fish market to have the highest potential for small-scale fishers.

Gross domestic product

National economics statistics in Myanmar combine the fishery and agriculture sectors, which are reported to have accounted for around 7.5% of gross domestic product (GDP) between 2005 and 2011. The contribution of fisheries and agriculture to GDP has remained fairly constant over the past two decades, ranging from 7.2% in 1990 to 8.2% in 2000, despite the apparent fivefold increase in fish catch between 1998 and 2015.

According to the Fisheries Global Information System of the FAO (FAO 2016), which depends primarily on national statistics, the value of aquaculture in Myanmar fluctuated between 2000 and 2007, and then increased steadily to around US$1.6 billion in 2014 (Figure 13). The value of aquaculture production in 2014 equates to an average of US$1,690 per tonne (t); however, this is greater than the average value of export-quality fishery products.[7]

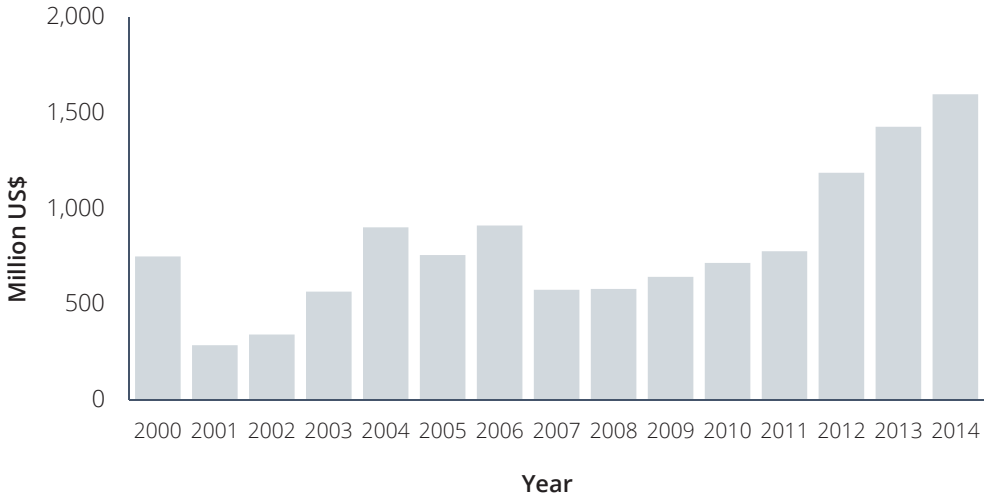

Figure 13. Annual value of inland aquaculture in Myanmar, 2000–14
Source: FAO (2016)

Exports

National statistics report that, in 2016, Myanmar exported 0.439 million t of fish and fish products, which was 8% of total fisheries production (DoF 2017). According to official figures, export volumes grew steadily between 2004 and 2012, the exception being a drop in 2008 due to the impacts of Cyclone Nargis. From 2012 to 2015, fishery export volumes declined by an average of 4% annually (Figure 14).

Export values followed a similar but more pronounced trend to export volumes. In 2016, the value of all fishery sector exports was reported as US$606 million (Figure 15).

Inland fisheries accounted for 1–3% of the value and volume of total reported fishery sector exports between 2009 and 2012 (DoF 2011b, 2013). A number of freshwater fish species are classified as 'other aquatic products',[8] including some high-value species such as eels, dried gourami, freshwater prawns and ornamental fish species. In 2010–11, exports of the 'other' category totalled 85,000 t and US$171 million.

[7] According to DoF statistics, exported aquatic products in 2014 were valued at US$1,400 per tonne (DoF 2015).

[8] National statistics describe fishery sector exports according to the three main categories of fish, prawns/shrimps and other aquatic products. Other aquatic products include bycatch (exported as fishmeal), ornamental fishes, by-products (e.g. fish maw, dried trash fish), processed by-products (e.g. prawn shell chitin, fish scales), molluscs, cephalopods and jellyfish.

In their analysis of the aquaculture sector, Belton et al. (2015) found that less than 14% of annual freshwater aquaculture production is exported, indicating that the sector is more oriented towards domestic supply than previously suggested. The study also found that Myanmar has a limited number of trade partners, with 91% of aquaculture exports destined for only five countries: Kuwait (34%), Saudi Arabia (18%), Bangladesh (17%), the United Arab Emirates (12%) and Singapore (9%). The authors suggested that this reflects the limited popularity of Myanmar's main aquaculture species (rohu and major Indian carps); exports to Gulf states are driven by the demand from south Asian expatriate populations (Belton et al. 2015).

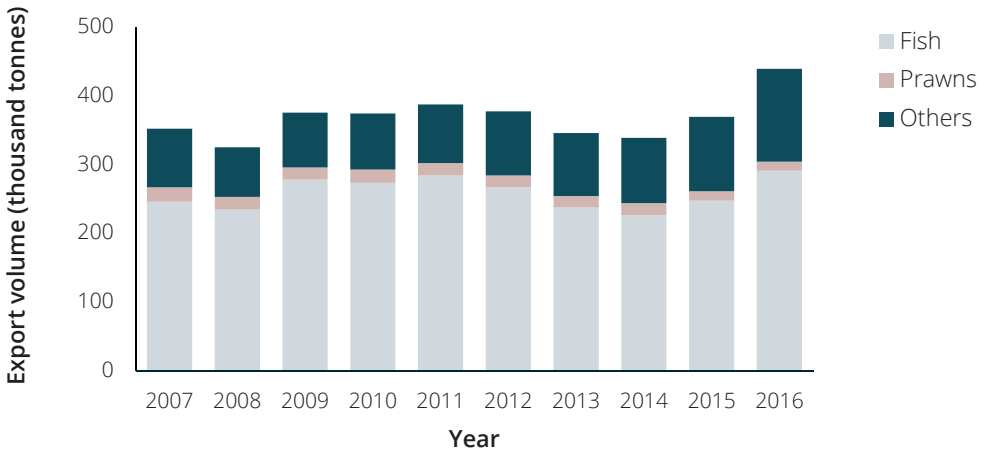

Figure 14. Fishery export volumes, by category, 2007–16

Source: DoF (2017)

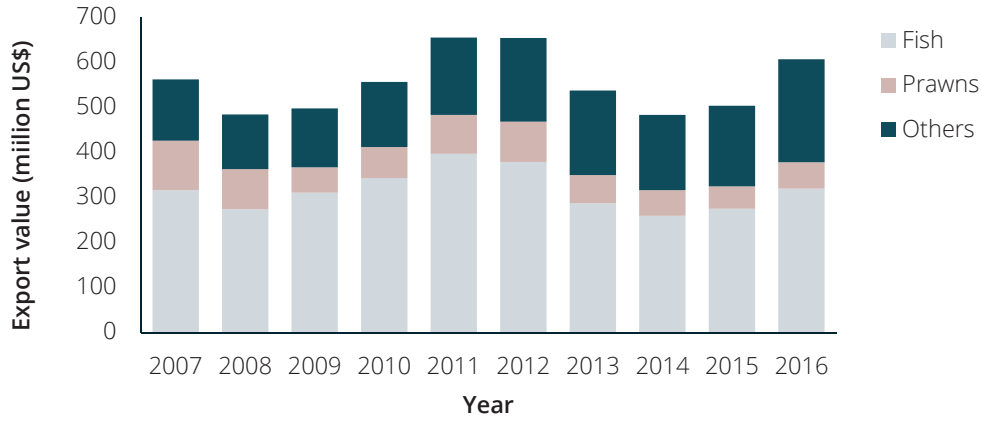

Figure 15. Fishery export values, by category, 2007–16

Source: DoF (2017)

Rohu is the top export species in terms of volume and value (Table 2); 30% of rohu produced is exported (Edwards 2009), making Myanmar the world's largest exporter of rohu (Johnstone et al. 2012).

The majority of large-sized hilsa caught are exported, mostly to India and China. Hilsa is of particularly high commercial value; although prices vary by both season and fish size, hilsa can obtain prices 10 times higher than other species, and fishers can receive as much as 80% of the final retail price for large-sized fish and 50% for small-sized fish (Dagon University 2015). DoF statistics report a 60% drop in hilsa exports between 2011 (17,006 t) and 2015 (6,107 t), which is probably an indication of stock decline (DoF 2011a, 2015).

A large proportion of mud crab exports goes to Singapore and China, including significant quantities transported to China by road (LEI Wageningen UR 2012).

Table 2. Top 10 species of exported fish and crustaceans, and fisheries products

Species	Export volume (t)	Export value (US$ million)	Rank
Rohu	64,017	60.3	1
Live mud crab	16,471	48.9	2
Live swamp eel	7,497	26.1	3
Pink shrimp	10,322	22.9	4
Tiger prawn	4,203	20.3	5
Hilsa	6,107	15.5	6
Ribbon fish	9,265	15.0	7
Soft shell crab	2,835	14.7	8
Fishmeal	21,158	12.8	9
White prawn	2,554	11.5	10

Source: DoF (2015)

Threats to inland fisheries

Climate change

Myanmar is believed to be one of the world's most vulnerable countries to climate change (World Bank 2014) and, excluding small island states, the most vulnerable in the Asia–Pacific region (Kreft, Eckstein & Melchior 2017). There is already evidence of increased climate variability, particularly rainfall, and rising annual temperatures (World Bank 2014). Many studies downscaled to the regional and national levels indicate that Myanmar is projected to experience a mean annual temperature increase of 1–4 °C by the end of the century (Baroang 2013). The continued increase in temperature is expected to be accompanied by more variable rainfall, the possibility of more extreme climate events such as cyclones (Baroang 2013) and a 1–5 m rise in sea level, which is projected to affect 10% of the country (World Bank 2014).

Climate change will have implications for Myanmar's fisheries. Fish habitat, food resources, migration and recruitment patterns, and migration and recruitment success, as well as the distribution of predators and pathogens, will be influenced by:

- higher inland water temperatures, causing a decline in water quality and dissolved oxygen
- changes in rainfall, causing shifts in hydrological cycles
- drought, causing reduced water availability
- rising sea levels, causing changes in salinity.

In the CDZ, fishery resources are already constrained by low water availability in the dry season and low temperatures in the cool season.

In both aquaculture and capture fisheries, the decline and changing distribution of water and fishery resources, and the increasing frequency and severity of extreme weather events are likely to lead to increased competition and conflict, higher costs of resource maintenance and exploitation, and potentially fisher migration (FAO 2010).

The challenges posed by climate change require early decision-making about long-term adaptation strategies to minimise the impacts on livelihoods and food security, particularly of the poorest fishers (FAO 2010; Schmidt & Soe 2014).

Human activities

Human activities will further exacerbate fishery degradation in Myanmar. These include water management schemes for improving navigation, drainage for flood control, construction of hydropower dams, irrigation, and establishment of interbasin connections and water transfer (DoF 2011a). Anthropogenic stressors will affect the abundance and composition of fish stocks targeted by capture fisheries and stocks used to supply wild seed for aquaculture. Stakeholder interviews suggest that fishery degradation caused by human activities is already occurring—stakeholders in the CDZ unanimously reported declining abundance in commercially important species, which they attributed to pollution, changes in sediment load and illegal fishing (Johnstone et al. 2013).

