Integrated Mangrove Management in Myanmar

Asia-Pacific Network for Sustainble Forest Management and Rehabilitation (APFNet)

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Special thanks to the Project Coordinator, Dr. Sang Phan, who was available for further questions - even after the project.

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ACRONYMS AND ABBREVIATIONS

ADB	Asian Development Bank
APFNet	Asia-Pacific Network for Sustainable Forest Management and Rehabilitation
BOBLME	Bay of Bengal Large Marine Ecosystem Project
CF	Community Forestry
CFI	Community Forestry Instruction
CFUG	Community Forestry User Group
CIFOR	Center for International Forestry Research
CIRAD	Centre de coopération internationale en recherche agronomique pour le développement
DANIDA	Danish International Development Agency
DBH	Diameter at Breast Height
FAO	Food and Agriculture Organization of the United Nations
FD	Forest Department
GGGI	Global Green Growth Institute
GIS	Geographic Information System
GPS	Global Positioning System
JICA	Japan International Cooperation Agency
LSWC	Local supply working circle
MMK	Myanmar Kyat
MONREC	Ministry of Natural Resources and Environmental Conservation
MRRP	Myanmar Reforestation and Rehabilitation Programme
M&E	Monitoring and Evaluation
NAPA	National Adaptation Program of Action
NBSAP	National Biodiversity Strategies and Action Plan
NFMP	National Forest Master Plan
NGO	Non-governmental Organization
NP	National Park
NTFP	Non-Timber Forest Product
PA	Protected Area
PFE	Permanent Forest Estate
PMFR	Pyindaye Mangrove Forest Reserve
PPF	Protected Public Forest
RF	Reserve Forest
SFM	Sustainable Forest Management
UNDP	United Nations Development Programme
UNEP	United Nations Environment Programme
UNFCCC	United Nations Framework Convention on Climate Change
UQ	The University of Queensland
WIF	Worldview International Foundation

EXECUTIVE SUMMARY

This report provides an overview of the APFNet project "Integrated planning and practices for mangrove management associated with agriculture and aquaculture in Myanmar", conducted from 2018 to 2022 in the Pyindaye Mangrove Forest Reserve, Amar Sub-township, Republic of the Union of Myanmar. The project was implemented in cooperation with the University of Queensland, Australia serving as the Executing Agency, and Myanmar Forest Department (FD) as the Supervisory Agency. The project aimed to restore mangroves, improve local communities' quality of life, and promote sustainable mangrove forest and mangrove aquaculture management. The project successfully contributed to the development of policies and regulatory frameworks supporting sustainable mangrove forest management practices.

Key impacts of the project include changes to policies, strategies and plans in the forest sector. The project facilitated the establishment of **71 ha** of mangrove restoration and aquaculture demonstration models by both local communities and technical staff. It focused on integrating mangrove restoration with aquaculture activities in five villages, promoting sustainable approaches. As such Community Forestry User Group (CFUG) members were allowed to utilize water bodies inside their land parcel in the Community Forest (CF) for fish, crab, and shrimp production, offering a more sustainable approach to aquaculture. Over **400 CFUG** households directly benefited from participating in the project, with a **55%** increase in mud-crab productivity observed in pilot mangrove aquaculture models.

Additionally, the project established pure mangrove restoration demonstration models covering **5 ha**. These pilot models allowed for a comprehensive study of factors influencing successful mangrove growth and increased overall wood production, contributing to an increased income from timber and firewood for mangrove owners. The project included the cultivation and distribution of the Rhu tree (*Casuarina equisetifolia*) and paper bark tree (*Melaleuca cajuputi*) seedlings. Over **17,000 seedlings of *C. equisetifolia* and 6,000 seedlings of *M. cajuputi*** were given to the Pyapon FD and local communities. Moreover, the project facilitated the planting of 20,000 seedlings of *M. cajuputi*, covering an area of **2.8 ha** on private land. Planting these species in the coastal areas brought benefits to both the community and the environment, with economic opportunities for landowners.

In terms of capacity building, **30 forestry officers** were trained in geographic information systems (GIS) and land use planning for mangrove forest management. The project effectively engaged **195 village leaders, local staff, and key farmers**, with a focus on the empowerment of women in mangrove management. Gender equality was promoted through the participation of **60 women**.

In conclusion, the project successfully achieved its objectives of mangrove restoration, improved community livelihoods, and promoted sustainable forest management and mangrove aquaculture. The project's impact will continue through the capacity built among local institutions and communities, enabling them to sustainably manage their forest resources.

OVERVIEW

Project title:	Integrated planning and practices for mangrove management associated with agriculture and aquaculture in Myanmar
Supervisory agency:	Myanmar Forest Department
Executing agency:	The University of Queensland, Australia
Implementation agencies:	The University of Queensland, Australia, and the Watershed Management Division, Forest Department of Myanmar
Project Location:	Pyindaye Mangrove Forest Reserve, Amar Sub-township, Republic of the Union of Myanmar
Project Period:	54 months (January 2018 – June 2022)
Total Budget USD:	US$ 547,070
APFNet grant:	US$ 309,670

PROJECT GOAL:

Building capacity for mangrove restoration and sustainable forest management (SFM) in the project region of the Ayeyarwady Delta in Myanmar while enhancing agriculture and aquaculture related to and compatible with the sustainable management of mangroves within the project area.

PROJECT OBJECTIVES:

- Investigate key issues associated with mangrove deforestation and degradation
- Conduct participatory micro-planning for mangrove management associated with agriculture and aquaculture development
- Apply best practices in mangrove restoration, mangrove management and aquaculture in mangrove forests in the project area
- Enhance policy development capacity to facilitate mangrove restoration and mangrove management design and implementation
- Contribute to sustainable livelihoods and community development within the project area

1 INTRODUCTION

From 2018 to 2022, APFNet worked with the FD of Myanmar and the University of Queensland (UQ) in Australia on a project titled 'Integrated planning and practices for mangrove management associated with agriculture and aquaculture in Myanmar".

The target areas are the communities and forests in Pyindaye Mangrove Forest Reserve (PMFR), which covers over 485.6 km^2 (48,562 ha) and includes the Amar sub-township with over 100,000 inhabitants. The PMFR is located in the eastern part of the Ayeyarwady Delta (between the latitudes 15° 42′ and 16° 3′ N and 95° 16′ and 96° 41′ E) and is surrounded by the Myanmar Sea and the Bay of Bengal to the south and southwest (Fig.1). For the purpose of planning and management, the reserve was divided into 66 compartments. Local communities, especially villages within the PMFR, have livelihoods that heavily rely on mangrove forests, as well as agriculture and aquaculture on land converted from mangroves. This project explored approaches for the sustainable restoration and management of mangroves in line with livelihood improvement through agriculture and aquaculture practices by investigating issues associated with mangrove conversion and degradation in the project area.

The total actual budget of the project was USD 547,070, of which APFNet provided USD 309,670. The execution of the project with some in-kind contributions was undertaken by UQ, Australia. The Watershed Management Division of the Myanmar Forest Department and UQ collaborated on project implementation

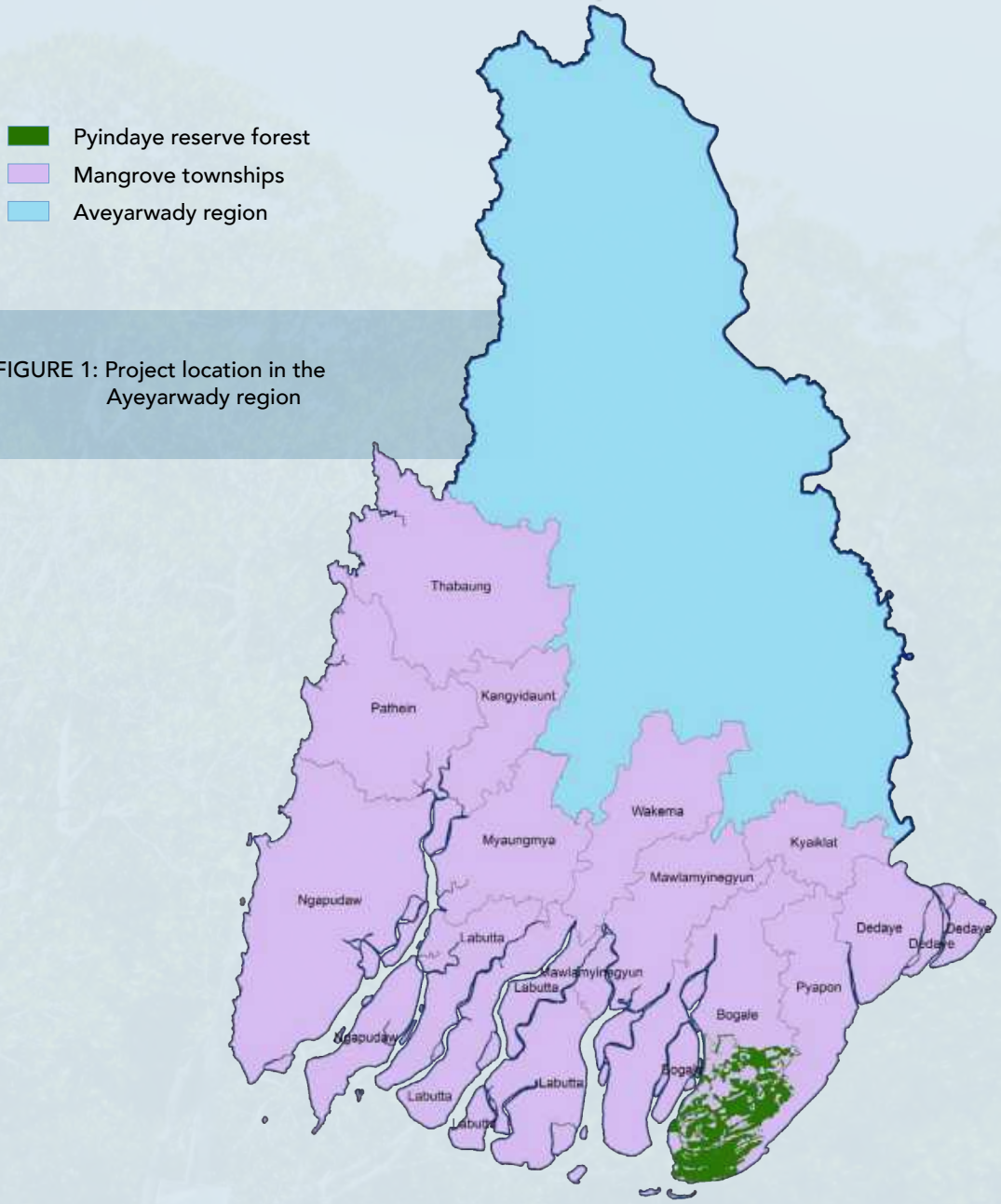


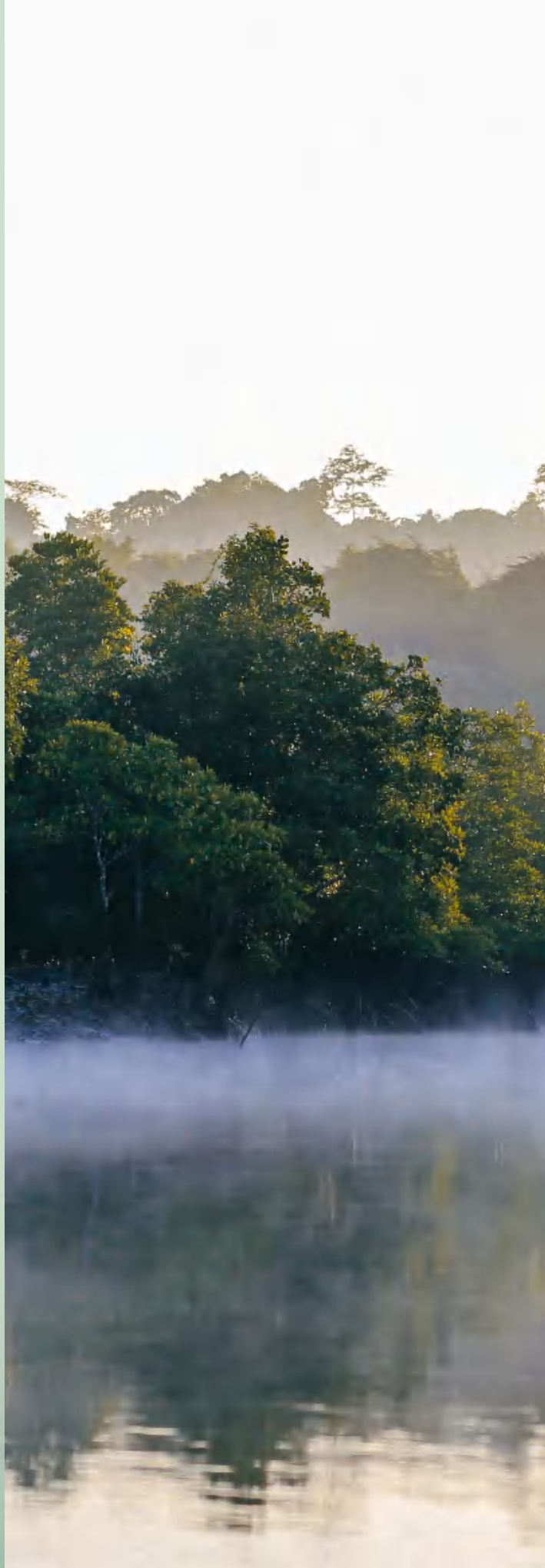
FIGURE 1: Project location in the Ayeyarwady region

The project aimed to achieve four specific outcomes;

1. The development of integrated micro-planning approaches for sustainable mangrove management associated with agriculture production in the selected landscapes;
2. The implementation of the plans developed by the community and the establishment of pilot models to demonstrate best practices on mangrove restoration and management in Myanmar;
3. Capacity building and expertise exchange;
4. The improvement of ecosystem services, local livelihoods, and various scientific outputs.

