STRATEGIC ENVIRONMENTAL ASSESSMENT

PREPARED BY MYANMAR KOEI INTERNATIONAL LTD.

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LIST OF ACRONYMS

ACIAR	Australian Center for International Agricultural Research
BMP	Best Management Practice
BOD	Biochemical Oxygen Demand
CaCO3	Calcium Carbonate
CH_4	Methane
CO_2	Carbon dioxide
CO_2e	Carbon dioxide equivalent
DO	Dissolved Oxygen
DOF	Department of Fisheries
ECD	Environmental Conservation Department
EF	Emission Factor
EHS	Environmental, Health and Safety
EIA	Environmental Impact Assessment
EU	European Union
FAO	Feed and Agriculture Organization
FCR	Feed Conversion Ratio
ft	Feet
FY	Fiscal Year
FIQC	Fish Inspection and Quality Control Section
GAD	General Administration Department
GDP	Gross domestic product
GHG	Green House Gas
GrAqP	Green aquaculture practices
IEE	Initial Environmental Examination
IFC	International Finance Cooperation
IPOA	International Plan of Action
IUU	Illegal, Unreported and Unregulated
IOT	Internet of Things
Kg	Kilogram
LW	Live Weight
MFF	Myanmar Fisheries Federation
MKI	Myanmar Koei International Ltd.
MOECAF	Ministry of Environmental Conservation and Forestry
MONREC	Ministry of Natural Resource and Environmental Conservation
MSDP	Myanmar Sustainable Development Plan
MSME	Micro, Small, Medium Enterprise
NADP	National Aquaculture Development Plan
NACA	Network of Aquaculture Centers in Asia-Pacific
NEQG	National Environmental Quality Emission Guidelines
NES	National Export Strategy
NGA	Nurturing Green Aquaculture
NTU	Nephelometric Turbidity Unit
N_2O	Nitrous Oxide
RAS	Recirculating Aquaculture Systems
SEA	Strategic Environmental Assessment
SEI	Strategic Environmental Impacts
TN	Total Nitrogen
TOEs	Team of Experts
TOR	Terms of Reference
TP	Total Phosphorous
TSS	Total suspended solids
UNCED	United Nations Conference on Environment and Development
USAID	United States Agency for International Development
USD	United States Dollar

DEFINITIONS

Acre	A unit of area equal to 43,560 square feet, 4,047 square meters or 0.4047 hectares (ha).
Algae	Simple photosynthetic plants with unicellular organs of reproduction and not possessing true roots, stems, or leaves.
Ammonia	A nitrogen compound that occurs as a colorless, relatively dense, pungent gas that has the chemical formula NH3 (unionized) or NH4+ (ionized); the ionic form is also known as ammonium.
Aquaculture	Farming of plants and animals that live in water, e.g., fish, shellfish, and algae.
Best Management Practices	Management practices developed to minimize or prevent water pollution. Often, in more general usage, referring to any good environmental stewardship practices.
Carbon footprint	A measurement of the total greenhouse gas emissions caused directly and indirectly by the production of a product.
Constructed wetlands	A designed and man-made complex of water saturated substrates, emergent and submergent vegetation, animal life, and water that simulates natural wetlands for human use and benefits
Drainage systems	A drainage system is an arrangement to move liquids away from where they are not required for disposal in appropriate locations.
Effluent	Wastewater or other liquid-raw, untreated , partially or completely treated- flowing from a reservoir, basin, treatment process, or treatment plant.
Eutrophication	Complex sequence of events in a water body initiated by nutrient enrichment; that is, an increase in trophic state.
Extensive aquaculture system	A system that uses low stocking densities and no supplemental feeding, although fertilization may be done to stimulate the growth and production of natural feed in the water. Water change is affected through tidal means.
Fecal material	Excrement or waste material excreted from the bowels of animals.
Fertilizer	A large number of natural or synthetic materials, including manure and nitrogen, phosphorus, and potassium compounds, spread on or worked into soil to increase its fertility.
Groundwater	(1) Water that flows or seeps downward and saturates soil or rock, supplying springs and wells. The upper surface of the saturated zone is called the water table. (2) Water stored underground in rock crevices and in the pores of geologic materials that make up the Earth's crust.
Grow-out ponds/business	The ponds/business which are intended to stock fingerlings and grow them to harvestable size.
Hatcheries ponds/business	The facilities/business where aquaculture products are bred and raised for at least part of their life cycle.
Integrated fish farming	Integrated fish farming refers to the simultaneous culture of fish or shellfish along with other culture systems.