The potential impacts of hydropower development on Myanmar's fisheries demand particular attention. Myanmar's rivers have not yet been extensively dammed, and there are currently only 22 hydropower projects in the country (IFC 2017). Myanmar's relatively unobstructed large rivers support the country's important wetlands and productive aquatic ecosystems. A report mapping the ecological importance of different river reaches emphasised the need for environmental safeguarding of particularly sensitive river basins (IFC 2017). The consequences of fragmentation, and changes in the flow and sedimentation of Myanmar's rivers may be substantial, considering the scale of the fishery sector and its contribution to livelihoods, and the number of important migratory species in the country (Baran et al. 2015; Ko et al. 2016).

Cyclone Nargis

Cyclone Nargis, the worst natural disaster in the recorded history of Myanmar, provides an example of the vulnerability of the country's population and fisheries to natural hazards. The cyclone hit the country in May 2008, causing at least 130,000 fatalities, mostly in the delta; millions more were affected by losses of homes and livelihoods (World Bank 2014). The disaster had a severe impact on fishing capacity in the delta; overall, 20% of households (28% in Bogalay township) lost a boat, and 58% experienced a reduction in their number of fishing gears (Figure 16). The cyclone forced many resource-poor fishers to change their profession, and those who continued fishing reported lower catches (MMRD 2015).

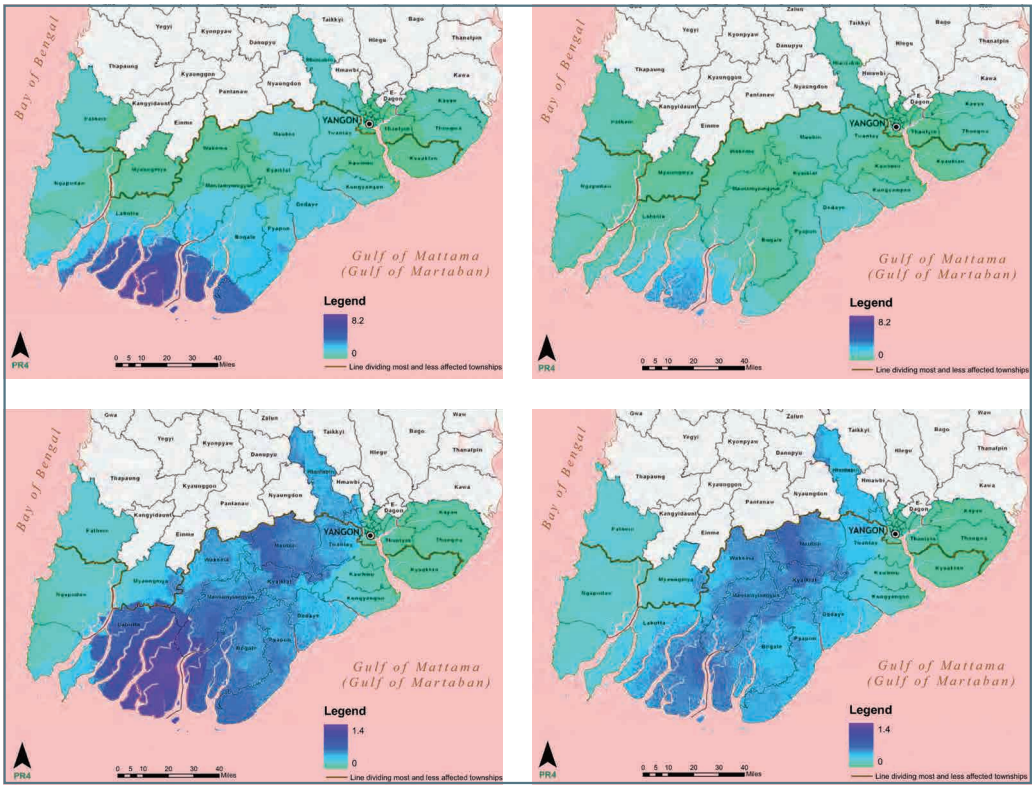

Figure 16. Reduction in average number of commercial fishing gears and boats owned by households following Cyclone Nargis. Upper left: commercial fishing gear before cyclone; upper right: commercial fishing gear after cyclone (May 2010); bottom left: boats owned per household before cyclone; bottom right: boats owned per household after cyclone (May 2010)

Source: United Nations Information Centre, Yangon

The cyclone affected fish habitats (MMRD 2014), particularly mangroves (Oo 2014). Research between August 2006 and May 2010 in the mangrove forest between Bago River and Ngamoeyeik Creek (Tharkayta, Yangon Division) showed a decline in aquatic populations caused by the environmental changes due to Nargis (MYFish 2013a). Overall, the cyclone resulted indirectly in the depletion of fish resources in rivers and estuaries, and a sharp decline in capture fisheries production (MMRD 2014, 2015). The decline in fisheries production, and probably value chain disorganisation, was reflected in decreased fish and seafood exports in 2008.

After the cyclone, international aid supplied boats and fishing gear to communities in the AD. However, fishing communities expressed concern about the consequential increase in the number of fishers, which may have contributed to the decrease in catch per fisher (MMRD 2010, 2014). Many non-government organisations (NGOs) attempted to stimulate small-scale aquaculture across the AD, with mixed success (Johnstone et al. 2012). Eel culture was introduced as an alternative livelihood option—it had limited commercial success, and increased pressures on natural stocks as juveniles were collected from the wild (Pant et al. 2014).

The cyclone also induced changes in hatchery and stocking activities: a rapid increase in fish nurseries replaced destroyed mango orchards in some areas, and the destruction of the country's only commercial tilapia hatcheries ended the production of monosex tilapia seed (free-breeding feral tilapia), which appeared to be previously present in most carp ponds (Belton et al. 2015).

Ecological and socioeconomic recovery from Cyclone Nargis has been slow. According to DoF statistics, live crab exports recovered in 2009, but fish production was slower to recover—2013 fish catches remained lower than before the cyclone (Johnstone et al. 2012; Van Driel and Nauta 2013). The result has been a cycle of poverty for many poor families who had to borrow credit at high interest rates to cover their losses; many were still worse off in 2011–12 (Johnstone et al. 2012; Mercy Corps 2011; WorldFish et al. 2014).

Chapter 4

Governance

Policy

Myanmar's dynamic policy environment has been shaped by a turbulent political history. In 1824, the British occupation marked the end of the last period of royal rule in Myanmar. It was during the British occupation (1824–1948) that inland fisheries were first managed as a source of revenue for the state (Reeves, Pokrant & McGuire 1999). Under the periods of Military Socialism (1962–1988) and Market Reform Military Rule (1988–2010), fisheries policy continued to focus on revenue generation through taxes and licensing; for instance, the military imposed an annual 10% increase in leasehold floor prices and demarcated the most productive open fishery areas as tender lot fisheries (Tezzo et al. 2016).

Since 2010, Myanmar has undergone a process of political transition, most notably the democratic election of the National League for Democracy (NLD) in 2015. Under the NLD, there are plans to reform fisheries and agricultural policy to better support rural livelihoods, poverty alleviation and benefit sharing. These reforms will require a shift away from the previous culture of corruption and revenue-based policies towards fisheries management. This includes DoF being responsible for the role of fisheries in food security, and local and national economies.

Institutional structures

Government

The policy environment for water is dispersed across numerous government departments,[9] which has created a confusing jurisdictional context. For instance, all mangrove forests are protected under the *Forest Law* but they are not categorised as reserves under the *Freshwater Fisheries Law* (Tsamenyi 2011). Article 83 of the Freshwater Fisheries Procedure asserts that, in areas also under the jurisdiction of other government departments, DoF 'shall obtain the remarks from the Government Department or organization concerned' and that 'conditions set out by the other Government Department or organization shall be incorporated' when granting leases, tender lots or gear licences (Tsamenyi 2011). According to the *Freshwater Fisheries Law*, fishing gears permitted without a licence in open waters can be used in mangrove zones, but this contravenes the *Forest Law*.

Historically, the complexity and sensitivity of the overlaps and conflicts surrounding authority and natural resource management have limited interagency cooperation (Tsamenyi 2011). However, according to its 2010 report, DoF has been working with external agencies—including the FAO, the Network of Aquaculture Centres in Asia-Pacific, the Southeast Asian Fisheries Development Center (SEAFDEC), the Japan International

[9] Including the Department of Agriculture, the Department of Irrigation, the Water Resources Utilization Department (which manages rural water supply), the Department of Rural Development (which manages rural water resources), the Department of Human Settlement (which is responsible for domestic water supply) and the Department of Transport (which is responsible for inland navigation) (Johnstone et al. 2013; WorldFish et al. 2014).

Cooperation Agency, and other regional and international fisheries-related organisations—to improve its services. In July 2013, a National Water Resources Committee was set up, bringing together representatives from 23 government agencies, with the task of integrating their work.

In 2016, the Ministry of Livestock, Fisheries and Rural Development and the Ministry of Agriculture and Irrigation were integrated to form the Ministry of Agriculture, Livestock and Irrigation. This created an opportunity to review existing and confusing policy, and design mixed-use water management strategies, with input from all relevant departments. In Sagaing, where the departments were merged in 2011, the merger has made the process of gaining permission to start aquaculture faster and smoother (MYFish 2013b).

The mandate to oversee and develop fisheries in Myanmar belongs to DoF (part of the Ministry of Agriculture, Livestock and Irrigation) and the Myanmar Fisheries Federation (MFF). DoF and the MFF broadly share the goals of the National Policy on Fishery Sector (DoF 2011a) to:

- promote general development in fisheries
- increase fish production for domestic consumption and share the surplus with neighbouring countries
- encourage the expansion of marine and freshwater aquaculture
- upgrade the socioeconomic status of fishery communities.

There are four divisions within DoF: Fishery Supervision and Revenue, Aquaculture, Fishery Research and Development, and Administration and Budget. State- and regional-level DoF offices operate alongside the divisions (Figure 17). The duties of DoF include advising the government on fishery matters, regulating sector conduct, issuing fishery and aquaculture licences, administering leasable fisheries and collecting associated revenue, evaluating and administering water bodies for fisheries and aquaculture, producing fingerlings for sale, stocking open-access waters, inspecting tradeable fish products, collecting and communicating sector knowledge, and providing training and extension services (FAO and NACA 2003). The vision of DoF is 'Sustainable development of fisheries sector for food security, improvement of the socio-economic of rural people and contribution to the economic development of the nation based on fisheries industry' (DoF 2019).

The Inland Fisheries Section of DoF is within the Fishery Management Division (Figure 17). This section is responsible for licensing associated with freshwater fisheries, revenue collection, law enforcement, data collection and compilation, conservation and awareness raising (DoF 2019).

The Aquaculture Division is responsible for overseeing the development of the sector (including technological improvements), providing technical assistance and capacity building, monitoring the impacts of climate change and supporting sector adaptation, and collecting tax revenue.