2 FORESTS IN MYANMAR

Myanmar is the largest economy in mainland Southeast Asia with a land area of about 67,657,700 ha and its **geographic location** between 9° 32′ and 28° 31′ N latitude and 92° 10′ and 101° 11′ E longitude. The Myanmar coastline is about 2,832 km long, with the continental shelf covering an area of approximately 23,000,000 ha. Myanmar shares common maritime boundaries with Bangladesh in the Bay of Bengal and India and Thailand in the Andaman Sea. Its Exclusive Economic Zone (EEZ)[1] has a size of about 48,600,000 ha and freshwater bodies cover 8,100,000 ha (BOBLME, 2012). Fishery resources in Myanmar waters are typical of Southeast Asia with a large quantity of fish and shrimp in the EEZ. Myanmar has a tropical to subtropical monsoon **climate**. However, the local climate varies across Myanmar's different ecological zones, mainly being influenced by altitude and distance from the coasts. Myanmar's southern regions in and around the Ayeyarwady Delta and along the Rakhine, Mon, and Tanintharyi coast lines experience a tropical climate of Southeast Asia: precipitation can be very high ranging between 2,538 mm and 5,076 mm per year, while temperatures are high and generally show little variation throughout the year. Due to the wide extent, varied topography, and different climatic conditions, Myanmar's **forests** have a diverse species composition and stand structure, which makes them a valuable ecosystem. About 42.19% of the Myanmar's land area is covered by forests, accounting for 28,543,900 ha (FAO, 2020). Based on the Forestry in Myanmar report (2020), there are six major forest types in Myanmar, however, the majority of the forest area is covered by mixed deciduous forest (38.20%), and hill and temperate evergreen forests (26.92%). The remaining forest types are tropical evergreen forest (17.30%), dry forest (10%), deciduous dipterocarp forest (4.26%), and tidal, beach, dune, and swamp forest (3.32%), respectively (Fig.2).



[1] The exclusive economic zone is a maritime area extending up to 200 nautical miles from the nation's coastline. It grants the coastal state exclusive rights over the exploration and use of resources in the zone's waters and seabed, while allowing other nations freedom of navigation and certain limited activities.

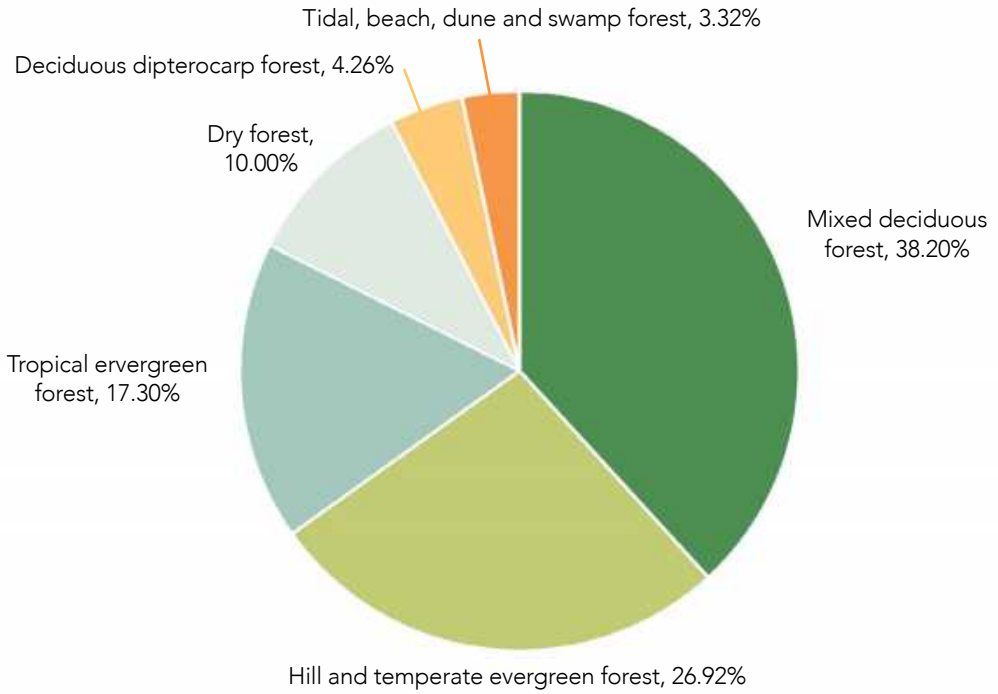


FIGURE 2: Forest types in Myanmar

Legal Protection of Forests in Myanmar

All land in Myanmar is state-owned. The responsibility for the management of forest resources lies with the FD under the Ministry of Natural Resources and Environmental Conservation. The concept of Permanent Forest Estate (PFE) encompasses several sub-types, such as Reserved Forests (RFs), Protected Public Forests (PPFs), and Protected Areas (PAs) and this division is used to manage all forest types in Myanmar. PFE refers to designated forest areas that are legally protected and managed using sustainable forestry principles and for conservation purposes. Mangroves have been managed under the PFE since the British colonial days. As of August 2021, the PFE area covers about a quarter of Myanmar's land (17,326,446 ha), with the RF sub-type accounting for most (12,017,240.5 ha) and PPF is 5,309,205.5 ha. Furthermore, an estimated 4,121,496 ha of distinct forest ecosystems have been preserved under the category of PA which covered 6.09% of total forest area in Myanmar.

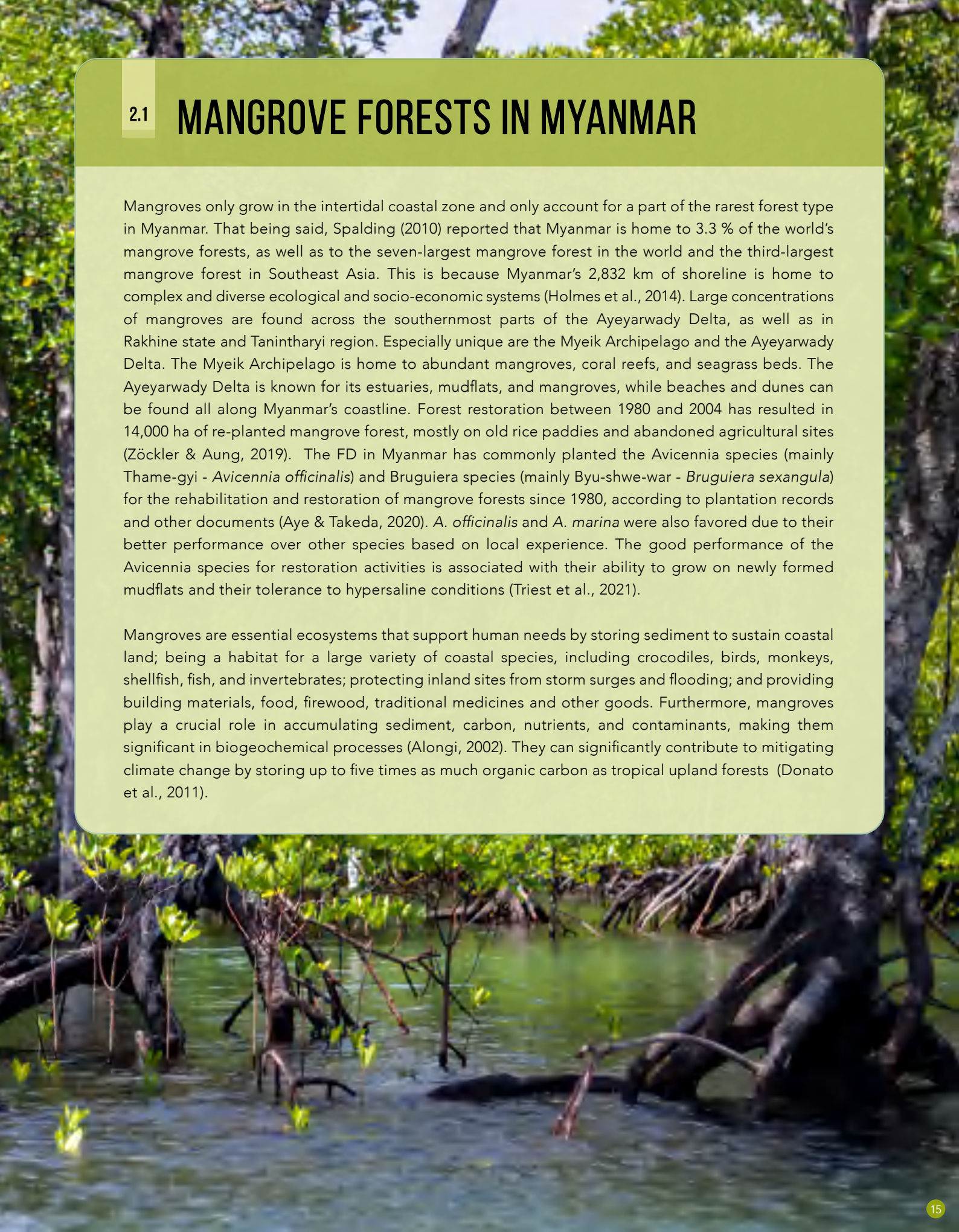
Much of Myanmar's forests, including mangroves remain "Unclassified Forests". These areas are not included in the legally defined "Forest Lands". The responsibility for the management of these "Unclassified Forests" lies primarily with the Department of Agricultural Land Management and Statistics within the Ministry of Agriculture, Livestock, and Irrigation as well as other land-managing departments and ministries (UNEP-WCMC, 2022). This management is conducted through the implementation of the 2012 *Vacant, Fallow and Virgin Lands Management Law*.

Conservation and Protection of Myanmar's Forests

In Myanmar, the terms "**Reserved Forest**," "**Protected Public Forest**," and "**Protected Areas**" refer to different categories of forest management and conservation. The responsibility of forest resources rests with the FD under the Ministry of Natural Resources and Environmental Conservation.

1. **Reserved Forest (RF)**: Reserved Forest is an area of land that is legally protected and set aside for the conservation and management of forest resources. These forests are known for their best quality and high commercial value. Access and utilization of forest resources within a reserve forest are subject to specific regulations and restrictions to ensure sustainable management and conservation. However, no harvesting rights are granted to the public in reserve forests.
2. **Protected Public Forest (PPF)**: Protected Public Forest is another category of legally protected forestland in Myanmar. These forests are designated to prevent the degradation of natural resources. These forests typically have lower commercial value compared to reserve forests. They are relatively more accessible and importantly, grant certain harvesting rights to the public.
3. **Protected Areas**: The Protected Area System in Myanmar comprises a network of designated areas that are legally protected to conserve biodiversity, ecosystems, and natural heritage. These areas can include national parks, wildlife sanctuaries, nature reserves, and other protected zones. The PA System aims to safeguard key habitats, ecosystems, and species of conservation importance while providing opportunities for scientific research, environmental education, and sustainable nature-based tourism.