Intensive aquaculture system	A system that uses very high densities of culture organism and is totally dependent on artificial, formulated feeds.
Monoculture	Only one species is cultured in the fishponds.
Natural fish feed	Feed naturally found in water such as detritus, bacteria, plankton, worms, insects, snails, aquatic plants, and fish, etc. that can be consumed by the fish for their growth.
Nutrient	A chemical that is an essential raw material for the growth, development, or maintenance of an organism.
Full harvesting	All the water in the pond is emptied and all the fish species are sold to the market.
Viss	Equivalent to 0.01375 metric tons.
Partial harvesting	Without draining the pond water, only some fish which can be sold to the market are harvested by using appropriate net size.
pH	A measure of the relative acidity or alkalinity of water. Water with a pH of 7 is neutral; lower pH levels indicate increasing acidity, while pH levels higher than 7 indicate increasingly basic solutions
Poultry - fish ponds/business	A fish farming which is integrated with poultry farming where poultry droppings or deep litter materials are utilized by fish as feed materials.
Polyculture	Culturing two or more species in a pond.
Project bank	An interactive, web-based, publicly accessible database or project information bank that includes Projects that implementing government agencies plan to develop to implement the MSDP and its Strategic Action Plans.
Receiving waters	Bodies of water that receive runoff or wastewater discharges, such as rivers, streams, lakes, estuaries, and groundwater.
Recirculating Aquaculture Systems	A system for farming fish or other aquatic organisms by reusing the water and other resources in the production.
Semi-intensive aquaculture system	A system that uses densities higher than extensive systems and use supplementary feeding.
Spread feeding	The fish is fed by dispersion of the feed over the water's surface directly.
Spot feeding	The fish feed is placed at a specific location such as inside a floating bamboo or rope feeding rings which are attached to the bottom of the pond and, the fish needs to come the specific point/part of the pond to get the feed.
Total nitrogen	The total amount of nitrogen available in a sample.
Total phosphorous	The total amount of reactive acid hydrolysable and organic phosphorus available in sample following hydrolysis and oxidative reduction of the water sample.
Total suspended solids	A fixed volume of sample is filtered through a pre-weighed and washed glass fiber filter. The filter is then rinsed and dried at 103- 105 C. The change in the weight of the filter represents the weight of suspended materials.

EXECUTIVE SUMMARY

Nurturing Green Aquaculture in Myanmar (NGA-Myanmar) supports micro, small, and medium enterprises (MSMEs) to increase productivity while improving resource efficiency and reducing water pollution and carbon emissions in the Ayeyarwady delta ecosystem. The Strategic Environmental Assessment (SEA) was carried out to assess environmental impacts of aquaculture on the ecosystem and collect data and information on relevant environmental parameters to help NGA-Myanmar prioritizes key intervention areas.

Despite its growth potential, the aquaculture sector faces several constraints in terms of good practices and technologies. As producers and investors are endeavoring to improve productivity and marketability, there is an urgent need to establish the practical foundation on environmental sustainability in the sector.

Review of literatures suggests that aquaculture is a priority sector in Myanmar. The Myanmar Sustainable Development Plan (2018-2030), National Export Strategy (2020-2025), and the Agriculture Development Strategy and Investment Plan (2018-2023) recognize the economic significance of aquaculture and put an emphasis on ensuring its sustainable development.

This SEA provides a high-level examination of the environment safeguarding aspects of the aquaculture sector in the Yangon-Ayeyarwady production centers to contribute to the integration of environmental considerations into the implementation of the European Union (EU) funded NGA-Myanmar.

An analysis of water quality parameters from the 16 water samples, 8 at fishpond level and the other 8 at ambient water level[1] were done to measure key water quality parameters. Those sampled locations are within the four targeted townships of NGA-Myanmar[2]. Analyzed samples at laboratories were compared with the Myanmar's National Environmental Quality (Emission) Guidelines (NEQG) for aquaculture effluent and permissible level of pond water quality.