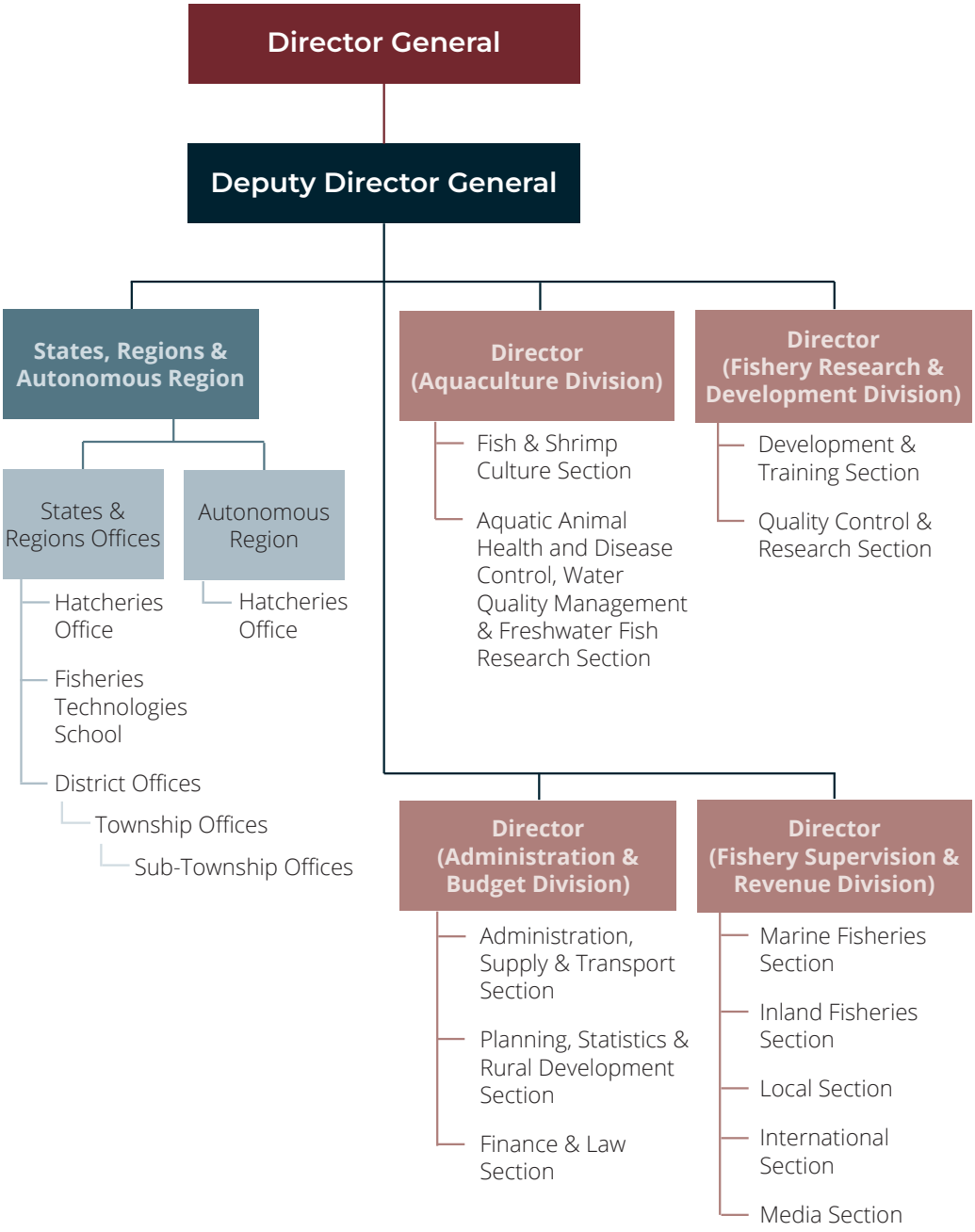

Figure 17. Organisation of the Department of Fisheries
Source: DoF (2017)

Private sector

The MFF is a non-profit organisation that is part of the Union of Myanmar Federation of Chambers of Commerce and Industry. Responsibilities of the MFF include representing fisheries at local, regional/state and national levels, representing and safeguarding the interests of the private sector, and promoting foreign investment. The services offered by the MFF to its members include support for loans and permits, representation at local-level government, support and rehabilitation following disasters, development of relationships with government organisations and NGOs, issuing of country-of-origin certificates, and communication and cooperation with trans-boundary organisations (the MFF was constituted as a member of the ASEAN Fisheries Federation in 2002) (FAO & NACA 2003; MFF 2016).

The MFF encompasses nine associations.[10] In December 2014, membership of the MFF comprised 29,504 individuals and 840 companies (MFF 2016). MFF board members are volunteer senior industry insiders, and thus the MFF enjoys considerable political favour with higher levels of government. Although MFF membership is inexpensive (300 kyats for one year and 5,000 kyats for life in 2010;[11] DoF 2011a), members are mainly wealthy business people, lessees of fishing areas and owners of large aquaculture organisations (FAO & NACA 2003). Low membership levels among smallholders might indicate that the MFF is not perceived to offer services that meet their needs.

Legislation

Inland fisheries legislation

Myanmar operates under a mixed legal system of customary law and English common law introduced by the British (CIA 2016).

Figure 18 illustrates the development of Myanmar's fisheries law since the early 1900s. The key legislation relating to inland fisheries is the *Freshwater Fisheries Law* (1991), which applies to:

> *waters, pond, river course, stream and lake which is of a permanent or temporary nature and in which fish live and thrive and which is situated within the inland boundary along the sea coast of Myanmar. This expression also includes a leasable fishery, reserved fishery, fisheries waters in which rights of fishery are permitted under a licence, reservoirs, waters in an area belonging to any Government department, inland tidal places, waters on an island, crocodile nests and turtle banks in which turtles and crocodiles lay their eggs and brackish waters. Furthermore, waters on the inland side of the straight line drawn from one extreme end of one bank to the extreme end of the other bank of the river mouths and creek mouths contiguous to the sea are freshwater fisheries waters.*

[10] Myanmar Marine Fisheries Association, Myanmar Freshwater Capture Fisheries Association, Myanmar Fish Farmers Association, Myanmar Shrimp Association, Myanmar Crab Entrepreneurs Association, Eel Entrepreneurs Association, Ornamental Fish Entrepreneurs Association, Myanmar Fishery Products Processors and Exporters Association, and Myanmar Aqua Feed Association

[11] In 2010, MMK 6.42 = US$1.

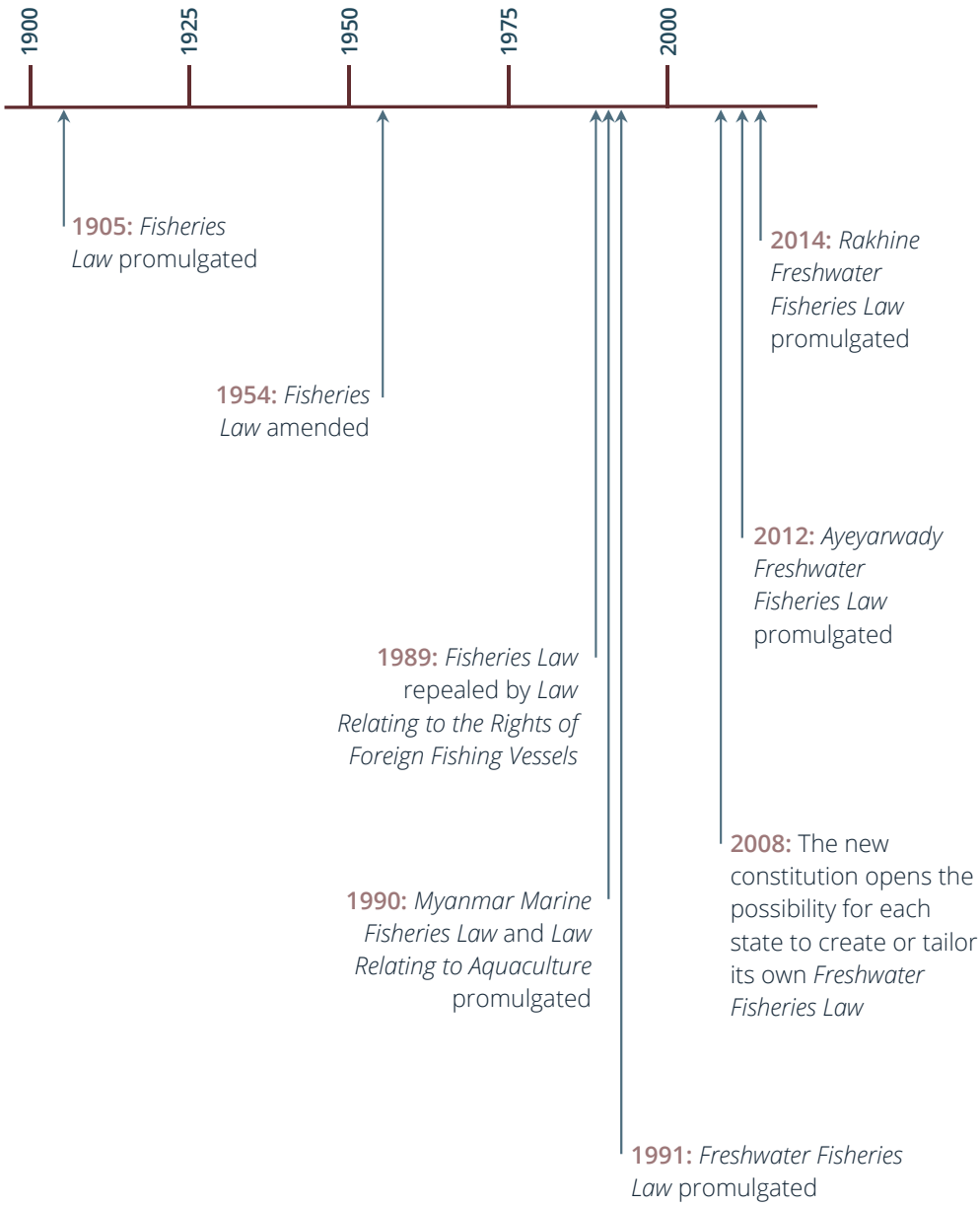

Figure 18. Historical development of Myanmar fisheries legislation

The specific objectives of the *Freshwater Fisheries Law* are set out in Chapter II, Section 3, of the legislation. The main objectives include to further develop the fisheries, prevent the extinction of fish, safeguard and prevent the destruction of freshwater fisheries waters, obtain duties and fees payable to the state, manage the fisheries, and take action in accordance with the law. The *Freshwater Fisheries Law* also describes detailed rules for leasable fisheries, including the requirement for leaseholders to reinvest a proportion of the lease price into stocking the leased water body (Tsamenyi 2011). Legislation relating to leasable fisheries dates back to 1864 during British occupation, when the *Burma Fishery Act 1864* passed the previous hereditary leaseholds to state control.