The specific management regulations, boundaries, and classifications of RFs, PPFs, and PAs may vary based on the applicable laws, polices and management plans in Myanmar.



2.1 MANGROVE FORESTS IN MYANMAR

Mangroves only grow in the intertidal coastal zone and only account for a part of the rarest forest type in Myanmar. That being said, Spalding (2010) reported that Myanmar is home to 3.3 % of the world's mangrove forests, as well as to the seven-largest mangrove forest in the world and the third-largest mangrove forest in Southeast Asia. This is because Myanmar's 2,832 km of shoreline is home to complex and diverse ecological and socio-economic systems (Holmes et al., 2014). Large concentrations of mangroves are found across the southernmost parts of the Ayeyarwady Delta, as well as in Rakhine state and Tanintharyi region. Especially unique are the Myeik Archipelago and the Ayeyarwady Delta. The Myeik Archipelago is home to abundant mangroves, coral reefs, and seagrass beds. The Ayeyarwady Delta is known for its estuaries, mudflats, and mangroves, while beaches and dunes can be found all along Myanmar's coastline. Forest restoration between 1980 and 2004 has resulted in 14,000 ha of re-planted mangrove forest, mostly on old rice paddies and abandoned agricultural sites (Zöckler & Aung, 2019). The FD in Myanmar has commonly planted the Avicennia species (mainly Thame-gyi - *Avicennia officinalis*) and Bruguiera species (mainly Byu-shwe-war - *Bruguiera sexangula*) for the rehabilitation and restoration of mangrove forests since 1980, according to plantation records and other documents (Aye & Takeda, 2020). *A. officinalis* and *A. marina* were also favored due to their better performance over other species based on local experience. The good performance of the Avicennia species for restoration activities is associated with their ability to grow on newly formed mudflats and their tolerance to hypersaline conditions (Triest et al., 2021).

Mangroves are essential ecosystems that support human needs by storing sediment to sustain coastal land; being a habitat for a large variety of coastal species, including crocodiles, birds, monkeys, shellfish, fish, and invertebrates; protecting inland sites from storm surges and flooding; and providing building materials, food, firewood, traditional medicines and other goods. Furthermore, mangroves play a crucial role in accumulating sediment, carbon, nutrients, and contaminants, making them significant in biogeochemical processes (Alongi, 2002). They can significantly contribute to mitigating climate change by storing up to five times as much organic carbon as tropical upland forests (Donato et al., 2011).

GLOBAL MANGROVE RESOURCES

Mangroves make up less than 1% of all tropical forests on the world, but they stand out from inland forests due to their unique characteristics. Mangroves are salt-tolerant woody plants that grow in the interface between land and sea of tropical and sub-tropical latitudes (Kathiresan & Bingham, 2001). They are adapted to a variety of harsh environmental factors, including salinity, high temperatures, low oxygen levels, and contaminated environments. Mangrove plants grow in waterlogged soils and are capable of tolerating oxygen from only 2% to as much as 90% (Africa, 2007). To deal with the salt stress, different mangrove species use different combinations of the three salt eliminating mechanisms: salt exclusion (roots), salt excretion, and salt accumulation (leaves) (Fig.3).

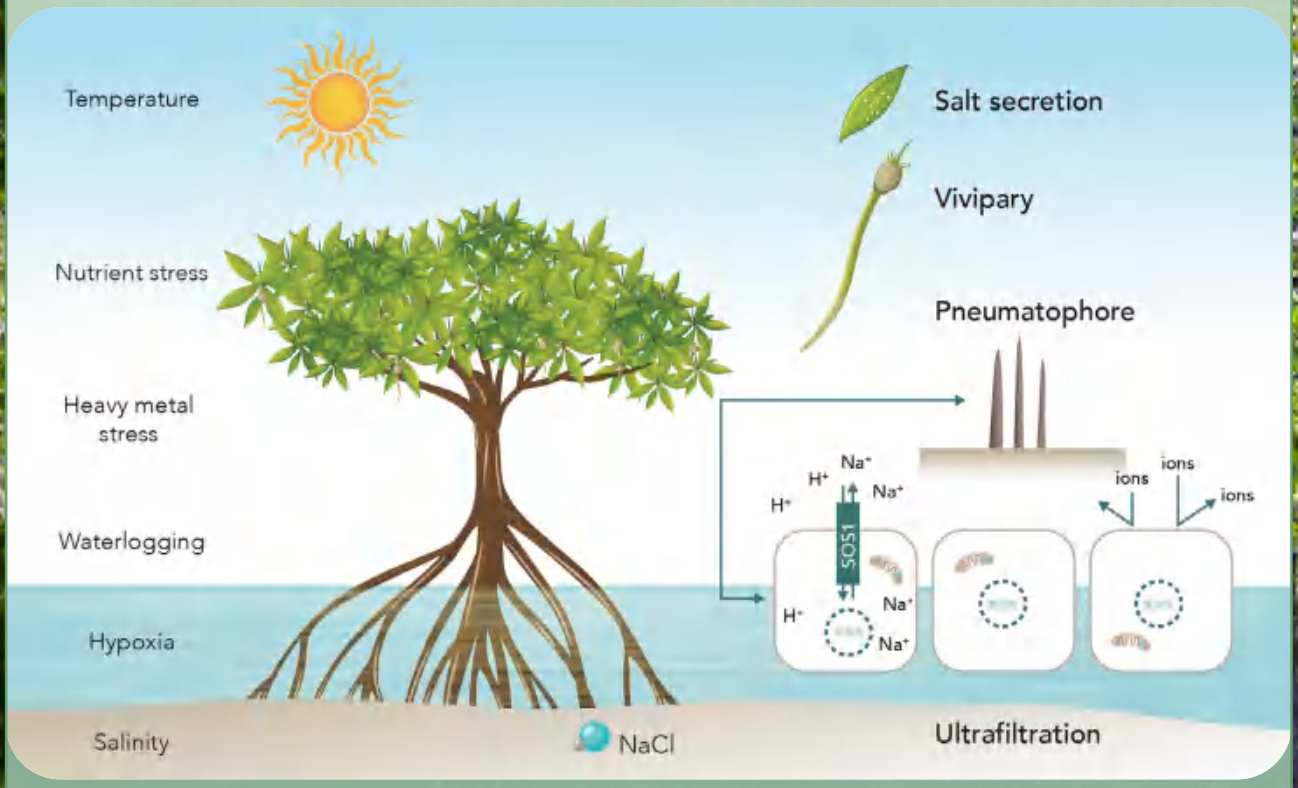


FIGURE 3: Environmental stresses dominating intertidal zones and unique mangrove adaptive traits to conditions (Nizam et al., 2022)

Distribution and zonation pattern of mangroves largely depend on the geographical location (sea or landward), tidal inundation, and freshwater inlets. In general, Avicennia, Sonneratia, Kandelia, and Rhizophora species tend to grow seaward, whereas Bruguiera and Excoecaria species were observed to grow on landwards coastal sections (Fig.4).

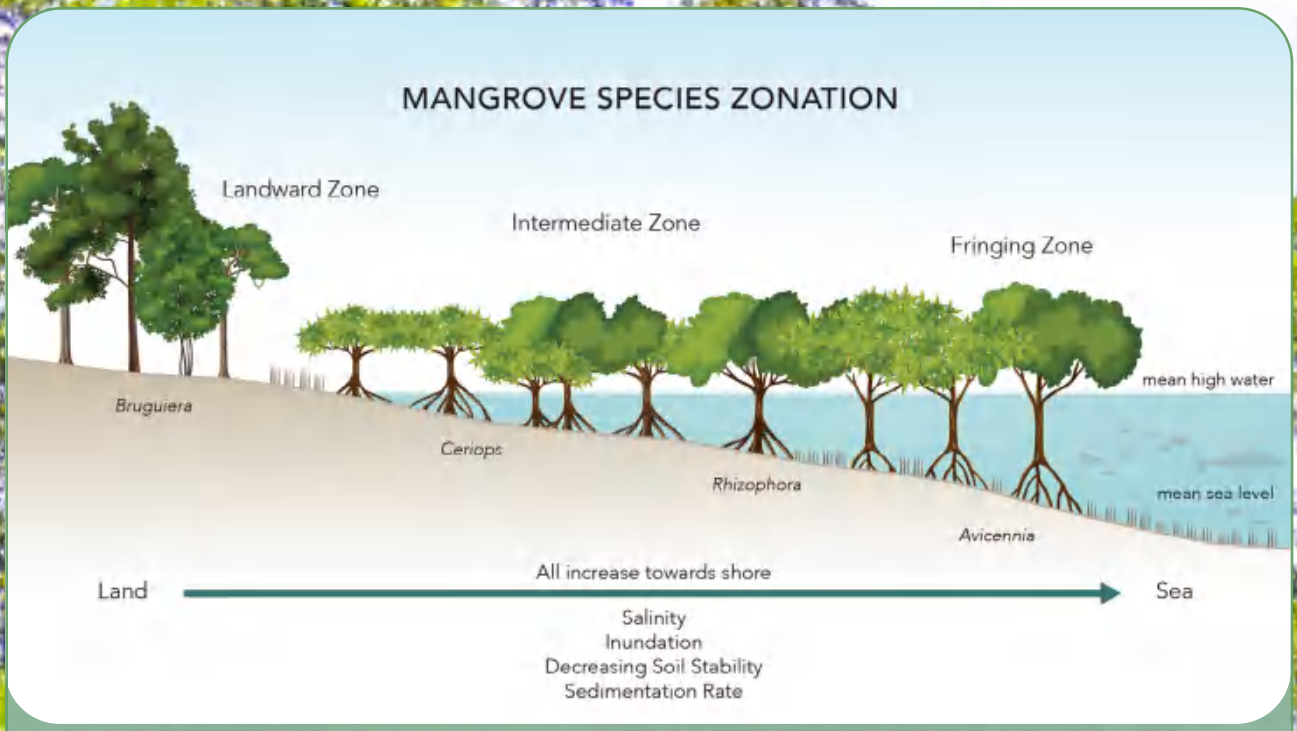


FIGURE 4: Mangrove species zonation (Photo by CCEF)

Mangroves can be found in more than a hundred economies in the tropical and subtropical regions of the world and are located mostly at the transition between freshwater and saline water environments (Giri et al., 2011, 2015). The largest areas of mangroves are found in Asia and Africa, followed by North and Central America, South America, and Oceania. The most extensive area of mangroves is found in Southeast Asia, with Indonesia alone comprising one fifth of the global total. Together, Indonesia, Brazil, Australia, Mexico, and Nigeria host almost half of the world's mangroves. Mangrove distribution zones and the number of mangrove species found in each region are shown on Fig.5.