[1] *The study targeted to assess also effluent water from ponds. But during the survey period, none ponds discharging effluent water, given that they are in the middle of growing season.*

[2] *Twantay in Yangon Region, and Maubin, Nyaungdon, and Pantanaw in Ayeyarwady Region*

Based on the analysis results, the pH varied from 6.5 to 8.0 among the 8 ponds, that was within the range of the requirement of fish cultivation and complied with NEQG effluent level for aquaculture. As for the Dissolved Oxygen (DO), results at 4 locations (TT-P2, ND-P2, PN-P2, MB-P1) were lower than 4 mg/L, which was concerning as healthy water should generally have DO concentrations above 6.5-8 mg/L. Furthermore, the Total Suspended Solids (TSS) at all points exceeded NEQG guideline values (50 mg/L), despite that they were still under the permissible level of pond water quality (200 mg/L), except in one location (PN-P1).

Total Phosphorous (TP) values in the water among the 8 ponds were under the NEQG effluent values for aquaculture and within the range of the requirement for fish cultivation. Total Nitrogen (TN) in the 5 locations ranged from <2 to 9 which were under the NEQG effluent values, but TN results in 3 locations (ND-P2, PN-P1 and MB-P1) were beyond the permissible limit.

Analysis results of ambient water were compared with Vietnam Surface Water Standard (A2 Class) for domestic water because Myanmar has no surface water quality standards as of August 2022. However, the Vietnam Surface Water Standards does not cover all the measured parameters. It covers only pH, DO, TSS, and nitrates. Based on the analysis, pH and nitrate results of all sampling points were under the standard values of Vietnamese guidelines. However, TSS results of five sampling points are higher than the guidelines. Dissolved Oxygen (DO) of the ambient water for all points were lower than standard values. The low DO was likely resulted from the high-water turbidity because the samples collection was done during the rainy season.

Based on the Water Quality Index (WQI) calculation using 4 parameters, 3 ambient water samples (TT-A1, PN-A2, MB-A2) were categorized as good, but the other 5 samples (TT-A2, ND-A1, ND-A2, PN-A1, MB-A1) were poor. It is projected that water quality parameters will be worse, if analysis was done during the dry season or during/after harvesting period, where effluent is discharged from ponds. Given the over-reliance of the communities in the Ayeyarwady delta to natural streams, the analysis results indicate the need to promote sustainable aquaculture practices in the studied locations.

Regarding to the water usage, some ponds use groundwater to maintain water level in the dry season. As fishponds require a large volume of water, the groundwater extractions could lead to its depletion that would negatively impact the surrounding community. In addition, the use of diesel generator for water pump also increases carbon footprint from aquaculture.

The carbon footprint from the aquaculture operations at farm level was also calculated based on the data provided by the operators/owners from their previous fish-farming cycle. Prior historical data was not available. The total emissions from the 8 ponds with the total fish harvesting area of 561.5 acre were 3,362.99 tons CO2e. The average emission amount released from an area of acre is 5.99 tons of CO2e, with the production of feed materials contributed the largest at 78% of the total emissions.

In-depth interviews with the operators covered most of the essential aquaculture operations, except the energy usage and detailed farm management. All sampled ponds were grow-out ponds to culture freshwater species. Manual feeding method by spreading feeds on the ponds with hands was mostly used –which is inefficient and ineffective. Both commercial pellets and farm-made feed were used. To reduce the acidity of the soil and water, lime (calcium bicarbonate/$CaCO_3$) was widely used thanks to its fair price. Overall, the pond operators have limited knowledge on hazardous materials, its safe applications, and environmental impacts. Furthermore, it was observed that there has been lack of interest and awareness among the operators to establish water treatment facilities and carry out systematic water quality testing and monitoring.

Finally, the potential environmental impacts of aquaculture and its mitigation measures were identified. Key environmental impacts identified include water quality, bottom sediment, solid waste, climate change, and community health. Recommendations to promote green aquaculture practices and water quality monitoring are provided to support NGA-Myanmar implementation.

INTRODUCTION

Aquaculture is an important pillar of Myanmar's economy, contributing roughly 2% of the gross domestic product (GDP) and 6% of the national employment.[3] National economic statistics reports that the fishery sector is making a steady increase in production and exports with the export revenue increasing from USD 530 million in 2013-2014 FY to USD 850 million in 2019-2020 FY.