There is evidence from as early as 1873 of destructive fishing methods in Myanmar—for example, damming of streams and use of small-meshed nets in areas of higher population density (Day 1873). Hence, the need for management and regulation of the industry has long been recognised. Key measures to sustainably manage fisheries include the seasonal fishery closure enacted under the provisions of the *Freshwater Fisheries Law*. The closed season aims to protect spawning and recruitment. It applies generally to all open-access fisheries from June to August, but closure periods can vary between locations depending on when local target species are expected to spawn. However, it is likely that seasonal closures are only enforced for large and commercial fishers, and that small-scale fishing in open-access areas happens all year (FAO & NACA 2003).

Notification 2/92 of the *Freshwater Fisheries Law* states that catch or capturing of freshwater fish spawners, breeders and fingerlings is prohibited from May to August without permission from the Director General of DoF.

There are also species-specific closures, and some areas have been declared fish sanctuaries in recognition of their importance for biodiversity, which could explain the decline in the number of leasable fisheries in recent years (Oo 2010). However, a survey of leasable fisheries in the Ayeyarwady and Yangon regions found that, of leaseholds known to contain fish breeding grounds, 18% were not declared protected areas (Wah et al. 2016). All mangrove forests are considered protected areas, and fishing within 300 yards of mangrove areas is strictly prohibited under the *Forest Law* (Oo 2002).

Other more general prohibitions included in Chapter 12 of the *Freshwater Fisheries Law* include prohibitions on:

- catching fish of a prohibited species and size, during a prohibited period or at a prohibited place
- catching, killing, selling, buying, transporting, storing or possessing fish that are migrating to spawn
- catching fish using explosive substances, poison, chemicals, electric short-circuiting, or a prohibited method or fishing implement
- erecting, constructing or maintaining any obstruction, such as a dam, bank or weir, in freshwater fisheries waters without permission
- cutting undergrowth or setting on fire habitat of fish
- disrupting the flow of water in fisheries—in particular, altering the quality of water, the volume of water or the watercourse in a leasable fishery
- cultivating agricultural crops within the boundary of a fishery creek.

There is also a complete ban on the use (including in aquaculture) or sale of African catfish (Oo 2010).

In 2010, the enactment and management of inland fisheries legislation was decentralised. In theory, this gave states and regions the ability to adapt the national *Freshwater Fisheries Law*. However, limited capacity and action by local government means that implementation has been slow (Tezzo et al. 2018). The opportunities provided by decentralisation are gradually being better realised under the National League for Democracy government, and with resource and technical support from international agencies that are encouraging innovation, multistakeholder dialogue and community consultation.

The Ayeyarwady Parliament was one of the first to draft a regional fisheries law. However, the *Ayeyarwady Freshwater Fisheries Law*, promulgated in 2012, remained largely unchanged from the 1991 national law in its focus on revenue collection; only minor concerns of fisher communities were integrated into the new law, including reducing the year-round fishing season to seven months, splitting large tender areas into smaller units, and authorising the use of up to 20 crab and eel traps in open areas without licence requirements.

The *Rakhine State Freshwater Fisheries Law*, passed in November 2014, provides the best example of legislative reform arising from decentralisation. The law was developed by the Rakhine Fisheries Partnership (RFP), which comprises DoF, civil society organisations in the private sector, and fishers, and is supported by NGOs and bilateral donors (RFP 2016).

The success of the RFP and the *Rakhine State Freshwater Fisheries Law* led to the development of the Myanmar Fisheries Partnership (MFP) in 2016. The MFP is an initiative that aims to establish effective collaboration between the government, the private sector, universities and fishers. It has focused on supporting DoF and the Ministry of Agriculture, Livestock and Irrigation to improve fishery governance and policy development.

Aquaculture legislation

Aquaculture activities fall mainly under the *Law Relating to Aquaculture* (1989). The *Marine Fisheries Law* (1990) and the *Freshwater Fisheries Law* (1991) also contain some relevant clauses. The *Law Relating to Aquaculture* focuses on regulating the provision of leases and licences. The content of the law can be summarised as follows (FAOLEX 2016):

- The exercise of aquaculture is subject to the issuance of a lease grant by state or division fisheries officers.
- The sale of fish seeds produced through artificial propagation or the breeding of aquarium fish is subject to the issuance of a licence.
- Licence holders are required to pay a grant fee or a licence fee, according to the procedure set out by DoF.
- DoF may designate aquaculture land from agricultural and virgin land for the development of aquaculture, for not more than 10 years.

The law also contains provisions relating to the powers of the Director General, conditions for the cancellation of a lease or licence, powers and duties of inspectors, and penalties for violation of the law.

Belton et al. (2015) discussed how land-use laws have shaped the development of the aquaculture sector in Myanmar. Strict agricultural land-use policy introduced in 1988 to favour rice as a strategic food security crop has limited the development of the aquaculture sector and the emergence of aquaculture as a viable rural activity for small-scale operators. Fish ponds can only be developed on land officially allocated to aquaculture, on land currently not being farmed or on wasteland. Even in areas where conversion to fish pond aquaculture would be more profitable than growing rice, it is forbidden to excavate ponds or ditches on land suitable for rice cultivation; confiscation of the land is a consequence (Belton et al. 2015; FAO & NACA 2003; Pant et al. 2014).

According to the *Land Nationalization Act* (1953), converting agricultural land to non-agricultural land requires permission from the state or division Peace and Development Council, and officially converting paddy fields to fish ponds requires permission from 16 relevant agencies (Johnstone et al. 2013). Only ponds smaller than 8 m × 17 m and ditches that do not exceed a width of 90 cm and a depth of 60 cm are permitted without a licence.

By effectively barring small-scale farmers from diversifying their livelihoods, existing land-use policies create substantial missed economic opportunity. As a low-input, high-return system, trap pond aquaculture is more profitable per hectare than rice farming (Oo and McKay 2018). Fish farmers with grow-out farms earn an average annual gross margin of US$650 per acre, compared with only US$150 per acre for field crops (Belton, Filipski & Hu 2017).

Simultaneously, the development of commercial, export-orientated aquaculture was encouraged by the government through the 1991 Wasteland Instructions, which enabled the transfer of land-use rights for land classified as wasteland or vacant and fallow land to private individuals and companies for the construction of large ponds (Belton et al. 2015). However, vacant and fallow lands are often cultivated by small-scale farmers, and the transfer of rights often involved forcible land acquisition by the government, with farmers receiving little or no compensation. Further, under the Wasteland Instructions, wetlands classified as wasteland have been converted to ponds, thereby degrading important ecological habitats. The land registration system introduced under the 2012 *Farmland Law* has done little to address the issue of land grabbing and secure the tenure of small-scale farmers; the government remains the ultimate owner of all land, and the registration process has stirred up historical conflicts surrounding land ownership.

This trend is beginning to change: since the political reform, enforcement of land-use policy has become more lenient, and pond construction in areas designated for rice paddies has been observed between Pyapon and Bogalay (WorldFish et al. 2014). In recent years, DoF has also actively promoted rice–fish culture in ditches. However, this has been limited to small pockets of development, which creates high transaction costs, making it a risky investment for farmers (MFP 2016b).

Chapter 5

Management practices

Inland fisheries management

Concessions and tenure

Three main systems are used to allocate fishing rights in Myanmar's inland fisheries: leasable fisheries, tender lot fisheries and open fisheries.

Leasable fisheries

Locally known as 'inn' fisheries, leasable fisheries are specific areas of water for which fishing rights are auctioned by the district fishery officer on an annual basis, usually to individuals. According to DoF (2017), in 2015, leaseholds generated 8,206 million kyats in revenue. Box 1 describes the history of the leasehold allocation system.

Box 1. History of Myanmar's fisheries leasehold system

Leaseholds were originally hereditary properties based on fixed rents. In 1864, they were placed under state control and directly allocated by the Ministry of Livestock and Fisheries at a predetermined fixed price to business operators, or as a reward to specific individuals who would sublease to professional operators (MMRD 2010). A small number of low-value leasable fisheries were ignored by their beneficiaries, and DoF auctioned them to ensure full exploitation of the resource and revenue generation. In 2012, leasable fisheries became fully and publicly auctioned by DoF at the state/division level. However, a compulsory 10% annual increase in leasehold floor price introduced by the military in the 1960s, which is still in place today, means that leaseholds are accessible only to the wealthiest operators (Oo 2010; Tezzo et al. 2016), and many have been acquired by prospective investors (Wah et al. 2016). In practice, however, if there are no bidders for a leasehold, the floor price is set as the average price from the previous five years.

A recent assessment of livelihoods in the AD confirmed that local fishers could not compete with wealthy operators, even when pooling their resources (MMRD 2014). Nevertheless, leasable fisheries provide an important source of employment for nearby villages and, even when operated by businessmen, can support up to 100 families (FAO & NACA 2003; Wah et al. 2016). In the Ayeyarwady and Yangon regions, lease prices reflect the size, productivity and species composition of leased areas; they ranged from US$50 to US$165,000 per lot and from US$0.9 to US$36,000 per hectare (Wah et al. 2016).

A recently implemented government poverty alleviation program has started to make leases accessible to a wider range of bidders by providing support and facilitating community management. For example, in 2012, a group of 25 farmers secured the lease of Pauk Inn, a large water body of 6,500 ha, thanks to individual loans at subsidised interest rates (MYFish 2013b).

A survey of 180 leasable fisheries in the Ayeyarwady and Yangon regions found that 96% of leases were associated with large rivers, river channels, or a combination of rivers and wetlands; 43% contained seasonal wetlands; 40% were within, or encompassed, protected areas subject to fishing restrictions; and 32% contained known fish breeding areas (Wah et al. 2016).

The duration of an auctioned lease is one year; depending on the region, this can be extended in three-year cycles for up to 10 years. Leaseholders have exclusive rights to the fishing ground and some control over management of the resource (FAO and NACA 2003). Leasable fisheries management ranges from extensive, with minimal or no stocking and feeding, to intensive stocking and feeding. According to DoF, the number of leasable fisheries declined slightly from 3,481 in 2000 to 3,304 in 2014 (DoF 2011a, 2015). In other literature, the number of leaseholds reported ranged from 2,084 in 2004 (Duan 2008) to 3,722 in 2003 and 2005 (FAO 2010; FAO & NACA 2003).

Tender lot fisheries

The rights to use a specific type and number of fishing gear (usually stow nets) in particular stretches of river are allocated to operators through tender licences. Introduced in 1992, tender lots are a relatively new form of fisheries management in Myanmar that encroach on open fishery resources. The tender lot system essentially provides a mechanism through which DoF can commercially manage the most productive open fisheries; tender lot catches are included in the open fisheries category in national statistics.

Tender licences are auctioned by DoF at the state/division level to the highest bidders—these are often business operators who sublease the fishing rights to fishery operators (Lamberts and Wah 2008; Venkatesh 2015). According to DoF statistics, in 2016, the revenue from tender fees was 2,824 million kyats (DoF 2017).

Tender licences are typically valid for one year, starting at a different date depending on the type of tender: 1 April for 'legal tenders', 16 October for 'sea-shore tenders' and 16 June for 'forest tenders'. Tender lot owners can also give access, with remuneration, to small-scale fishers to operate in the tender area.