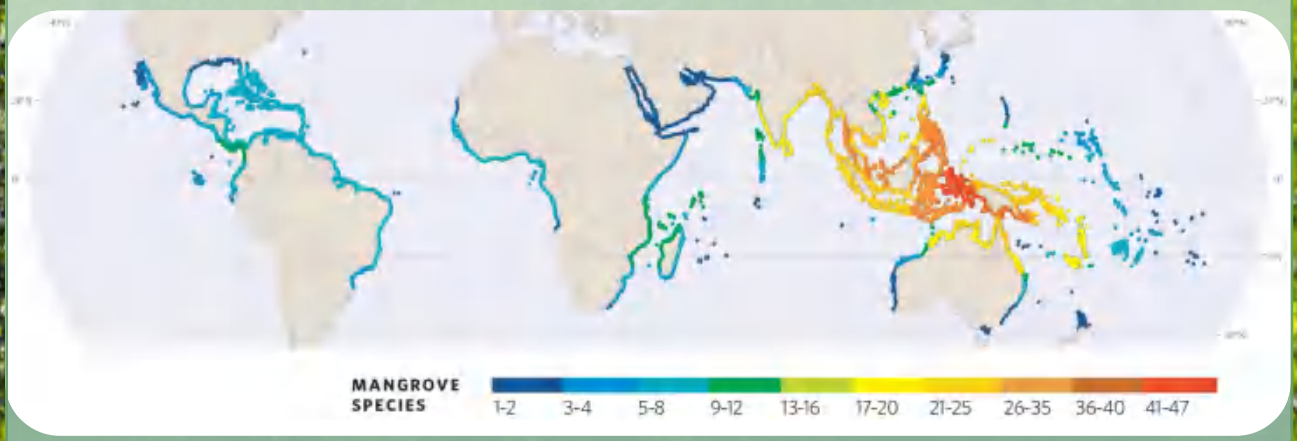


FIGURE 5: World map of the mangrove distribution zones and the number of mangrove species along each region (Ecoshape, 2016)

MANGROVES IN AYEYARWADY REGION

The Ayeyarwady Delta is a vast alluvial floodplain and has an area of 3,367,000 ha (JICA, 2005). The mangrove forests in this delta region are the largest in Myanmar, comprising 46.4% of the nation's total mangrove forests (Htay, 2016). These mangroves extend inland for up to 60 km. The soil in the area mostly consists of mudflats and silty clay soil. The salinity level in the soil varies between dry and rainy season. During the dry season, the salinity reaches the highest levels, ranging from 30 to 35 parts per thousand (ppt), whereas in the rainy season, the salinity ranges from 0 to 20 parts per thousand (ppt). The Ayeyarwady Delta harbors diverse mangrove systems, with 29 confirmed species of mangrove trees, making it the most complex mangrove system in Asia, as stated by Tomlinson (1986).

The Ayeyarwady mangroves consist of Byu-chi-dauk apo (*Rhizophora apiculata*) (Fig.6), Byu-chi-dauk ama (*Rhizophora mucronata*), Byu-shwe-war (*Bruguiera sexangula*), Byu-kyet-tet (*Bruguiera parviflora*), Byu-u-talon (*Bruguiera gymnorhiza*), Byu-war-kyeit-lain (*Bruguiera cylindrica*), Kanazo (*Heritiera fomes*), Kanbala (*Sonneratia apetala*), Laba (*Sonneratia griffithii*), Lamu (*Sonneratia caseolaris*), (*Xylocarpus granatum*), Pinle-on (*Xylocarpus moluccensis*), Madama (*Ceriops decandra*), Thame-kyet-tet (*Avicennia alba*), Dani (*Nypa fruticans*), Thame-gyi (*Avicennia officinalis*) (Fig.7), Baing-daung-she (*Kandelia candel*), Thayaw (*Excoecaria agallocha*) and other halophytic associates. Besides a wide variety of flora, fauna associated with mangroves such as mammals, reptiles, amphibians, birds, shellfish, and fish are found in Ayeyarwady Region.

FIGURE 7: Two years old planted mangrove *Avicennia officinalis* in the Ayeyarwady region (Photo: APFNet)

FIGURE 6: *Rhizophora apiculata* in Shwe Taung Yan, Ayeyarwady Region (Photo: Moe Min Aung)

SOCIAL AND ECONOMIC STATUS IN AYEYARWADY REGION

The delta region plays a dominant role in the fishing and rice cultivation industry. This region is densely populated, and land use choices are closely linked to the tenure status of the land. Those who own land are mainly engaged in agriculture, especially rice farming using rain during the rainy season and with one harvest per year. Home gardens are another form of private land use. Additionally, small farmers with limited landholdings and seasonal workers without access to land are employed as migrant laborers on large-scale farms. They typically rely on fishery, catching crabs and shrimps for a living, and on resources that can be obtained free of cost in the mangrove forests, such as fuel and food. Crab catches from RFs and national parks (NPs) in the Ayeyarwady Delta are shown in Table 1.

TABLE 1: Crab catching from public mangroves within RFs and NPs in the Ayeyarwady Delta

	Unit	Average amount	Std*
Number of households per village	household	231	199
Number of full-time crab catchers per village	catcher	43	32
Number of part-time crab catchers per village	catcher	26	18
Average number of crabs caught per day by crab catchers	Crabs	20	4
Average weight of crabs caught per day by crab catchers	kg	2.1	0.9
Average monthly income of full-time crab catchers	MMK (USD)	237,000 (113)	62,000 (30)
Average monthly income of part-time crab catchers	MMK (USD)	164,000 (78)	60,000 (29)
Average money that crabs catchers borrow from middleman (as advanced payments)	MMK (USD)	120,000 (57)	81,000 (39)

**Std: mean standard deviation* *(Source: GGGI)*

In addition to fishing and intensive aquaculture, another income source for villagers in this region is mangrove-based charcoal production (Htay,2016). In all of Myanmar's extensive coastal regions, mangrove wood is still in high demand for domestic purposes (such as cooking, heating, and house construction), as well as fuelwood for drying fish or pole wood.

FIGURE 8: Kanazo (*Heritiera fomes*) tree
Photo: Aung (2022)

Mangrove fuel wood logging in the delta is quantified in Table 2. A fuelwood collector collects fuelwood equivalent to 137,500 MMK (approx. 65 USD) per month, of which typically 20% is consumed by the household itself and the remaining 80% is sold to local shops, bamboo raft owners and traders in the value chain. For example, Kanazo (*Heritiera fomes*) is the main mangrove timber species utilized for construction (such as for houses and boats), as well as for fuel and charcoal production (Fig. 8). As a result of such excessive extraction of fuelwood for nearby cities and towns, mangroves, particularly in the Ayeyarwady Region, have been destroyed.

TABLE 2: Fuel wood logging from mangroves in the Ayeyarwady Delta

	Unit	Average amount	Std*
Number of households per village	household	252	225
Number of full-time fuel wood loggers per village	logger	17	15
Number of part-time fuel wood loggers per village	logger	26	21
Monthly income of full-time loggers	MMK (USD)	221,000 (105)	28,000 (13)
Monthly income of part-time loggers	MMK (USD)	145,000 (69)	42,000 (20)
Monthly expenditures for fuelwood collection (excluding labor cost) for full-time logger	MMK (USD)	32,000 (15)	12,000 (6)
+ Patrol payment (normally each time 1,000 MMK)	MMK (USD)	5,000 (2)	3,000 (1.4)

**Std: mean standard deviation* *(Source: GGGI)*

CAUSES OF MANGROVE DEFORESTATION

Deforestation of mangroves in Myanmar has a significant historical precedent, as stated by Estoque et al. (2018). Research by Giri et al. (2008) revealed that Myanmar's mangrove forest cover declined at an annual rate of 1% between 1975 and 2005. Additionally, Hamilton & Casey (2016) reported a yearly loss rate of 0.7% of mangroves in Myanmar from 2000 and 2014. The expansion of agriculture and aquaculture has been identified as the primary causes of mangrove deforestation as highlighted by Friess et al. (2019). Furthermore, over-exploitation, illegal logging, fuel wood extraction and charcoal production contribute to the degradation of mangroves. Fig.9 shows illegal harvesting of Byu-chi-dauk apo (*Rhizophora apiculata*) in Bokepyin township of Myanmar.

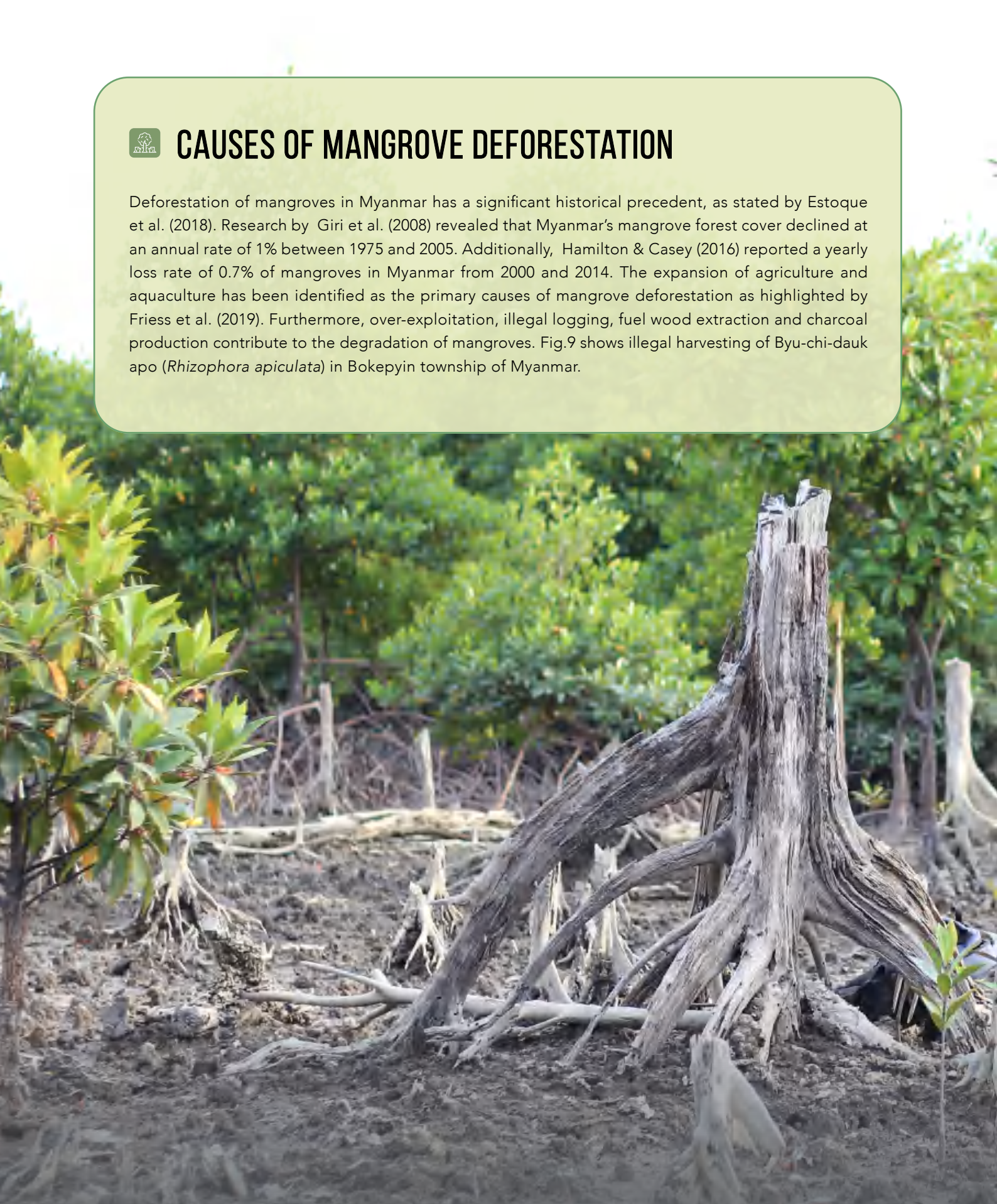
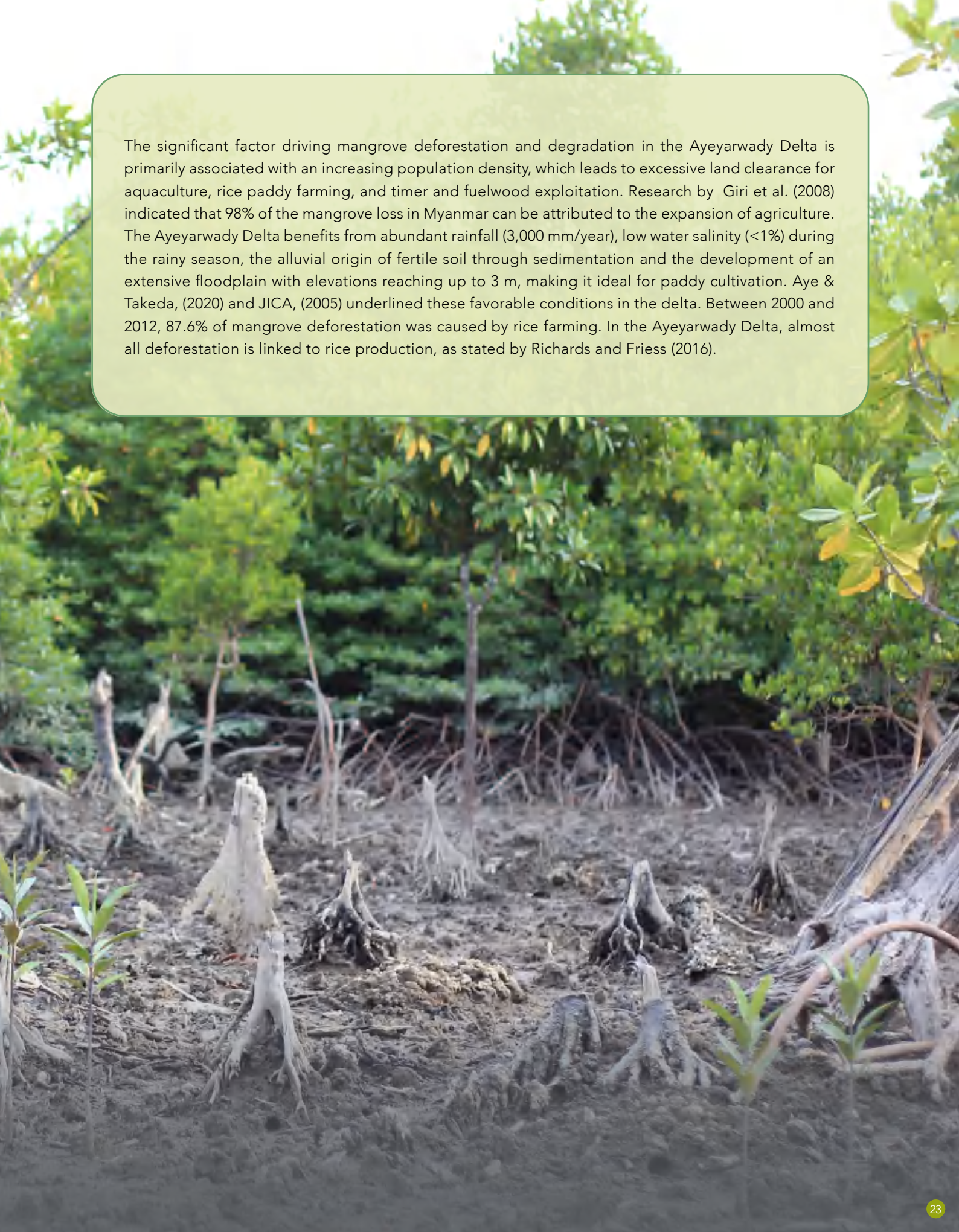