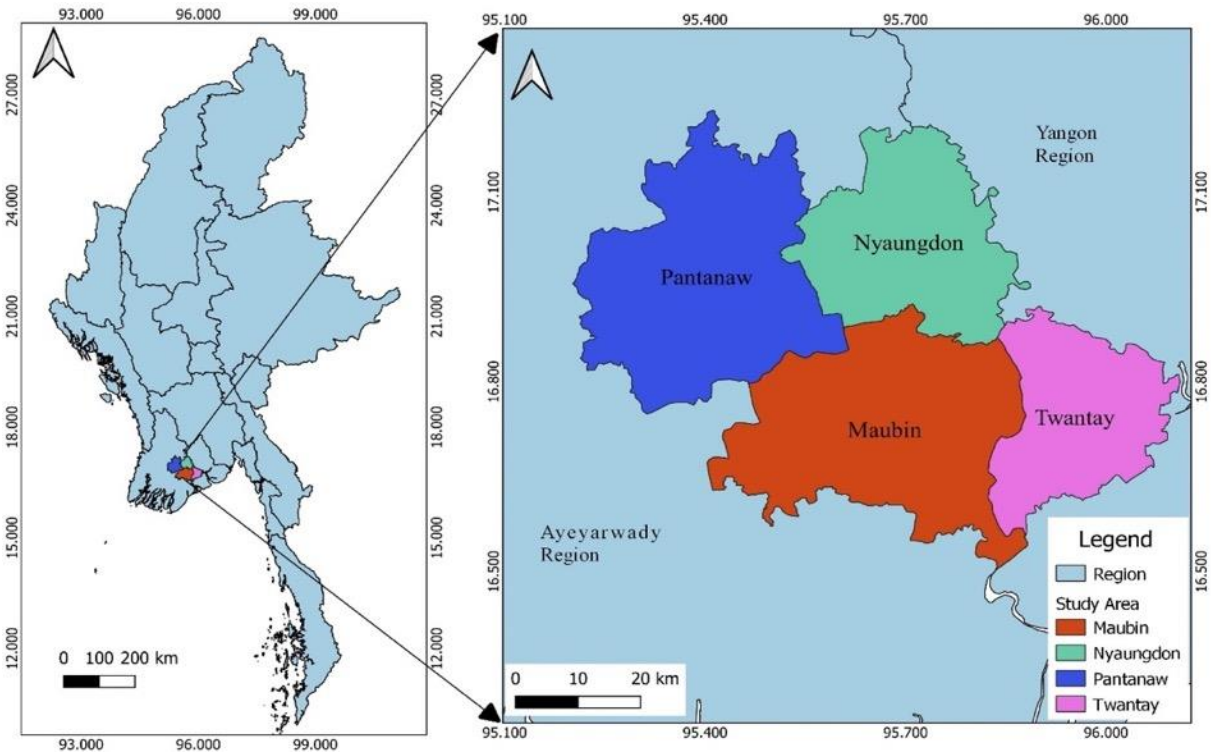
This SEA aims at providing a high-level examination of the environment protection aspects in aquaculture sector in the Yangon-Ayeyarwady aquaculture production centers to contribute to the integration of environmental considerations into the implementation of the EU funded NGA-Myanmar program, with a view of promoting sustainable development.

Box 1: Key elements of the SEA

- Legal and institutional framework,
- Water quality parameters,
- On-farm carbon footprints,
- Other environmental aquaculture impacts.

According to the National Aquaculture Development Plan (NADP) 2020, 93.6% of the aquaculture farms in Myanmar are in Yangon, Ayeyarwady, Bago, and Rakhine. NGA-Myanmar targets 4 main producing townships along the Yangon-Ayeyarwady corridor. Those townships are Twantay in Yangon Region, as well as Nyaungdone, Pantanaw, and Maubin in Ayeyarwady Region –which become the study areas of this SEA.

Figure 1: SEA study areas



Source: Myanmar Koei International Ltd.

[3] *Rapid Market Assessment of Aquaculture Sector in Myanmar, USAID, 2021*

PART 1: LEGAL FRAMEWORK AND INSTITUTIONAL LANDSCAPE

LEGAL FRAMEWORK

The political events of 1 February 2021, which came after a period of relative stability, marked a major setback for the country's economy and fledgling democracy. Besides the alarming humanitarian situation, the compounded political, health and social crises, have weakened domestic demand and trade, and disrupted business operations. Despite that, the State Administration Council[4] (SAC) continues to impose most (if not all) existing policies related to aquaculture businesses. This section is therefore laid out the existing legal framework governing the aquaculture sector in Myanmar.