Open fisheries

All legal fishing areas outside leasable and tender lot fisheries, including streams and other aquatic ecosystems, are open fisheries (Oo 2010). Access to open fishing grounds is free, but most fishing gears require a licence issued by the district fishery officer for a yearly set fee (FAO & NACA 2003; Lamberts & Wah 2008).

According to the *Freshwater Fisheries Law*, fishing in open grounds with licensed gear is categorised as 'implement licence fisheries', whereas fishing with gear that does not require a licence[12] is categorised as 'non-licence fisheries'. Non-licence fisheries are truly open-access and extremely important to local populations, particularly the landless, because they require limited investment (small fishing nets cost as little as US$10), and provide a source of food and income (Duan 2008; UNDP 2004). In some fishing areas, non-licence fisheries can represent more than half of fishers (MMRD 2010; SEAFDEC 2012).

The *Freshwater Fisheries Law* also refers to 'reserved fisheries', which are places or periods where fishing is prohibited.

Stock enhancement

Stocking of inland waters with cultured fish to enhance natural fish production and recruitment has been underway in Myanmar since 1967 (FAO & NACA 2003), creating a unique continuum between capture fisheries and aquaculture. The government enhances the stock of rivers each year using fingerlings of mainly fast-growing Indian carps and, to a lesser extent, Chinese carps (7–10 cm in length), along with some indigenous species to augment the natural recruitment (Oo 2010). It is expected that fishers operating in the areas where stock have been released will return a certain number of potential breeders to the government hatcheries to sustain genetic diversity in the hatcheries and to replenish the broodstock, which is replaced every 1–5 years, depending on the hatchery (Oo 2010). However, in practice, there is no genetic management in hatcheries or stocking programs. The reported quantities of fish fry and fingerlings released in different types of environments from 2000 to 2009 are shown in Table 3. DoF reported that it released 154 million fish fry into Myanmar's inland waters in 2016 (DoF 2017).

Stocking of leasable fisheries is compulsory by decree; leaseholders are required to reinvest 1–3% of the lease price in stocking the water body (Wah et al. 2016). According to national statistics, in 2016, 66.6 million fingerlings were released into leaseholds (DoF 2017). However, the number of hatcheries and their production are limited, which is a key constraint to stock enhancement in leasable fisheries (Oo 2010). A characterisation study of leasable fisheries in the AD revealed that only 79% of leaseholders restocked their leases (Wah et al. 2016). DoF hatcheries, which provide fingerlings on a cost–recovery, revenue-raising basis, are the most common source of fingerlings stocked in leasable fisheries (Table 4).

[12] The 16 small fishing gear types that, for a limited number of gear units, do not require a licence are hook and line with weight, stationary hook and line with rod, pole and line, submerged longline with weight, surface longline with float, push net, large mobile scoop net, large fixed scoop net, sieve (strainer), small bamboo traps, large inland bamboo traps, small entrapment, large entrapment, spear single blade, banana leaves (banana leaves spread on the boat reflect under the moonlight and attract fish to jump onto the boat) and pit trap.

Table 3. Number of seed stocked in inland waters of Myanmar, 2000–09

Year	Number of fish stocked (million)				
	Ayeyarwady River	Reservoirs (number of reservoirs)	Natural rivers and streams	Ponds	Rice–fish culture
2000	126.22	34.72 (53)	27.48	23.59	0.00
2001	134.70	34.67 (77)	41.59	16.55	0.00
2002	159.25	38.80 (81)	39.05	56.48	0.00
2003	178.01	109.99 (105)	62.27	43.08	3.28
2004	186.73	108.70 (164)	63.27	59.76	4.84
2005	199.06	117.79 (218)	56.18	25.49	6.17
2006	214.92	85.93 (228)	44.38	6.04	6.55
2007	181.45	90.62 (219)	80.40	3.18	7.08
2008	197.10	103.17 (228)	91.72	3.41	7.10
2009	182.70	110.17 (228)	75.98	2.46	7.44

Source: Oo (2010)

DoF hatcheries provide a limited variety of species for leasable fisheries: most fingerlings are rohu, silver barb and catla (Table 4). Fingerlings from DoF hatcheries are usually quite small (average length 2.8–4.6 cm) (Wah et al. 2016). Snakeskin gourami, which ranks among the top stocked fingerlings, are almost entirely sourced from the wild. Interestingly, the study found that no leaseholders reported catching silver barb, even though this is one of the most commonly stocked species.

Despite decades of systematic stocking of Myanmar's water bodies with cultured fish, few, if any studies have been done to determine its effectiveness or impacts. Observations both support and refute the expectation that stocking will lead to higher yields, and there are conflicting views on the implications for wild stocks. The FAO and the Network of Aquaculture Centres in Asia-Pacific considered the stocking program to be worthwhile, recommending that the government scale up its nursing operations to improve the survival rates of stocked fingerlings (FAO & NACA 2003). The report presented the example of Susan Inn, a leasable fishery where the yield almost entirely comprised stocked species (rohu and common carp). The stocking rate in this case was 0.4 fish per square metre, and the size of fish at stocking was about 13 cm (i.e. advanced fingerlings). The yield was approximately 3.3 t/ha, with total harvest reaching 160 t. However, other stocked fisheries visited by the same mission showed little evidence of recapture of stocked fish. This was attributed to the small size of very juvenile fingerlings, which have a poorer survival rate, and the density of stocking.

Table 4. Origin of fingerlings stocked in leaseholds in the Ayeyarwady Delta, 2000–09

Species	Sources of fingerlings (number of leaseholders)				Total number of fingerlings
	DoF hatchery	Private hatchery	Wild	Not specified	
Rohu	91	8	4	4	5,540,360
Snakeskin gourami	0	0	9	2	994,200
Catla	19	1	12	3	837,550
Silver barb	66	2	0	7	706,602
Mrigal	4	0	0	3	316,000
Stinging catfish	1	1	5	2	26,500
Striped snakehead	1	0	8	3	24,366
Walking catfish	1	1	7	3	17,050
Spotted snakehead	0	0	3	1	7,940
Climbing perch	0	0	2	1	7,500
Tilapia	3	0	0	1	7,200
Bronze featherback	0	0	1	0	1,000
Pangas catfish	2	0	0	2	na
Pool barb	0	0	0	2	na
Common carp	0	0	0	1	na
Total	**188**	**13**	**51**	**35**	**8,486,268**

na = not available

Source: Wah et al. (2016)

Oo (2010) also reported that artisanal fishers in the villages near rivers claim higher catch rates resulting from stocking in open waterways, although he does not specify the basis for this claim. According to the same author, there is no evidence to support concern that stocking has resulted in a reduction in genetic diversity of wild stocks. However, fishers tend to complain about the competition between stocked and wild species, with subsequent changes in fish communities (Johnstone et al. 2013). This is illustrated by the Duya leasable fishery (Hinthada District, Ayeyarwady Region) where 10 years of annual stocking with fingerlings of carp species, tilapia and silver barb resulted in a dramatic reduction of the original wild stock. Of the 761 t harvested in 2007, only 7.4% were species that were originally present (MYFish 2013a).

Venkatesh (2015) underlined the persistent low level of government supervision and concluded that 'there is hardly any way to assess the quantity or the quality (age, size range and health) of the stocked fish species, or to assess the impacts of the restocking on the resource health in the water bodies'. The perception among some leaseholders that stocking is a compulsory activity means that best-practice recommendations are not always followed (De Silva & Funge-Smith 2005; UNDP 2004). Key improvements needed include 'stocking of advanced large sized fingerlings, using appropriate stocking rates and possibly strategic feeding in some of the smaller leases' (UNDP 2004).

Stocking, even when technically optimal, cannot be expected to have the same environmental impacts and achieve similar productivity outputs in all environmental conditions, which vary from enclosed water bodies (oxbow lakes, reservoirs) to fully open waterways (floodplain areas, rivers and creeks). Investment in methodical assessments and testing to develop guidelines (e.g. for species to be stocked, optimal size and densities, target water bodies, timing) would considerably improve the activity through resource optimisation, cost-effective management and minimisation of impacts (Johnstone et al. 2013). Several specialists also recommend a more nuanced approach to stocking—in particular, the breeding of naturally occurring fish species (Edwards 2009; MYFish 2013a). De Silva and Funge-Smith (2005) noted that, given prevalent social traditions and hierarchies, the benefits of stocking water bodies may be captured by an elite group. This will require careful consideration if Myanmar wants its stocking program to contribute to alleviating poverty among the poorest fishers.

Community management

Historically, communities and local groups have not been recognised as legal entities in Myanmar. This has prevented the emergence of community-based management arrangements, including those involving fisher cooperatives, and partnership arrangements with authorities and other organisations. Community-based management would have multiple benefits for livelihoods and the sector in general. For example, group investment enables communities to purchase fishery rights, such as leaseholds and tender lots, or build aquaculture systems and purchase necessary inputs (e.g. feed, seed). These activities would be financially unviable for individuals. As a result, poor and vulnerable groups are able to access the sector and diversify their livelihoods, which contributes to poverty alleviation and food security objectives (UNDP 2004). Collectively, fishers can strengthen their role in value chains to obtain the necessary economies of scale to reach distant markets with fewer intermediaries and gain the leverage needed to bargain with the existing market intermediaries for a bigger share in the final value of the product (Venkatesh 2015). Increased responsibility and benefits from fishery resources provide an incentive for local communities to enforce fishery regulations, monitor fish stocks and sustainably manage the resource. Finally, community-based management and partnership arrangements could lead to improved communication between DoF and fisher communities, and create a knowledge-sharing platform (Pomeroy, Katon & Harkes 2001).

Efforts to support community-based fishery management through the formation of stakeholder and production groups during the 2011–15 period of government reform was intended to address the growing claims of resource users that they were excluded from the most productive fisheries under the current rights allocation system (Johnstone et al. 2013). An encouraging example of community-based management arrangements in the CDZ is the management of a Pauk Inn leasehold by a fishery sector cluster group with assistance from the Regional Fishery Officer for loan arrangements (Johnstone et al. 2013). Another example is the obtaining of local leaseholds and tender lots by fisheries development committees set up by the Network Activities Group in collaboration with the Myanmar Fisheries Association (Venkatesh 2015). Several development agencies have

formed production groups in agriculture or fishery projects (e.g. FAO, WorldFish, Network Activities Group). However, the emerging fishing rights movement has been met by resistance from big business. The recent resignation of the fisheries minister responsible for changes in the licensing system of the AD renders the continued reform of the region's fisheries and the rights of its fishers uncertain (Soe 2018).

Reservoirs and fisheries

Historically, reservoir fishing in Myanmar was encouraged, but in 1995 the practice was banned by the Department of Irrigation on the grounds that fishing in reservoirs was environmentally unsound and would deprive surrounding farmers of spillover fish (FAO & NACA 2003). Since then, only limited small-scale subsistence fishing tends to continue in reservoirs (MYFish 2013b). A lack of clear regulation and competing administration has prevented the development of culture-based fisheries and cage aquaculture in reservoirs or irrigation canals. Nevertheless, DoF has continued stocking reservoirs with Indian and Chinese major carp 'for conservation purposes' (UNDP 2004). For instance, in 2012–13, DoF released 400,000 seeds into the Tha Phan Seik reservoir in Kyun Hla township of Sagaing Region (MYFish 2013).