FIGURE 9: Illegal logging of Byu-chi-dauk apo (*Rhizophora apiculata)* in Bokepyin township (Photo: Moe Min Aung)

The significant factor driving mangrove deforestation and degradation in the Ayeyarwady Delta is primarily associated with an increasing population density, which leads to excessive land clearance for aquaculture, rice paddy farming, and timer and fuelwood exploitation. Research by Giri et al. (2008) indicated that 98% of the mangrove loss in Myanmar can be attributed to the expansion of agriculture. The Ayeyarwady Delta benefits from abundant rainfall (3,000 mm/year), low water salinity (<1%) during the rainy season, the alluvial origin of fertile soil through sedimentation and the development of an extensive floodplain with elevations reaching up to 3 m, making it ideal for paddy cultivation. Aye & Takeda, (2020) and JICA, (2005) underlined these favorable conditions in the delta. Between 2000 and 2012, 87.6% of mangrove deforestation was caused by rice farming. In the Ayeyarwady Delta, almost all deforestation is linked to rice production, as stated by Richards and Friess (2016).



SHRIMP AQUACULTURE

Shrimp aquaculture has been widely criticized for causing mangrove forest degradation and loss. Since 1980, mangrove aquaculture has been practiced at a small scale in the northern part of Rakhine, Myanmar; most of these areas were previously degraded unclassified mangrove forests. Mangroves were eventually transformed into brackish water shrimp ponds in the southwest part of Ayeyarwady Delta; this development is currently continuing (Freda & Actmang, 2012) and adding to the loss caused by agricultural conversion.

While mangroves are naturally adapted to saline and waterlogged conditions, and their root systems help maintain soil stability and prevent excessive oxidation, mangrove aquaculture farming involves modifications to the natural hydrological patterns, such as construction of embankments or sluice gates to regulate water levels in the ponds that can disrupt the natural flushing and water exchange processes, further contributing to soil acidification and degradation. Acid sulfate soils are typically found below the water table in anaerobic (low oxygen) conditions. When the land is cleared and drainage systems are implemented, the waterlogged conditions are altered, leading to the exposure of previously submerged acid sulfate soils to oxygen and produce sulfuric acid. The sulfuric acid produced from the oxidation of sulfides can lower the pH of the soil, making it highly acidic. Acidic soil conditions affect the growth and survival of mangrove vegetation and can also harm aquaculture species. Additionally, the acidified runoff can impact water bodies, leading to detrimental effects on aquatic life.

FIGURE 10:
Coastal areas of Myanmar
(Photo: NBSAP, 2015)

RICE PADDY FARMING

The Ayeyarwady River originates from the confluence of the Mai Kha and Mali Kha rivers in Kachin State. It flows in a predominantly north to south direction before reaching the nine-armed Ayeyarwady Delta and eventually emptying into the Andaman Sea. The river has a drainage area of approximately 413,000 km^2, which covers a significant portion of the economy. The highest point of the Ayeyarwady Delta is located near Seiktha, about 93 km above the city of Hinthada, and approximately 290 km from its exit point at the Andaman Sea. The Ayeyarwady River forms the delta, which includes nine major distributaries: Pathein River, the Thetkethaung River, the Ywe River, the Pyamalaw River, the Ayeyarwady River, the Bogale River, the Pyapon River, the Toe River and the Yangon River.

Although the Ayeyarwady River is the primary contributor of sediment deposits in the delta, other rivers in the region also contribute to its formation. Multiple rivers collectively contribute sediment, including the Ayeyarwady River, which is essential for the formation and preservation of the delta. The deposited sediments enrich the soils of the Ayeyarwady Delta, making them fertile for agriculture and supporting unique ecosystems in the area.

Rice cultivation is a significant agricultural activity in the Ayeyarwady Delta, utilizing fertile soils. The region is the primary rice-producing area in Myanmar, contributing approximately 35% of Myanmar's rice production and playing a crucial role in the economy (Webb et al., 2014). During the rainy season, the middle and upper regions of the delta are submerged with freshwater, making them favorable for agriculture.

In the Ayeyarwady Delta, rice paddy farming takes place within the mangrove forests. Farmers have developed traditional techniques to adapt to the saline and waterlogged conditions of the mangrove environment. Due to tidal movements, saltwater intrusion can occur in the rice paddies. To manage this, farmers employ strategies like building embankments and implementing controlled irrigation. However, these measures disturb the natural water flows and drainage patterns of the mangrove ecosystems. Changes in water circulation and saltwater intrusion have negatively impacted the mangrove vegetation.

Furthermore, the use of agrochemicals in rice farming, such as pesticides and fertilizers, leads to water pollution. These substances can be carried by runoff from agricultural fields into water bodies, including mangrove areas. Water pollution harms aquatic life and disrupts the ecosystem's balance. Consequently, farmers have been forced to abandon rice fields, encroaching upon mangrove areas located farther away from the coastline to establish new agricultural land.

FUELWOOD AND WOOD PRODUCTS

Firewood demand is a driver of deforestation, not just in mangrove areas but in all forest areas of Myanmar. Various factors contribute to this situation, including limited access to the electricity grid, insufficient investment in the power sector, economic constraints and lack of technical capacity contribute. These factors have resulted in Myanmar having one of the lowest per capita electricity consumption rates globally (ADB, 2016). Consequently, people heavily rely on wood as a primary fuel source due to the low electricity consumption. Approximately 81% of households in Myanmar rely on wood for cooking (Department of Population, 2015). Wood is also utilized for construction, furniture making, tool crafting, the creation of decorative items and traditional medical practices.

The Ayeyarwady Delta's mangrove forests have been a source of firewood and charcoal for Yangon and other towns in the delta region for over a century. However, since the 1980s, the production of firewood previously around 432,200 tons per year, has become unsustainable, leading to rapid depletion of the mangrove forest (Zöckler & Aung, 2019). The establishment of RFs in the delta, primarily for timber and fuelwood production, began in 1895 and was completed by 1904 under the FD during the colonial period (Oo, 2002). During World War II, the exploitation of mangrove forests in the delta escalated due to increased demand for timber and fuelwood for military purposes (Friess et al., 2019; Oo, 2002). Based on the studies of Kyi (1992) and Oo (2002), it is estimated that more than half of the Ayeyarwady Delta's mangrove forests have been degraded and depleted for over thirty years.

CLIMATE CHANGE AND NATURAL DISASTERS

Climate change and natural disasters are also significant factors affecting the Ayeyarwady Delta. A climate scenario analysis done by an initial national communication project under the United Nations Framework Convention on Climate Change (UNFCCC) predicts a temperature increase of over 1 degree Celsius in most parts of Myanmar in the next 30 years, impacting agriculture, forestry, biodiversity, water resources, and human health. The Myanmar National Adaptation Program of Action (NAPA) highlights that the population will experience more natural disasters, such as extreme weather events including cyclones, flood, intense rains, high temperatures and drought across the economy. In the coastal and marine areas, frequent and intense storms, strong winds and waves directly affect fisheries both inshore and offshore. Cyclone Nargis, which struck the Ayeyarwady Delta in May 2008, caused extensive damage and loss of life, with approximately 140,000 people dead or missing. The storm led to the collapse or severe damage of about 94% of buildings and devastated around 14,000 ha of mangrove forests and plantations, particularly in areas previously degraded by human activities (Aung, 2022; Thant, 2011).

MANAGEMENT OF MANGROVES INCLUDING PREVIOUS PROJECTS

The extent of mangrove areas in Myanmar is estimated to be approximately 452,958 ha, out of which 266,276 ha (59%) have been declared PFE (FAO, 2020; FD, 2020). The remaining mangroves (41%) are not part of the PFE and are at risk of being converted for the construction of resorts, long-term cash crops and shrimp farming. Myanmar has established 45 PAs, two of which are largely marine: Lampi Marine National Park and Mainmahla Kyuun Wildlife Sanctuary (see Fig.11).

FIGURE 11: Location of PAs in Myanmar
(Photo: NBSAP, 2015)

The Myanmar FD has introduced the **Myanmar Reforestation and Rehabilitation Programme (MRRP)** for the period of 2018 to 2027, with the objective of restoring over 1.2 million ha of degraded and deforested land by 2026 through plantations, community forest, agroforestry, natural forest regeneration, and enrichment planting. Mangrove plantations aim to restore damaged ecosystems in the degraded mangrove areas, fulfill the subsistence needs of local communities, improve mangrove forest health and resilience, provide mangrove windbreaks for the safety of local communities, and help to adapt the livelihoods of local communities to climate change.

The FD of Myanmar has collaborated with international organizations such as the United Nation Development Programme (UNDP) and the Food and Agriculture Organization (FAO), the Japan International Cooperation Agency (JICA), the Worldview International Foundation (WIF), UQ, the Danish International Development Agency (DANIDA) and several local non-governmental organizations (NGOs) to implement mangrove projects.

These projects have focused on various aspects of mangrove forest conservation and restoration. Some projects put a larger emphasis on mangrove restoration, while others have worked on developing community forestry institutions and frameworks. Additionally, some projects supported the development of aquaculture practices in mangrove areas. However, it is crucial to develop more sustainable and environmentally friendly aquaculture practices for the mangrove area's existing aquaculture systems.

One notable project implemented by the FD in collaboration with JICA between 2007 and 2013 was the "**Integrated Mangrove Rehabilitation and Management Project through Community Participation in the Ayeyarwady Delta**". The project involved establishing community forestry, implementing Action Research Plantation (ARP)[2], and constructing CF Extension and Nursery Centers in the Ayeyarwady Delta. As a result, mangrove forest cover increased by 1,438 ha in select areas (i.e., CF plantations, CF Natural Forest Improvement Operation, and ARP sites). However, further support is needed at the upstream level to strengthen policy, institutional and organizational arrangements, capacity development, and various procedural aspects of community forestry and mangrove management. The formulation of standards and criteria for forest management, including community forestry and comprehensive land use planning, are also crucial requirements.