Relevant Laws

There are three main laws governing the fishery sector in Myanmar, they are: the Aquaculture Law (1989), the Marine Fisheries Law (1990) and Freshwater Fisheries Law (1991). The 1989 Aquaculture Law is primary legislation regulating aquaculture. This law requires that any individual wishing to engage in aquaculture must obtain a license from the Department of Fisheries (DOF), except where the pond covers a surface area of less than 25 x 50 square feet and is operated by a family for its personal consumption. This law also regulates the application for aquaculture leases and licenses.

For agricultural land to be converted to ponds in a legally compliant manner, the land user must apply for a change of land title –a document called *La Na* 39. Applications for *La Na* 39 must pass multiple government departments at village, township, and union levels. Farms that convert paddy or other agricultural land to ponds without obtaining *La Na* 39 are at risk of fines, imprisonment, or the confiscation of the land. This effectively weakens the people tenure security, although in practice enforcement of these punishments appears to be patchy, and mostly focusing in areas with high concentration of ponds.

Moreover, the current land-use policies are constraining the emergence of small-scale aquaculture in many parts of Myanmar. Potential new fish farmers are discouraged from converting even small parcels of lands to ponds, for fear of losing their land-use rights. Specifically, the Farmland Law (2012) restricts the conversion of land registered for rice cultivation for any other permanent purposes without authorization. While the Vacant, Fallow, and Virgin (VFV) Land Law (2012) allows for land to be used for aquaculture purposes, however this does require prior consent of the Central Committee. In September 2018, the VFV Land Law was amended reinforcing the requirement that all persons using VFV land must register their land within 6-months after the amendment being enacted, resulting in many suffered from losing the land previously used.

The existing Aquaculture Law gives the DOF the authority to designate VFV land to be used for the aquaculture purposes. The DOF may also lease fisheries water for the purpose to be used for aquaculture. It should be noted that approval to use agricultural and wastelands for aquaculture requires procedures to be followed under applicable land laws. Recognizing the importance of mangrove forest and coral reefs, the Forest Law (1992) declares that mangrove forests and protected forest are for conservation process. Fishing within three hundred yards of coastal areas and around mangrove areas are also strictly prohibited. The coral reefs along the coast of Myanmar act as a buffer zone and stabilize the bottom sediments, control the local mean water level and the direction of water flow. Enforcement of the law, however, has always been an issue.

[4] *It refers to the council currently governing Myanmar, established following the military government takeover.*

The Marine Fisheries Law (1990) and the Freshwater Fisheries Law (1991) focus on establishing an effective mechanism for taxation and revenue collection. The Freshwater Fisheries Law is applicable to freshwater fisheries in inland waters, which include ponds, courses, rivers, streams, and lakes of permanent or temporary nature, in which fish live and thrive and which are situated within the inland boundary along the seacoast of Myanmar. The Law distinguishes the permission to operate a freshwater fishery into leases, to be purchased through competitive bidding and licenses, both to be issued by officer-in-charge in the respective Township.

The Myanmar Marine Fisheries Law (1990) is currently being revised and is in an advanced draft form, but this is yet to be released due to reported procedural issues and the current political crisis. This law, interestingly, contains also relevant licensing requirements for aquaculture activities. According to the Law, fishery includes the hatching and breeding of fish, and onshore and offshore fishery activities. Onshore fishery means any fishery carried out in the inshore area along the Myanmar coast. While offshore fishery means any fishery carried out in the Myanmar marine waters. Onshore and offshore waters are as determined by relevant Director General.

Box 2: Relevant laws and regulations

National laws

- Law relating to the fishing rights of foreign fishing vessels (1989)
- Aquaculture Law (1989)
- Myanmar Marine Fisheries Law (1990)
- Freshwater Fisheries Law (1991)
- Law amending the Myanmar Marine Fisheries Law (1993)
- Law amending the law relating to the fishing rights of foreign fishing vessels (1993)
- Environmental Conservation Law (2012)
- Environmental Conservation Rules (2014)
- National Environmental Policy (2019)
- National Environmental Quality (Emission) Guidelines (NEQG) (2015)

Compliance to international laws

- Code of Conduct for Responsible Fisheries
- International Plan of Action- Illegal, Unreported and Unregulated (IPOA –IUU) Fishing
- Port State Measure Agreement (2009)
- European Union (EU) regulation No. 1005/2008 and 1010/2009
- Regional Plan of Action-IUU (RPOA –IUU)
- ASEAN Regional Plan of Action for Managing Fishing Capacity –RPOA Capacity (2017)
- ASEAN Guidelines for Preventing the Entry of Fish and Fisheries Products from IUU Fishing Activities into Supply Chain
- WTO-SPS Agreement Obligation, EC Regulation and ASEAN common principles of feed hygiene, control system and labeling.