Management of aquaculture development

Aquaculture stocking

A survey of 136 small-scale aquaculture households in August–November 2013 in the AD found fish stocking densities to be far lower than recommended; this was associated with very low productivity (Pant et al. 2014). Recorded stocking densities, production and gross income for studied species are detailed in Table 5. The same study found that aquaculture operators use seed from both hatcheries and wild sources; fattening systems, including swamp eel and mud crab, were entirely dependent on the unsustainable extraction of wild juveniles (Pant et al. 2014). The use of wild fish to stock ponds is the basis of trap ponds (Oo & McKay 2018).

Table 5. Stocking density, production and gross income for aquaculture systems in the Ayeyarwady Delta

Aquaculture system	Stocking density (pieces/ha)	Production (kg/ha/year)	Gross income (kyat/ha/year)
Carp monoculture	400–800	378	482
Carp polyculture	400–800	1,507	1,912
Swamp eel culture	3,000	633	3,178
Mud crab fattening	800	6,387	14,069
Tiger shrimp culture	2,400	254	763
Wild fish culture	1,900	546	601

Source: Pant et al. (2014)

According to Win (2004), common practice in Myanmar involves stocking 7,400 yearlings per hectare of pond, with a culture period of 10–12 months. The same study found geographic variation in stocking sizes: farmers in lower Myanmar preferred to stock yearlings of 12–15 cm so that fish reached marketable size in a short time, whereas farmers in upper Myanmar preferred to stock fingerlings of 2–5 cm, possibly because they are cheaper to buy. There is also a better market for small fish in the CDZ than in the AD (Johnstone et al. 2013).

Hatcheries and nurseries

In the past, it was suggested that government hatcheries were the main source of seed and fingerlings for aquaculture in Myanmar (Needham & Funge-Smith 2014). However, Belton et al. (2015) revealed a heavy dependence on private hatcheries and nurseries, with most government hatchery production being used for stocking natural inland waters. Private hatcheries have emerged individually and in clusters, mostly in areas with large concentrations of ponds, including the Bago, Ayeyarwady and Yangon regions (Belton et al. 2015). Private hatcheries often use DoF hatcheries as a source of broodstock; private nurseries either produce their own fry or purchase fry from DoF hatcheries and grow them to the fingerling stage**.** Private sector hatcheries are believed to have far higher production rates than government hatcheries (FAO & NACA 2003). In 2016, 39 private hatcheries produced 1,875 million freshwater fish fry, while the 29 DoF hatcheries produced only 664 million freshwater fish fry (DoF 2017).

Many large, vertically integrated farms also run their own hatcheries and nurseries (Belton et al. 2015). Since 2005, the government has encouraged the establishment of small 'backyard' hatcheries through the allocation of loans to cluster groups by the Regional Department of Fisheries (MYFish 2013b). For the fiscal year 2014–15, DoF reported the construction of 62 backyard hatcheries in 14 different regions and states (DoF 2015).

In areas with higher numbers of hatcheries and nurseries, fish seed is accessible to small-scale aquaculture operators, including those who raise fish in homestead ponds. However, it is believed that seed production remains a constraint to small-scale aquaculture in more remote areas (Belton et al. 2015). Backyard hatcheries are mostly aimed at meeting increasing demand from aquaculture, but they can also supply fry to leasable fisheries (DoF 2011a).

In 2014–15, there were 26 government-run hatcheries distributed across 11 of Myanmar's regions. The Ayeyarwady Region contained the most hatcheries, while the hatcheries in Mandalay supported the highest production—157.18 million heads (Table 6). Total production for the period was approximately 575 million fish fry and fingerlings, of which 398 million were rohu (DoF 2015). Silver barb and common carp were the next most common species hatched, at 90 million and 39 million, respectively (DoF 2015). Government reporting of hatchery production is considered to be vague, and the reliability of the figures is uncertain, making it difficult to estimate the number of surviving fingerlings used for stocking (FAO & NACA 2003).

Table 6. Number of finfish hatcheries in states/divisions and production of seed stock used for stock enhancement, 2014

Area	Hatcheries	Production (millions)
Ayeyarwady Region	5	86.25
Mandalay Region	4	157.18
Yangon Region	3	152.83
Bago Region	3	68.64
Sagaing Region	3	24.45
Kachin State	2	9.89
Magway Region	2	8.41
Nay Pyi Taw Council	1	56.16
Shan State	1	4.46
Mon State	1	3.22
Kayin State	1	3.22

Source: DoF (2015)

Use of hormone treatment and hypophysation (inducing breeding by injecting fish with pituitary gland extract) is common in government hatcheries; access to Chinese fish-breeding hormones (human chorionic gonadotropin, luteinising hormone and possibly luteinising hormone-releasing hormone analogue) has enabled mass breeding, and unseasonal and repeat breeding of carp species (FAO & NACA 2003).

Developing mud crab hatcheries to replenish decreasing wild stocks is a priority for DoF as the demand for domestic consumption and export increases (DoF 2015); two previous attempts in 2002–03 and 2009–10 failed (Marius 2013).

Feed

The fish feed manufacturing industry in Myanmar is severely underdeveloped (Belton et al. 2015). Only a few domestic companies produce and sell fish feeds, and these companies are dominated by one firm. The lack of competition means that commercial feed prices in Myanmar are high (10–30% more than in neighbouring countries). This makes cost concerns a key issue for many fish farmers (Gregory 2013), particularly small-scale operators who depend on informal credit and loans at high interest rates (4–6% monthly). Consequently, a few large vertically integrated farms produce their own feed, and a majority of aquaculture farmers feed fish with agricultural by-products, which leads to low levels of production (Belton et al. 2015; Johnstone et al. 2012; MYFish, in press). A survey found that no fish farmers in the AD and only 1.2% in the CDZ used commercial feeds (MYFish, in press). The most common fish feed is rice bran; some carnivorous species in the AD are fed fishmeal, and some farmers feed fish with kitchen waste (MYFish, in press). Most fish farmers only feed fish occasionally, and 18% in the CDZ never feed fish (MYFish, in press).

Chapter 6

Data collection and information systems

Data collection systems

Like many other developing countries, Myanmar is characterised by a poor fisheries data collection system and by official adjustments made to statistics (De Graaf 2014). SEAFDEC (2012) explains that collection of what should be basic and routine data and statistics is very complicated because of the very nature of freshwater capture fisheries: 'small-scale, multi-species, multi-gear, involving a large number of fishers which are mostly part-time fishers, while the major parts of the fishery production are meant for household consumption'.

SEAFDEC (2012) further suggests that lack of accurate reporting from the inland fisheries sector means that the sector is accorded a low priority by planners and policymakers in relation to other development sectors. The problem of underfunding, leading to poor data collection, thus appears to lead back to ongoing underfunding, making the issue circular. This, reports SEAFDEC (2012), is the case across the whole of South-East Asia, despite the crucial role that inland fisheries play in food security and poverty alleviation across the region.

National fisheries data in Myanmar have been shaped by three distinct reporting phases:

1. Before the mid 1990s, there was limited incentive to assess and evaluate catch information. Low catch volumes recorded during this period are likely to reflect substantial under-reporting. It is believed that the culture of unreliable reporting originates from 1994, when production statistics became the responsibility of the Planning Division of DoF (De Graaf 2014). In his assessment of Myanmar inland fishery statistics from 1990 to 1999, Coates (2002) believed the reported annual catch of approximately 145,000 t was underestimated by as much 2.5 to 3.8 times. Thus, during this phase, figures suggest a relatively underexploited fishery.
2. In the mid 1990s, the military government laid out a 30-year plan for fisheries development, which included total fisheries production of 41.5 million t by 2030. Rapid linear growth in officially reported catch volumes from 2000 onwards paints a picture of an increasingly overexploited fishery. However, these figures are largely believed to reflect government targets rather than actual production levels (De Graaf 2014).
3. Around 2013, the reporting issues of the second phase started to be identified. The engagement of the international community brought with it independent stock assessments and consumption surveys (Belton et al. 2015; Krakstad et al. 2014; Needham & Funge-Smith 2014), the findings of which indicated far lower production than national statistics. Thus, the third and current phase is characterised by scrutiny of official reporting methods and concerns about the validity of official figures from the first two phases.

A key shortcoming in Myanmar's national fishery statistics is the dependency on factor calculations to estimate inland fisheries yield. Reported annual yields from leasable fisheries are calculated at the local level based on the surface area and a per-unit area biomass constant, which varies from place to place depending on local productivity estimates. A similar situation is apparent in open fishery statistics, which are often calculated by multiplying the count of licensed gear (e.g. gillnets, stow nets, traps, longlines) by a biomass constant. No direct sampling of inland catches or landings is carried out to verify factor-based calculations, meaning that figures do not necessarily reflect actual catches.

The reliability of aquaculture statistics in Myanmar is also under question. There is no evidence of a data collection program, and productivity estimates are constrained by the uncertainty surrounding the number and size of aquaculture operations. Further, DoF statistics do not include unlicensed and untaxable activities such as fish production in the large number of homestead ponds increasingly being converted for aquaculture and trap pond systems. Consequently, very little is known about these practices, and production figures are likely to be an underestimate. The limited quantity and quality of fisheries data for Myanmar creates unique development challenges. As the only source of national-scale fisheries data for Myanmar, official statistics are widely cited, and so the data issues are integrated into further analysis and assessments of Myanmar's fisheries in a global context.

Statistics on production

National statistics suggest considerable growth in Myanmar's fishery production over the past 18 years, with a reported increase from 1 million t in 1998 to 5.68 million t in 2015 (Figure 19). According to the figures, inland catches and their relative contribution to total production increased from 0.16 million t in 1998, which was 16% of total production, to 1.589 million t in 2016, which was 28% of total production from all fisheries sectors. The DoF data suggest that the most rapid growth occurred between 2002 and 2003, when inland catches are reported to have increased by 81%.

National statistics attribute most of the growth in inland fisheries production to open fisheries; open fisheries landings are reported to have increased 14-fold between 1998 and 2016, with a remarkable 80% increase between 2002 and 2003. Over the same period, the data show a less than fivefold increase in leasable fisheries landings.

It is important to note that national statistics do not include data for subsistence and small-scale fishers, such as those who use unlicensed gear, or for fishing activities in reservoirs.