[2] ARP has the goal to identify applicable silvicultural techniques and suitable species for rehabilitation and management of mangrove forests in the delta.

POLICY AND LEGAL FRAMEWORKS

Legal frameworks that support the mangrove sector development and its conservation are the Forest Law (1992), the Forest Policy (1995), the Myanmar Action Plan for Disaster Risk Reduction (MAPDRR) (2009-2015), the National Biodiversity Strategy and Action Plan (NBSAP) (2015-2020), the Protection of Wildlife & Wild Plants & Conservation of Natural Areas Law and the Protection of Wildlife & Wild Plants & Conservation of Natural Areas Rules. Myanmar's **Forest Law**, revised in 2018 and based on the former Forest Law of 1992, is the main legal framework to achieve the effective implementation of the government's forest policy and environmental conservation policy. The Forest Law regulates mangrove forest conservation and protection, management of forest land, establishment of mangrove forest plantations, extraction and removal of forest products, establishment of a wood-based industry and administrative actions in respect of offences and penalties.

According to the Forest Law (2018), individuals are permitted to extract forest products for non-commercial private use, farming or fishery, provided that the total amount does not exceed one ton of timber. This extraction does not require a permit from the Ministry of Natural Resources and Environmental Conservation. The Forest Law also allows for the extraction of forest products from private forest plantations and community forests. Furthermore, the Forest Law allows community forestry (Box 1) to encourage the participation of local people in forest management while contributing to their basic needs. The Myanmar **Forest Policy** was promulgated in 1995 and, since then, aims to ensure the sustainable development of forest resources for social, environmental, and economic purposes (Box 2).

Conforming with the forest policy stipulations, a long-term plan (1), an immediate or short-term plan (2) and annual plans (3) are being formulated to achieve SFM[3]. The **National Forestry Master Plan** (NFMP) was approved in 2000 by the then Ministry of Forestry[4] and put into action. The plan covers a 30-year period from 2001/2002 to 2030/2031. The FD defined the goal to include most of the "Unclassified Forest[5]" into the Forest Lands[6]/PFE by increasing the area of RF/PPFs to 30% of the total land area and PAs to 10% by 2030 (NFMP). Key targets include establishing 4,634 ha of government-established mangrove plantations by 2027 (MONREC 2021); prioritizing the conservation of important mangrove areas; and increasing the resilience of mangrove and coastal communities at risk of flooding.

[3] Sustainable Forest Management (SFM) is the management of forests according to the principles of sustainable development. SFM has to keep a balance between three main pillars: ecology, economy and society.
[4] Now "Ministry of Natural Resources and Environmental Conservation", changed in 2016.
[5] Unclassified forests are areas outside those of legally defined Forest Lands.
[6] Forest Land means land comprising RFs and PPFs (Forest Law, 2018).

The NFMP partly covers coastal conservation and management through community forestry development, biodiversity conservation, sustainable forest harvesting, bioenergy, human resource development and forestry and environmental awareness. Accordingly, the **Community Forestry Instructions** (CFIs) issued by the FD in 1995 (updated in 2016) focus on a significant development in the areas of partnership, participation, and decentralization in managing the forests, including coastal forests and mangroves in Myanmar (Box 3). According to pre-2021 data, over 140 CFs in Myanmar are located in mangrove areas, covering 15,000 ha (UNEP-WCMC, 2022).

The CFI grants the local communities' trees and forest land tenure rights for an initial 30-year period that is extendable based on the success of implementation. Community forests can be established in RFs, PPFs, buffer zones of PAs, lands at the disposal of the government[7], forest-covered lands managed by government organizations and natural forests and mangrove forest traditionally conserved by local communities[8]. Ethnic communities can formalize their rights over traditionally managed land through securing a CF certificate. Some ethnic groups in Myanmar have been able to demarcate the boundaries of their traditional land through establishing CF boundaries and signs, and consequently have reduced the frequency of encroachment into their forests. CFI allows local communities to be involved in protection, conservation, and restoration of forests particularly in the vicinities of their settlements. CFI provides a 30-year land use and the ownership rights and disposal of products from the CF under the guidance of FD. The FD provides technical assistance and plays the leadership role in the implementation of CF. Moreover, recognizing the traditional land use system, customary rights and cultural values, community forestry is mostly implemented as agroforestry. In the agroforestry system of Ayeyarwady Region, various crop plantations and fruit trees can be combined with timber trees to maximize agricultural productivity and improve ecosystem stability. The following crops - paddy rice, sticky rice, mung bean, as well as fruit trees (mango, banana, papaya, citrus and coconut) are commonly associated with agroforestry in the Ayeyarwady Region, though specific practices may vary depending on local conditions and farmer preferences.

[7] *"Land at the disposal of the government" means any land with the exception of land in which any government department, organization or any person has the rights of cultivation, possession, use and occupancy, beneficial enjoyment, heritable right or transferable right under any existing law (Forest Law, 2018).*

[8] *The Ministry, with the comment of Naypyitaw Council, Region or State Government and with the approval of the Union Government may recognize natural forests and mangrove forests conserved customarily or traditionally by the local people (Forest Law Section 7, Sub-section (d)).*

CFUGs can use forest products in the community forest in accordance with the community forestry management plan. Those forest products are exempt from taxes if they are used by members of the CFUG, but also if they are sold to non-members of the village at reasonable prices. The user group can utilize forest products of the community forest and surplus cash to develop business enterprises that produce high quality products. However, the land allotted for the CF must not be used for other purposes or activities, except for those prescribed in the community forestry management plan. Selling, renting, mortgaging, handing over or donating of parts of the CF, as well as mining of metals, pebbles or stones; construction of permanent buildings or settlements, which are not relevant to the establishment and conservation of the CF and planting of crops and trees are prohibited under the existing laws.

The landscape of the Ayeyarwady Delta has for a long time been without systematic urban and rural planning or an integrated planning approach. Sectors have been disintegrated with limited coordination. The overlap of the Freshwater Fishery Law and the Forestry Law has not been solved, yet. The main cause of the overlap between the Freshwater Fishery Law and the Forest Law is that all the laws are equally valid individually and there is no hierarchy amongst them. A possible approach is to consider a legislative review of one of the two laws alongside the Wildlife and Conservation of Natural Areas Law to avoid any conflict. The enforcement of the Forestry Law is weak because of insufficient human and financial resources for effective conservation and management measures. Although the mangroves have been protected on paper for many decades, illegal encroachment of rice fields has effectively not been well prevented and illegal activities are still carried out. The Ministry of Natural Resources and Environmental Conservation (MONREC) led the reformulation of the **national land-use policy**, which was issued in January 2016, but still needs to be implemented on the ground by relevant authorities and by decision-makers.

BOX 1: Emergence of Community Forestry in Myanmar

The management of the entire forest ecosystem, which includes communities that depend on the forest, is necessary for SFM. To achieve sustainable and effective forest management, the forest development and management system must involve the local community's participation, give the community a sense of ownership and address its needs.

In fact, this element was originally conceived during the initial stages of science-based forestry in Myanmar. Local supply working circles (LSWCs) were previously included in forest district working plans in order to provide continuous flow of goods and services from forest lands and to strengthen the concept of participatory forest management. These were established in easily accessible forests close to the communities and were managed to provide the local community with fuel wood, poles, posts, small timber, and a variety of non-timber forest products (NTFPs). However, due to the increased population, LSWC cannot provide adequate supply of forest products to the communities residing in and around the forests. At this juncture, community forestry emerged as a realistic option to complement the LSWC in 1995.

The key improvement from the LSWC to the CF is that while the LSWC was managed by the FD to satisfy the basic needs of the local community, the CF is managed by the local community itself. CF is the first program introduced for and managed by communities themselves to provide stewardship over the forest resources and alleviate poverty.

BOX 2: Forest Policy (1995)

The Myanmar Forest Policy (1995) has been formulated in a holistic and balanced manner considering the overall context of the environment and its sustainable development raking. It formalizes the commitment and intent of the government to ensure the sustainable development of forest resources for social, environmental, and economic purposes. The policy paves the way for prudent use and enhanced benefit from the forest while maintaining ecosystem integrity and environmental balance. The six imperatives identified in the policy are:

1. Protection of soil, water, wildlife, biodiversity, and the entire environment
2. Sustainability of forest resources to ensure a perpetual supply of both tangible and intangible benefits accrued from forests for present and future generations
3. Fulfillment of basic needs of the people for fuel, shelter, food, and recreation
4. Efficiency to harness, in a socio-environmentally friendly manner, the full economic potential of forest resources
5. Participation of local people in the conservation and utilization forests; and
6. Public awareness about the vital role of forests in the well-being and socio-economic development of the economy.

BOX 3: Community Forestry Instruction (2016)

The CFI of 2016 replaces the earlier Community Forestry Instructions (1995). CF refers to a form of forestry in which the local community itself is involved in SFM and forest utilization. Households, irrespectively of status, ethnicity and religion, have the right to join a CFUG if they have lived within five miles of forests for five years continuously, or if the forest area has been managed traditionally by them under customary rights.

CFI (2016) has five objectives:

1. Support forest-related basic needs such as wood products and NTFPs for local communities
2. Reduce rural poverty through better employment and income opportunities for local communities
3. Increase the forest cover area and ensure the sustainable utilization of forest products
4. Promote forest management systems with peoples' participation
5. Enhance environmental services that can support climate change mitigation and adaptation by protecting against deforestation and forest degradation.

3 PROJECT INTERVENTIONS TARGETING SUSTAINABLE MANGROVE FOREST MANAGEMENT

The project was conducted in the lower Ayeyarwady Delta's Pyapon, Bogale and Labutta townships, which have some of the largest remaining mangrove areas in the delta. The mangroves in Ayeyarwady Delta are managed by the FD, which established the MRRP. CF arrangements also occur over limited areas. In the project area mangroves are located on lands that have a variety of management arrangements including:

(1) the Meinmahla Kyun Wildlife Sanctuary, which is an NP, is a mangrove sanctuary where extractive activities are prohibited;
(2) RFs, which are mangroves managed by the FD and include mangrove plantations and where extractive activities are also prohibited;
(3) CF plots managed by the CFUGs that control the use of, and access to, the mangroves;
(4) CF land which are common village woodlots access to the mangroves is limited to the village community members; and
(5) Private land.

The range of stakeholders in the study region needed to be identified in order to analyze their management activities related to mangroves. Stakeholders involved in value chains of different mangrove products were identified via previous surveys in the study area. Based on this actors mainly involved in aquaculture and agricultural activities, fuelwood, crab fattening, shrimp production, and rice production were considered.

3.1 KEY ACTIVITIES

FOREST INVENTORY

To assess the current condition of the forest, a comprehensive survey was conducted, establishing a total of 274 plots on both mangroves and adjacent land uses. In the project's mangrove forests several sample plots were located, each with a reference area of 2.25 ha. Withing these plots, a nested design is implemented, consisting of two areas dedicated to tree measurement and one area for regeneration sampling. The allocation of these sub-plots is based on the tree diameter at breast height (DBH), allowing for an efficient assessment process that reduces time and effort.

The whole plot A, measuring 10 × 10 m (100 m^2), is dedicated to trees with a DBH ≥ 2 cm (Fig.12). In this area, tree measurements are conducted, and NFTPs are recorded to capture additional ecological information. Sub-area B, measuring 4 × 4 m (16 m^2), focuses on advanced regeneration, specifically measuring trees with a DBH < 2 cm. The sub-area enables the evaluation of young tree populations within the ecosystem. To assess regeneration at the plot's center, a circular plot with a radius of 5.65 m is applied. This comprehensive approach ensures a thorough evaluation of the mangrove ecosystem's condition and dynamic.