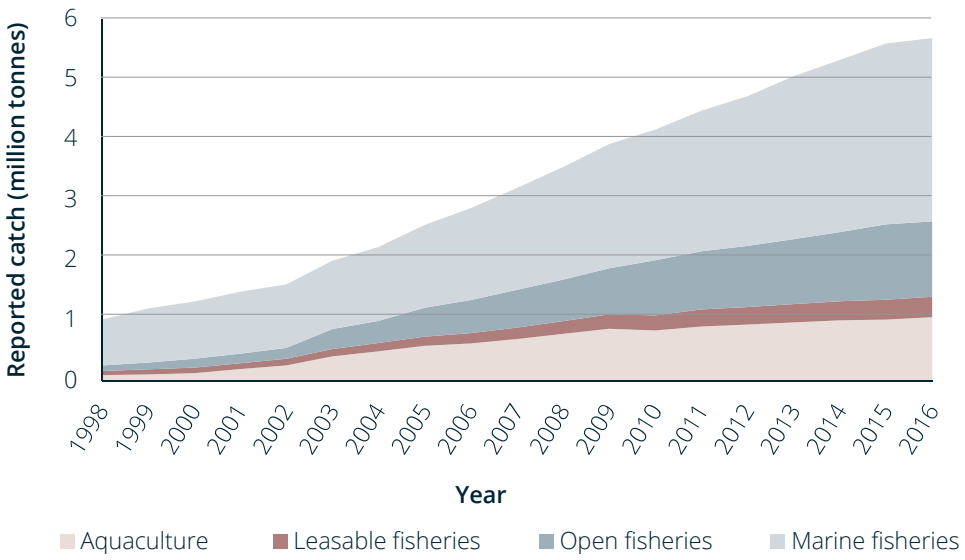

Figure 19. Reported production of inland leasable and open fisheries, marine fisheries and aquaculture, 1998–2016

Sources: DoF (2017); Oo (2010)

According to DoF data, aquaculture production rose from 0.09 million t in 1998 to 1.05 million t in 2016. The data suggest that the most rapid increase occurred between 2000 and 2003, when aquaculture production apparently increased by an average of 49% per year. Freshwater aquaculture production was reported to increase from 0.09 million t to 0.9 million t between 2000 and 2014—that is, a 10-fold increase over 14 years (FAO 2016). A comparison of the aquaculture production and pond area figures given in national statistics implies that per-hectare production nearly doubled between 2003 and 2014, increasing from 2.75 t/ha to 5.42 t/ha. However, DoF reports average aquaculture production to be 10.7 t/ha (DoF 2015).

When national statistics are plotted against data from other South-East Asian countries, the production and rate of growth reported in Myanmar's inland capture fisheries (Figure 20) are remarkable. These figures formed the basis of a 2012 report and a regional statistical bulletin that placed Myanmar as the top South-East Asian producer from inland fisheries in terms of volume and value from 2008 to 2014 (SEAFDEC 2012, 2014).

The unreliable production figures are also reflected in the apparent increase of more than 100% in per-capita fish consumption between 2002 and 2007 (MMRD 2010).

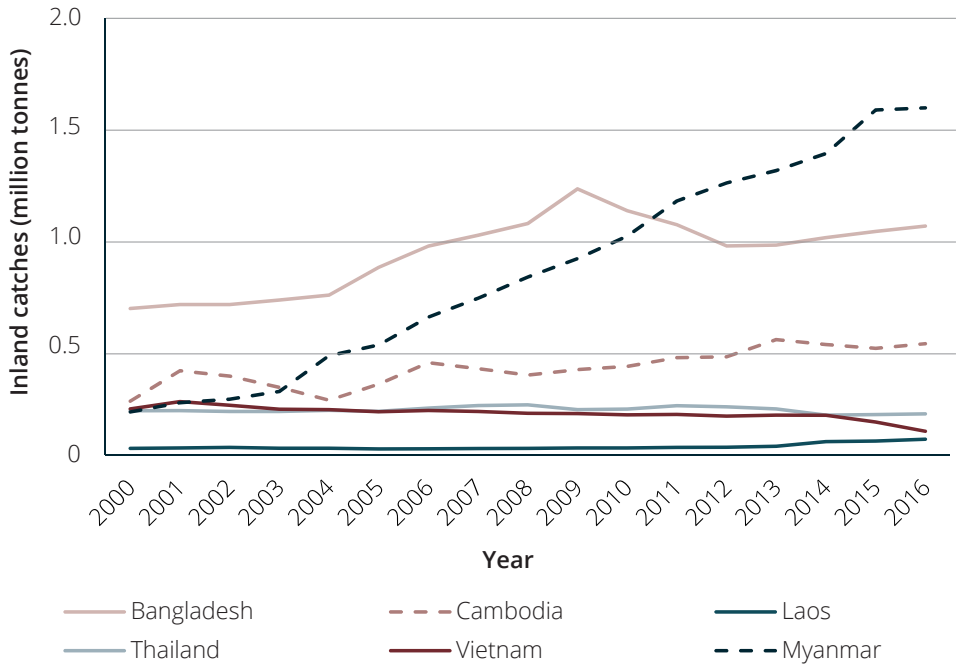

Figure 20. Reported inland fish catches for Myanmar compared with other countries in South-East Asia, 2000–16

Sources: Baran et al. (2017)

Alternative figures

Independent stock assessments and consumption surveys carried out during the third reporting phase paint a very different picture of Myanmar's fishery sector than the one portrayed in national statistics. Current wisdom suggests, contrary to the findings of Coates (2002) for the period before 2000, that official figures may be an overestimate of catch that may even exceed the available biomass. Using national household survey data on fish consumption and expenditure, Needham and Funge-Smith (2014) estimated that actual catch is likely to be around 600,000 t per year, about half that reported by official statistics.

A revision of national statistics by the FAO suggests that marine fishery production has decreased since 2005 and that growth in inland capture fisheries has slowed to a very gradual increase (Figure 21). No adjustments were made to aquaculture production statistics in the revised figures. According to the revised figures, fisheries production in Myanmar in 2015 was 2.9 million t (compared with the 5.6 million t reported by DoF). Nevertheless, the revised values still place Myanmar as one of the world's most important fishery producers, accounting for 7.2% of total global fish production (FAO 2016).

Inland fisheries are estimated to have contributed 30% (863,000 t) of fish production in 2015, marine fisheries 37% (1,062,000 t) and aquaculture 33% (942,000 t). Thus, the revised figures indicate that inland fisheries and aquaculture (a majority of which is from freshwater systems) are much more important to fisheries production in Myanmar than was previously believed.

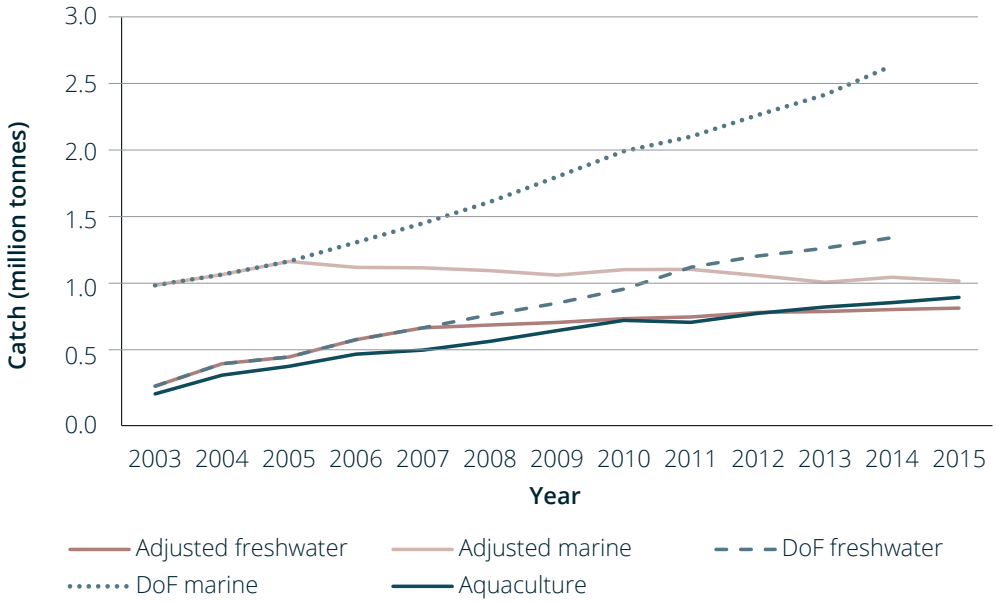

Figure 21. Comparison of Department of Fisheries statistics and the adjusted figures calculated by FAO (2016) for marine and inland capture fisheries production (FAO did not adjust DoF aquaculture statistics)

The significant discrepancies generated by factor-based calculations are apparent in the DoF data for production from open and leasable fisheries. The increasing number of gear licences issued by DoF directly translates to rising production figures for open-access fisheries, with no relation to actual landings; as a result, the contribution of leasable fisheries to total inland catches is under-reported, despite leasable production being over-reported (Tezzo et al. 2016). A comparison of the yield and number of leasable fisheries suggests a 300% increase in productivity between 1996 (3,385 leasable fisheries producing 62,600 t) and 2007 (3,460 leasable fisheries producing 191,000 t) (MMRD 2010). According to official figures, leaseholds accounted for 45% of the inland fisheries production in 1994 and only 22% in 2014. There is no biological rationale to explain such rapid growth in open fisheries production compared with leasable fisheries. On the contrary, most evidence suggests that leaseholds are areas demarked because they support the most productive fisheries areas.

The average rate of aquaculture production, reported in national statistics as 10.7 t/ha (DoF 2015), is also believed to be an overestimate, which is probably a result of DoF collecting production data only from large-scale and more intensive operations. During interviews in 2014, fish farmers reported yields ranging from 1 to 10 t/ha, with average yields of 3.7 t/ha (Belton et al. 2015). This figure is similar to that found in a study of 3,000 large-scale farmers in 2009, in which the average yield was 4.5 t/ha, with only the best-performing farmers reporting 12.5–16 t/ha (Edwards 2009).

National figures of pond surface area are also misleading; a study of satellite data revealed roughly a doubling in pond surface area in the AD over the past decade, a significantly larger increase than reported by DoF (Belton et al. 2015). Hence, in contrast to what is implied by national statistics, increased aquaculture production is partly explained by increased pond area, as well as rising yields per hectare due to the stocking of larger fingerlings, which reduces the length of production cycles (from 12 to 9 months), and some increase in feed use (Belton et al. 2015).

Chapter 7

Areas for improvement

The following sections draw upon the recommendations developed by the Myanmar Fisheries Partnership. The recommendations summarise the priority improvements needed to support the sustainable development of Myanmar's inland fishery sector (MFP 2016a) and aquaculture sector (MFP 2016b).

Inland fisheries

Building a better knowledge base

The historical focus of DoF on revenue and stocking, and the tradition of using factor-based calculations and centralised targets has compromised data quality and encouraged misreporting in national statistics. As a result, knowledge of Myanmar's fishery resources is limited (Johnstone et al. 2013). Understanding the environmental and biological limitations to the country's fishery resources will be critical to ensuring the sustainable development of the sector and assessing the viability of the optimistic target for a 30-fold production increase over three decades.

Actual sampling, rather than factor-based estimates, of fishing activities and catches in Myanmar's inland fisheries is needed. Reliable, comprehensive and disaggregated data would support improved management and prevent overexploitation from continuing undetected. Improved monitoring should involve some form of regulation of the 16 types of gear that currently do not require licensing by DoF—in some areas, unlicensed gear can account for more than half of fishing activities, and failing to take these activities into account will provide misleading figures (MMRD 2010; SEAFDEC 2012).