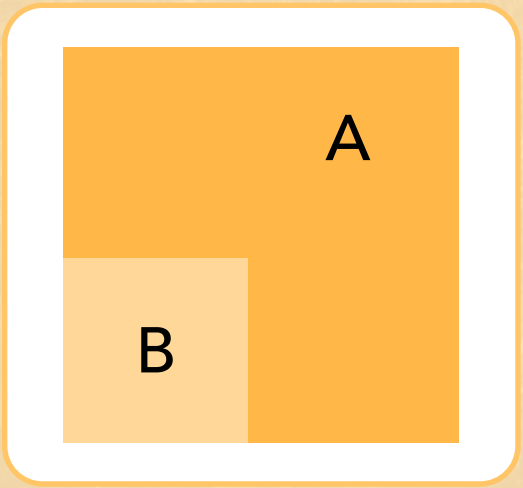


FIGURE 12: Shape and size of sample plot

FIGURE 13: Biomass measurement in inventory plot

FIGURE 14: Soil sample collection on a rice field (former mangrove land and adjacent to current mangrove forests)

Biomass measurements and soil sample for the analysis of soil properties were also carried out as additional survey components in sample plots (Fig.13 and 14). Data collected included the source of investments in mangrove plantations, tree species, age, investment cost, management practices (mainly based on community involvement), tree density, plantation type (mixed or monoculture), details of whether plantations were in or outside shrimp ponds, and location (GPS coordinates). The forest inventory data was used as the baseline and land use planning for the project's communities. Sample plots were in rice fields, salt ponds, both natural and planted mangroves, as well as inside and outside of mangrove aquaculture ponds.

The data analysis revealed that 26 mangrove species, as well as numerous shrub and grass species, were present in the surveyed plots. The largest tree measured in a natural forest had a diameter of 9.7 cm and a height of 15.0 m, whereas the largest tree measured in a plantation had a diameter of 39 cm and a height of 22 m. Some plantations are of higher quality than the adjacent natural mangroves. Most of the plantations are well protected by the local FD. More intact natural mangrove forests were found in Meinmahla Kyun Wildlife Sanctuary than in other areas of the delta. Most of the higher-quality natural mangroves belong to CFUGs of local people. In contrast, the natural mangroves directly managed by government authorities face continuous illegal logging for fuelwood and timber. The main challenge stems from the insufficient allocation of staff and resources for mangrove protection, which consequently limits protection activities. To ensure the sustainability of mangrove management, comprehensive planning, community involvement, and effective long-term governance are essential. Therefore, decentralization of mangrove management by contracting or allocating to local communities can have positive impacts on mangrove forests and contribute to their improvement in the delta.

SOCIO-ECONOMIC SURVEY

Interviews with key participants and other villagers were conducted in 9 villages in the project's region to collect information about livelihoods, land tenure, and rights for ecosystem-based land use planning, in accordance with the practical guidelines for socio-economic surveys by the Center for International Forestry Research (CIFOR) and the French Agricultural Research Centre for International Development (CIRAD) (Fig.15). The key participants were village leaders, group leaders (e.g., of CFUGs), and other key farmers who are familiar with the background and context of their villages. In total, 176 key participants and households participated in interviews and group discussions. Detailed questions related to mangrove aquaculture activities, crab catching, and fuelwood harvesting were developed. The survey was intended to develop an understanding of rural livelihoods and the institutions that affect them. The survey's findings were used to analyze the factors contributing to mangrove degradation and deforestation in the Ayeyarwady Delta.

FIGURE 15: Key informants' interview

CRAB HATCHERY AND SEED PRODUCTION

Prior to 1995, mud crab production in Myanmar primarily served the domestic market, but it later expanded into a significant export industry in the China-Myanmar trade. Small and medium-sized mud crabs have a high hatching rate and are easily caught in the wild, although egg quantities may vary with the season. However, the future of crab harvesting faces several challenges.

Firstly, the market conditions for crabs are unstable, leading to difficulty in maintaining consistent prices and demand. Secondly, temporary maintenance facilities are required during transportation to ensure crab quality, adding complexity and extra costs. Thirdly, there is a preference for female mud crabs in the market, which may result in selective harvesting practices due to consumer preferences related to taste, texture, or culinary qualities. Finally, crabs that fail to meet the marketable size limit are often discarded, resulting in lost potential harvest and economic value.

To address these challenges, mud crab breeding has been undertaken along Myanmar's coast, varying in scale depending on the financial situation of local communities. Mangrove-friendly aquaculture methods have the potential to improve the livelihoods of these communities while contributing to mangrove conservation. Cultivation techniques for mud crabs in Myanmar include pond culture and fattening procedures.

As part of the APFNet project, a crab fattening training course was conducted (Fig.16) for farmers and community leaders. Each training course accommodated 20-25 participants. The training covered various aspects of rearing juvenile mud crabs, including water treatment, tank preparation, brood stock selection, larval rearing methods, and the harvesting and transportation of mud crab seeds in pens within mangrove forests. Furthermore, 8 key technical staff members, local experts, and community leaders participated in 2 training and study tours in Ca Mau province, Vietnam. These tours focused on managing crab hatcheries and mangroves.

FIGURE 16: Training for CFUG members on mangrove-friendly crab fattening

With the support of the project, 23 crab fattening and 03 improved shrimp aquaculture models were established by local farmers, who also received technical training and assistance. The project facilitated the provision of juvenile crabs, shrimp fingerlings, technical training, and covered a proportion of the labor cost, thereby contributing to the successful implementation of these models.

BOX 4: Previous aquaculture practices in the CF area

Canals were constructed along the border line to store river water during high tide each year. These canals served as collection points for larvae and juvenile stages of fishes, shrimps, and crabs during high tide days. Water was allowed to flow into the canals, enabling the collection of these organisms. Some CFUG members purchased shrimp post larvae and small crabs to stock them in the canals.

The CF owners were responsible for managing the specific actions of collecting post larvae by allowing river water to flow into the canals and draining the water during the harvest of shrimp, fish, and crabs. However, they failed to provide regular feeding, shelters or sufficient water exchange for the stocked organisms. It is important to note that the stocked organisms encompassed multiple species (most are carnivores).

The lack of regular feeding, proper shelters, and adequate water exchange in the canals had repercussions for the stocked organisms. The absence of these essential requirements affected their growth, survival, and overall health. Carnivorous species in particular require a consistent supply of food to meet their dietary needs.

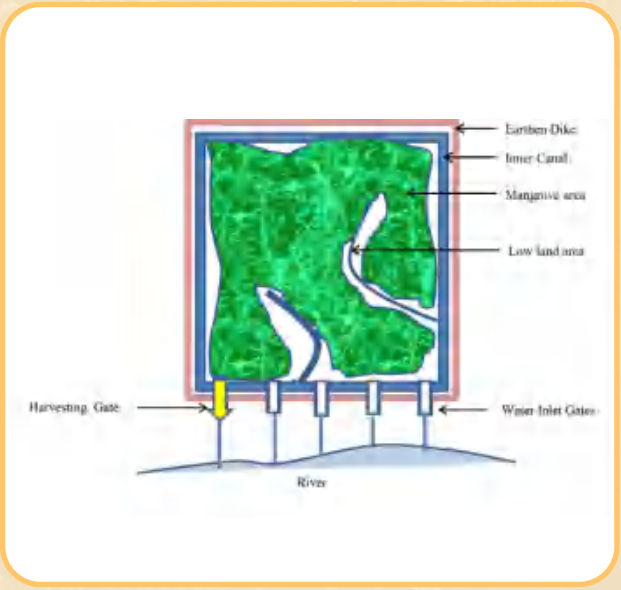


FIGURE 17: Previous aquaculture practices in the CF area

BUILDING CAPACITY FOR RESTORATION AND THE SUSTAINABLE MANAGEMENT OF MANGROVE FORESTS

The project supported training programs on mangrove restoration. Twenty to twenty-five key farmers and community leaders participated in each training course, 195 participants in total. The mangrove restoration training course covered topics such as the value of mangroves, causes of mangrove degradation; key mangrove tree species; how to restore mangroves including mangrove seed collection, nursery growing, weeding, planting, and trending.

ESTABLISHMENT OF CO-MANAGEMENT AND BENEFIT SHARING MECHANISM

Within the project's community, a benefit-sharing mechanism was developed and mutually accepted. It was integrated into the existing forest management plan of the key project's CFUG. The key concept of the benefit-sharing mechanism is that farmers who received project support for mangrove seedlings and juvenile crabs will contribute 5% of the revenue from mangrove aquaculture activities that year to the CFUG's fund.

ESTABLISHMENT OF MANGROVE RESTORATION AND AQUACULTURE DEMONSTRATION MODELS

The project supported the establishment of 71 ha of mangrove restoration and aquaculture demonstration models implemented by local communities and technical staff. The focus was on combining mangrove restoration and aquaculture, which was demonstrated on 66 ha. 5 ha were exclusively used to establish a sustainable model of mangrove restoration only.

Mangrove restoration is a process that aims to rehabilitate and enhance degraded mangrove areas by restoring the natural structure and function of mangrove forests. One technique used in this restoration effort is improvement thinning, which involves selectively removing specific trees within the degraded areas.

This removal focuses on undesirable or less desirable trees, improving the growth and quality of the remaining trees in a forest stand. Here, the project tested four restoration techniques of mangrove restoration: single-species enrichment planting after improvement thinning, mixed species enrichment planting after improvement thinning with a low planting density, mixed species enrichment planting after improvement thinning with a high planting density, and improvement thinning to promote natural regeneration only. These pilot models for mangrove restoration by planting were meticulously developed to facilitate the comprehensive study and understanding of the various factors influencing successful growth. Among them, the approach of planting a mixture of planted species after improvement thinning with a lower density was shown to be the most effective technique. This approach achieved a canopy cover that was comparable to that achieved through high-density planting but at a significantly reduced rehabilitation cost. It implies that by planting a variety of species with fewer trees per unit area, they were able to achieve a similar level of canopy cover while reducing the expenses associated with planting and maintaining a high-density forest. This approach offers a cost-effective method for restoring degraded mangrove areas while maintaining the ecological benefits of a well-developed canopy cover.

OUTREACH AND COMMUNICATIONS

The project provided support for the development of various technical guidelines. These include five silviculture and aquaculture technical guidelines covering topics such as forest establishment techniques, promoting natural regeneration, tree planting techniques, fish, shrimp, and crab growing techniques, as well as techniques to establish mixed aquaculture and mangrove forests. Additionally, the project contributed to the creation of six general guidelines, including a mangrove forest inventory guideline, a socio-economic survey guideline, a participatory rural appraisal and community forest management guidelines, a land use planning guideline, a GIS and mapping guideline, and monitoring and evaluation (M&E) criteria and indicators with a data collection manual. Furthermore, the project produced ten leaflets with valuable knowledge and techniques related to forest restoration, management, and aquaculture.

Several publications have benefited from the project's support or utilized its research data and analyses. These include:

1. Htike San Soe's master thesis (2021) on "**Contribution of Silvo-aquaculture on Local Communities' Livelihoods, focusing (A Case Study in Amar sub-township Under Pyapon Township, Ayeyarwady Region, Myanmar).**"
2. The joint study by the Global Green Growth Institute (GGGI) and the University of Queensland in 2020, which offers an "**Economic Appraisal of Ayeyarwady Delta Mangrove Forests.**"
3. The World Bank.2020. "**Investment Analysis for Mangrove Ecosystems in the Ayeyarwady Region.**"

3.2 PROJECT IMPACTS

The project's activities resulted in significant positive social, economic, and environmental impacts, including changes to forestry sector policies, strategies, and planning. The coastal communities residing within the project region were the primary beneficiaries, experiencing significant improvements in their livelihoods, increased income, and improved food security.

The environmental impact of the project was also noteworthy, benefiting not only the coastal communities but also the broader community at large. The project's activities directly contributed to conservation and improvement of vital ecosystem services provided by mangrove forests. These services include coastal protection, biodiversity conservation, carbon sequestration, and water purification, among others. The project had positive effects on the forestry sector, as well as the adoption of sustainable mangrove management practices leading to improved mangrove forest management and conservation.

ENVIRONMENTAL IMPACTS

The project had significant positive environmental impacts through the establishment of mangrove restoration demonstration plots. This included establishing **5 ha** of mangrove restoration pilot models using different species and planting approaches. Furthermore, over **71.6 ha** of enrichment planting was established in severely degraded mangrove forests across five villages - Laykyaw, Boe BaKone, Wa Pa Na, Htan Pin Kone, and Htaung Gyi Tan villages in Pyapon township.

Specific CFUGs, such as Htan Pin Kind and Htaung Gyi Tan, restored **4 ha** and **2 ha** of degraded mangroves on their own, respectively, using 15,000 mangrove seedlings provided by the project. The selected species for planting in the area were *Avicennia officinalis*, *Avicennia marina*, *Bruguiera sexangula*, and *Bruguiera gymnorrhiza*. The Lay Kyaw CFUG restored **15 ha** of degraded mangroves and established a small-scale nursery to cultivate 50,000 mangrove tree seedlings for the upcoming planting seasons.

The project also implemented 24 natural crab fattening pilot models and one mini crab hatchery rotation, covering a combined area of **66 ha** of mangrove forests. These initiatives contributed to the sustainable management and utilization of mangrove ecosystems, offering an alternative and more sustainable approach to aquaculture.

In terms of plantings along coastal areas, the project focused on the popular non-mangrove species of the Rhu tree (*Casuarina equisetifolia*) and paper bark tree (*Melaleuca cajuputi*). Over 17,000 seedlings of *C. equisetifolia* and 6,000 seedlings of *M. cajupti* were distributed to the Pyapon FD and local communities. Additionally, 20,000 seedlings of *M. cajuputi* were planted on private land, covering an area of **2.8 ha**. These tree plantings offered numerous benefits, including coastal protection, timber supply, and the provision of fuelwood, reducing pressure on mangrove resources. Capacity building on sustainable mangrove management practices was conducted, focusing on mangrove-friendly aquaculture and low-impact thinning, further improving the mangrove ecosystems.

ECONOMIC IMPACT

The project had several positive economic effects, particularly on the livelihoods of coastal communities in the project area. It enhanced the income and food security of these communities by promoting sustainable mangrove-based livelihoods, such as mangrove aquaculture, sustainable thinning and utilization of thinned material, and NTFP harvesting.

The restoration efforts resulted in a significant improvement in the growth rate of the remaining mangroves, with the average number of trees per ha with a DBH greater than 4 cm per ha doubling from less than 200 in 2018 to over 400 in 2022. This demonstrates the effectiveness of the restoration initiatives in enhancing the mangrove forests.

Casuarina equisetifolia and *Melaleuca cajuputi* grow rapidly and can be used as poles within 5-7 years, which may encourage landowners to sell them for various purposes, possibly outside the community. While planting these tree species brought benefits to both the community and the environment, it is important to note that they are not intended to replace mangroves as a fuelwood source as many coastal communities still have a preference for mangrove wood due to its high heat and low smoke burning qualities.

As the FD allowed to utilize 10% of CF area by CFUG members, which means the CFUG members can utilize water bodies inside their compound for fish, crab and shrimp production. Over 400 CFUG member households benefited from participating in project models on mangrove restoration and mangrove-friendly aquaculture. Pilot mangrove aquaculture models demonstrated **a 55% increase** in mud-carb productivity, and the rehabilitated mangroves in the project's models provided higher wood productivity, contributing to income improvement through timber and firewood for mangrove owners.

BOX 5: Improved crab fattening

The establishment of 24 natural crab fattening pilot models demonstrated that improved fattening methods for crabs require additional capital for juvenile crabs and expenditure for trash fishes used as feed during the initial cage stage before introducing them into ponds. The total cost for implementing the enhanced models exceeds that of regular practices by 150,000 MMK (71 USD) per ha. However, the economic profit from the enhanced models exceeds that of regular practices by 550,000 MMK (262 USD) per ha (1,500,000 MMK compared to 950,000 MMK), resulting in approximately **55%** higher economic returns for local farmers. In summary, the enhanced crab fattening methods offer significantly greater financial benefits to farmers compared to traditional practices.

Juvenile crab for crab fattening pilot models

TABLE 3: Comparison of enhanced crab fattening models with standard natural fattening

Products and Costs	Regular natural fattening sites (average per ha)	Improved fattening model (average per ha
Crab	95 kg ± 35	140 kg ± 40
Crab value	950,000 MMK ± 350,000	1,500,000 MMK ± 300,000
Juvenile crab procurement	40 kg per ha ± 10	55 kg per ha± 5
Costs of juvenile crab Procurement	150,000 MMK ± 40,000	220,000 MMK ± 20,000
Feeding costs	0	90,000 MMK (trash fish) ± 20,000

BOX 6: Community perspective on mud crab fattening

The project has equipped 12 households with equipment for mud crab fattening in a dug pond. Thirty participants have received one day of training in mud crab mangrove-friendly aquaculture. Traditionally, they used to have large mud crab ponds without providing any feed for the crabs. However, the project introduced them to a new approach of intensively fattening mud crabs in a smaller pond, secured with fine netting to prevent escape. In this method, the crabs are fed trash fish. This concept was particularly interesting to one female participant who primarily earned income through home gardening and selling coconuts.

SOCIAL IMPACT

The project had significant positive social impacts, particularly on the communities living in the project area. The training provided to **40** national, regional and township forestry and land use staff in topics such as GIS mapping and land use planning empowered local communities to actively manage their mangrove resources. This led to increased community participation, improved awareness of sustainable forest management, and the adoption of sustainable practices. The project directly trained **195** village leaders, local staff, and key farmers, including **60** women, promoting gender equality and women's empowerment in mangrove management and utilization activities.

CHANGE IN FORESTRY SECTOR POLICIES, STRATEGIES, AND PLANNING

The project has had a beneficial influence on policies, strategies, and planning in forestry sector. By promoting sustainable mangrove management practices, the project successfully redirected the focus of forest management from purely commercial and exploitative methods like monoculture plantations or non-mangrove brackish aquaculture to a more sustainable and community-oriented approach. Consequently, management policies and strategies were developed to support sustainable forest management practices such as community forestry and participatory forest management facilitated by local township forestry departments.

CHANGE IN PUBLIC BEHAVIOR/PRACTICE IN FOREST MANAGEMENT

The project had a significant impact on public behavior and practice related to mangrove management within the project's communities. By conducting training and providing extension activities to over 600 key staff and farmers, the project successfully raised awareness about the importance of sustainable mangrove management practices. It also encouraged the adoption of sustainable practices among local communities. This led to a change in behavior and practices, such as reduced-impact thinning, reduced clear-cutting, and the adoption of mangrove-friendly aquaculture techniques.

4 PROJECT SUSTAINABILITY

The project prioritizes sustainability to ensure the long-term continuation of its benefits and impacts. Several factors have been considered to sustain these outcomes even after the project concludes, namely institutional capacity, community engagement, value chain development, and policy frameworks.

INSTITUTIONAL SUSTAINABILITY

The project has supported government organizations, NGOs, and community groups, empowering them to implement sustainable practices in mangrove aquaculture such as crab hatcheries, mangrove restoration, and overall mangrove management. This support strengthens their ability to continue implementing sustainable practices beyond the project duration.

COMMUNITY PARTICIPATION

The project has fostered community engagement in forest management, instilling a sense of ownership and responsibility among local communities. Community based mangrove management initiatives have been vital in combating the decline of mangrove ecosystems and ensuring their long-term survival.

VALUE CHAINS FOR MANGROVE-BASED PRODUCTS

The project has encouraged the development of value chains for forest-based products, creating alternative sources of income for local communities. These value chains are expected to continue beyond the project, providing sustainable income for the communities.

POLICY AND REGULATORY FRAMEWORK

The project has advocated for the establishment of local policies and regulatory frameworks outlined in the forest management plans for CFUGs in the project area. It has effectively promoted sustainable practices in mangrove and aquaculture management, including community forestry and participatory forest management. These policies and frameworks will continue to guide effective management and ensure the long-term sustainability of mangroves associated with agriculture and aquaculture. Additionally, co-management and benefit-sharing regulations will enhance management effectiveness and promote long-term sustainable mangrove management.

In summary, these measures contribute to the sustainability of the project's benefits and impacts by addressing institutional capacity, involving communities, establishing viable value chains, and supporting policy frameworks.

5 LESSON LEARNED

COMMUNITY PARTICIPATION

The project highlighted the crucial role of community participation in mangrove restoration. Without the active participation of local communities, mangrove degradation may reach a point where restoration through assisted natural regeneration becomes challenging. Thus, it is vital to engage local communities in all stages of project design, planning, and implementation.

INSTITUTIONAL CAPACITY BUILDING

The project demonstrated the effectiveness of building capacity of local institutions, particularly CFUGs, in mangrove management and restoration. CFUGs, along with the FD and other village groups and organizations, have proven to be valuable micro-institutions for SFM and mangrove-friendly aquaculture. Strengthening their capacity ensures the continuity of mangrove restoration and sustainable practices beyond the project, emphasizing the importance of capacity building in future initiatives.

VALUE CHAINS FOR MANGROVE-BASED PRODUCTS

Through collaboration with the GGGI, the project conducted an economic appraisal of mangroves in the Ayeyarwady Delta, highlighting the potential for developing value chains around mangrove-based products, such as mud-crab. These value chains offer sustainable livelihood opportunities for local communities. Therefore, future projects should explore the potential for developing value chains around mangrove-based products in order to support community well-being.

POLICY AND REGULATORY FRAMEWORK

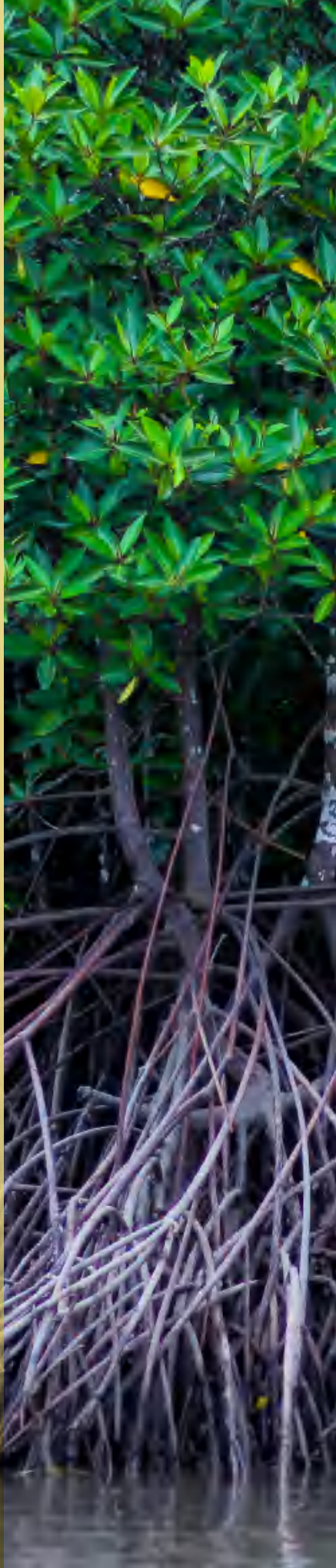
Analysis conducted during the project demonstrated the depletion of mangrove resources in the absence of community engagement in restoration and management efforts. The project emphasized the importance of policies and regulatory frameworks that facilitate local community participation in forest management. To promote SFM practices, future projects should collaborate with governments and stakeholders to establish policies and regulatory frameworks that foster community participation in mangrove management.

6 RECOMMENDATION AND CONCLUSION

Based on the comprehensive information provided, it can be concluded that the project has successfully achieved its intended outputs, objectives and goals. The project's completion has resulted in the restoration of mangrove forests, improved community livelihoods, and the promotion of SFM and mangrove aquaculture in the project area. The project was well-planned, with clear and achievable goals, and its implementation has significantly strengthened the capacity of local institutions and communities. The capacity building conducted ensures the sustainability of the project outcomes and facilities the continued implementation of SFM practices in the long term.

In addition, the project has actively contributed to the development of policies and regulatory frameworks that support sustainable mangrove forest management practices, further enhancing the long-term sustainability of the project's benefits and impacts. Overall, the project's implementation can be considered successful, as it has made a substantial positive impact on mangrove restoration, community livelihoods, and sustainable forest management in the project area.

For future projects, it is recommended to prioritize community participation, institutional capacity building, monitoring and evaluation, and the development of value chains for mangrove-based products. It is also essential to promote policies and regulatory frameworks that support SFM. Technical assistance and training should be provided to local institutions and communities to effectively implement sustainable forest management practices. These recommendations will contribute to the success and long-term sustainability of future projects in similar contexts.



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