A great deal more research is needed on the numbers, species and distribution of fishes, including the migration routes, breeding sites and life histories of targeted species, to develop locally appropriate management strategies (Johnstone et al. 2013). Better mapping of Myanmar's inland water resources, including rivers and flood plains, would help to identify and demarcate areas of ecological and fishery importance that should be prioritised for protection (FAO & NACA 2003). Understanding the ecological impacts of large-scale stocking programs should be a priority.

Introducing comprehensive sampling is an unrealistic ambition, and so a set of ecological and socioeconomic indicators should be developed that can be assessed at least monthly. Fisheries monitoring is still typically recorded on paper; consequently, there is no standardised system or centralised collation of data. A standardised digital system for fisheries should be introduced to enable data from across the country to be collated, compared and analysed (Baran & Joffre 2017; De Graaf 2014).

The existing strong presence of DoF at the township level means that officers are available to implement large-scale monitoring (Baran & Joffre 2017). However, for monitoring to be effective, the capacity of DoF will need to be strengthened. In December 2014, DoF established, for the first time, 11 leasable fisheries for research purposes. The key aims of these research leaseholds were to prevent the extinction of indigenous species and fisheries habitat, promote fish production and collect data related to leasable fisheries (DoF 2015). However, there is little evidence of these aims being realised. Forming partnerships and collaboration between government, NGOs, universities and the private sector will help build capacity in the fisheries sector (MFP 2016a).

Integrating land and water resource management

The recent integration of agriculture, irrigation and fishery departments under one ministry creates a better institutional environment for coordinating resource management. This should be used as an opportunity to address the confusing and sometimes conflicting policies surrounding land- and water-use rights, particularly in seasonally flooded areas (Campbell 2019; Tezzo et al. 2018).

Promoting a policy focus on livelihoods and food security

The focus of fisheries and rural development policy in Myanmar needs to shift to better support livelihoods, and improve nutrition and income security. Myanmar has a policy stating that fish can only be exported once domestic demand has been met, but existing information on fish consumption is inadequate (Soe 2008). Thus, monitoring of Myanmar's fishery sector needs to extend beyond harvesting activities and production to encompass associated value chains, including socioeconomic assessments. Socially disaggregated data are needed to understand the role of fish for income and nutrition security of different groups.

The successful development and implementation of policies and legislation that are more focused on livelihoods will depend on building the organisational capacity of DoF, and improving partnerships between the government, NGOs and civil society organisations. Management strategies should draw on the principles of the FAO Code of Conduct for Responsible Fisheries, and 'Voluntary guidelines for securing sustainable small-scale fisheries in the context of food security and poverty eradication' (MFP 2016a).

Improving the sustainability and benefits of production systems

Livelihoods-focused policy reform should also include improved social equity through changing the system of tenure for leasable fisheries and enabling community management arrangements. The current leasable system is at odds with sustainable fisheries management because high lease prices favour ownership by wealthy business people from remote urban centres, who have little interest in the long-term sustainability of the fishery resource. As well, relatively high fees paid by fishers to access leased fishing grounds leads to an incentive to maximise harvest in the shortest time possible (Tezzo et al. 2016; Venkatesh 2015).

Management of fishery resources by local resource users could be enabled through community-based arrangements. This will require capacity building and improved governance at all levels to ensure that the outcomes are meaningful, equitable and sustainable (Ratner 2006; Venkatesh 2015). Myanmar should capitalise on experiences and lessons learned in neighbouring countries. For example, in Cambodia, community-managed fisheries faced several management problems because fisheries management and conservation measures were not effectively conducted by the Cambodian Fisheries Administration (Ratner 2006).

Developing new systems

Permitting reservoir fisheries would benefit livelihoods through increased production. It has been estimated that permitting fishing in Myanmar's more than 115,000 ha of reservoirs could provide employment for 20,000–30,000 people (FAO & NACA 2003). Even very low production levels (50 kg/ha) in Myanmar's reservoirs would yield about 90,000 t of fish per year (UNDP 2004), and have a significant impact on national food supplies and the nutrition security of resource-poor inland families.

Further, licensing aquaculture in reservoirs would provide a new income stream for the government, increase fish production, encourage private sector investment in rural areas and improve the efficiency of water-resource use (MFP 2016b). A softening of the policy that bans reservoir fishing seems to be taking shape, at least at the regional level. For example, the Sagaing Regional Government agreed with the principle of allowing neighbouring communities to fish in reservoirs of less than 200 ha that are under local government control (bigger reservoirs are under ministry management; MYFish 2013b). Experience in other Asian countries demonstrates that there should not be any conflict between creation of reservoirs for irrigation purposes and use of these water bodies for fish production. Other countries have actively established very rich and successful fisheries in reservoirs with little environmental impact (FAO & NACA 2003; UNDP 2004).

Aquaculture

Reforming regulatory legislation

Issues of social inequity in the governance of aquaculture in Myanmar must be addressed for the sector to contribute to improved food and income security. Addressing the culture of land grabbing would support much-needed improvements in security of property rights in the country. Reviewing restrictive land-use policies, particularly the *Farmland Law*, would make fish farming a more viable livelihood option for small-scale operators. Changes in the policy environment aimed at promoting sector growth must be complemented by regulations to minimise the environmental degradation associated with unsustainable aquaculture activities, such as those observed in Vietnam (Bush, Kheim & Sinh 2009).

The current aquaculture monitoring system should be reviewed to account for small-scale operations. The *Union Aquaculture Law* requires the licensing of ponds larger than 121 m^2, although, in practice, DoF usually regards those smaller than 4,047 m^2 as 'backyard ponds'. Backyard ponds are not included in official reporting, thus essentially eliminating the small-scale sector from national statistics.

Improving access to inputs and technology

Improving small-scale aquaculture in Myanmar will require investment in infrastructure and building the capacity of fish farmers. Feed mills should be introduced and commercial feeds subsidised to reduce reliance on cheap, homemade feeds. Increasing the number of hatcheries, including by continuing to establish backyard hatcheries, and eliminating the use of suboptimal hatchery technologies and inbreeding should be prioritised to increase the availability of quality seed.

Hatcheries should also be encouraged to produce a more diverse range of fish species, particularly native species, to reduce reliance on rohu. There is some evidence of DoF hatcheries testing production methods for eels, snakeskin gourami and mola (DoF Aquaculture Deputy Director, pers. comm.), but the sector would benefit from collaboration with international research organisations to test new potential aquaculture species.

Different culture techniques should be tested to identify and develop ecologically and socially appropriate systems (Pant et al. 2014); for instance, in the CDZ, short-cycle fish farming techniques with local species and water-saving technology (e.g. using water from bathing in the household) should continue to be explored (MYFish 2013b). Relatively new systems, such as mud crab and swamp eel culture, should be assessed for their profitability and sustainability (Lat, Tezzo & Johnstone 2014; Marius 2013; MYFish 2013a; Oo 2014).

Investment in landing site, preservation and transport facilities would help to improve and expand aquaculture and inland fishery value chains and ensure good fish quality for the end consumer. The bargaining capacity of producers should be strengthened to reduce their dependency on middlemen. This will require development of community institutions, and access to ice, markets and credit. Restrictions and legislation that limit the transport of harvested fish between states and regions should be addressed to enable small-scale operators to trade in wider markets.

Strengthening capacity

Myanmar's small-scale aquaculture sector should capitalise on the considerable aquaculture knowledge base that already exists in several Asian countries, to establish best practices (Pant et al. 2014). Increased stocking densities, proper feeding and fertilisation, multiple harvest strategies and appropriate species selection should be encouraged through extension services and training for small-scale aquaculture households (Belton et al. 2015; Pant et al. 2014). Encouraging knowledge sharing will help to ensure widespread adoption of improved aquaculture activities (Pant et al. 2014).

Knowledge sharing must be supported by better access to formal credit to increase fish farmers' capacity to start and develop aquaculture activities and reduce the costs of informal borrowing (Belton et al. 2015). Limited access to bank loans for resource-poor households is a key obstacle to the development of small-scale aquaculture; the majority of small-scale fish farmers (70.6%) use their own funds to start their activity (Pant et al. 2014). Private sector partners will play an important role in supporting the development of small-scale aquaculture through the introduction of new technologies and knowledge-sharing platforms—for instance, mobile phone applications for fish farmers.

Chapter 8

Conclusions

Myanmar supports a highly productive and important fishery sector. Major features of the sector are as follows:

- Fishing and aquaculture activities and their associated value chains provide an important source of income and employment.
- Fish is the main source of protein consumed in Myanmar, and only a small proportion of fish production is exported.
- Consumers show a preference for inland species, and increasing demand is being met by growth in aquaculture production and better distribution through the urban fresh fish value chain.

Myanmar's inland capture fisheries depend on the country's large rivers and lakes. A variety of fish species are targeted in different habitats using a range of fishing gear. However, these fishery resources are vulnerable to the impacts of climate change and other anthropogenic stressors, including the development of hydropower, which may threaten important migratory species such as hilsa. The historical focus of fisheries policy on revenue collection has led to inequitable and unsustainable governance under which rights to the most productive fisheries are allocated to wealthy individuals or organisations through leases and licences.

Aquaculture in Myanmar is characterised by both small 'homestead' ponds and very large ponds. This dualism is the result of government policies restricting the conversion of paddy fields to ponds, while simultaneously providing concessions to commercial operations. Aquaculture management in Myanmar is suboptimal, and production is dominated by rohu. Stocking strategies appear to be determined by availability and convenience rather than best practice. The use of agricultural waste as feed to avoid the high price of commercial feeds has resulted in low yields.

Myanmar's fishery and aquaculture sectors are characterised by a dearth of knowledge. In the past, limited independent studies led to a heavy reliance on national statistics, which are widely believed to be inaccurate and based on targets. Poor reporting methods and factor-based calculations mean that, despite failure to account for subsistence and unlicensed fishing, national production figures overestimate production. An adjustment of national production statistics by the FAO still ranks Myanmar as one of the world's biggest fish producers, but suggests that growth in capture fisheries is declining, and that inland fisheries and aquaculture make a more important contribution than was previously believed. Inadequate data for Myanmar's fisheries prevent the monitoring of ecologically and commercially important stocks, and assessments of sector viability. Improved monitoring, to provide disaggregated catch data and information on the role of fish in

domestic consumption and local economies, must be a priority to strengthen scientific knowledge of the sector and fishery resources. Key focus should be placed on assessing the potential implications of hydropower development, on analysing the impacts of the stocking program and on building sector resilience to climate change.

Recent sector reforms have supported a shift towards an approach to fisheries management that focuses more on livelihoods. The restructuring of ministries has addressed some of the complexity and confusion surrounding resource governance, and the decentralisation of freshwater fisheries legislation and relaxing of land-use regulations are promoting more socially equitable rights and governance systems. However, many improvements are still needed.

The mismanagement of Myanmar's fisheries will have significant ecological and socioeconomic consequences. For the fishery and aquaculture sectors to sustainably support the livelihoods of the many people who depend on them will require capacity building at all levels, investment in infrastructure and further improvement in governance systems. DoF is severely short of funding and capacity to carry out its functions effectively, and budget and staff capabilities all need significant upgrading. Interagency cooperation and partnerships will play a key role in supporting a positive change in Myanmar's fisheries.

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