Brief explanations of those items are presented as Annex 1.

Government Strategies and Plans

The National Export Strategy (NES) 2020-2025 is a 5-year plan launched in 2015 and set to focus on seven key sectors and 4 supporting sectors within Myanmar. The initial purpose of the NES was to deliver broad-based socio-economic development to the people of Myanmar while alleviating poverty, catalyzing rural economic development, and accelerating income growth. For the last five years, NES served as a guiding principle recommending target investments to increase value addition in various export-oriented sectors. It provides Myanmar with a detailed framework and decision-making instrument to guide the country's trade development and boast its export competitiveness. It outlines concrete, market-based solutions to address competitiveness constraints affecting Myanmar's competitiveness in global markets.

In August 2018, the government released the Myanmar Sustainable Development Plan (MSDP) as the overarching framework to orient and guide the country's development efforts. It is an overall framework for coordination and cooperation across all ministries, and all states and regions to provide a development path for the Union.

In line with MSDP, the National Aquaculture Development Plan (NADP) 2020 was launched by DOF in early 2020 to lay out strategies to improve aquaculture sector productivity, competitiveness, and governance, through:

- Inclusive development – Aquaculture provides a more stable income stream, with higher pay rates, when compared to other employment opportunities in the agricultural sector.
- Export revenue– If Myanmar can increase its production, quality, and reliability of supply of these fishery products, there is great potential to increase exports leading to greater foreign currency export earnings.
- Job creation – It can increase not only the development of the aquaculture sector but also the job opportunities in rural Myanmar.
- Food and nutrition security – Aquaculture will improve food and nutrition security with fish products as a cost-effective source of animal protein.
- Environmental conservation – Aquaculture to utilize aquatic resources of marginal economic value, for example water with high salinity, thereby reducing pressure on increasingly scarce freshwater resources.

Policy Related to Environmental Assessment

In Myanmar, Environmental Impact Assessment (EIA) procedure was introduced in December 2015. Since then, EIA has widely practiced in development projects in a number of sectors. According to the procedure, investment proposals are required to conduct either EIA or IEE (Environmental Impact Evaluation). Being project specific, EIA has some limitations as it does not contribute to higher level decision making. Thus, SEA has emerged to bridge this gap. While EIA focus on individual project, SEA aims to provide overall guidance toward integrating environmental sustainability into higher level planning process and policy choices. However, since there is no clear guidance on how SEA should be carried out in Myanmar, the process as described in the EIA procedure is used as the main reference. Moreover, the SEA of NGA- Myanmar is done not to comply with the government regulation but rather to look at the relevance of NGA- Myanmar activity to address environmental issues in the aquaculture sector.

National Environmental Quality Emission Guidelines (NEQG)

The National Environmental Quality (Emission) Guidelines (NEQG) were set by the Ministry of Natural Resources and Environmental Conservation (MONREC) in December 2015. It regulates control of noise and vibration, air emissions, and liquid discharges from various sources to prevent pollution for purposes of protection of human and ecosystem health. The effluent standards relevant to the Aquaculture are given in the following table. This guideline applies to commercial production of aquatic species, including crustaceans, mollusks, seaweeds, and finfish.

Table 1: NEQG effluent levels for aquaculture

Parameter	Unit	Guideline Value
5-day biochemical oxygen demand	mg/l	50
Active ingredients/Antibiotics	To be determined on a case specific basis	
Chemical oxygen demand	mg/l	250
Oil and grease	mg/l	10
pH	Standard unit	6-9
Temperature increase	°C	<3
Total coliform bacteria	100 ml	400
Total nitrogen	mg/l	10
Total phosphorus	mg/l	2
Total suspended solids	mg/l	50

Source: National Environmental Quality (Emission) Guidelines (NEQG,2015)

INSTITUTIONAL LANDSCAPE

Following the military government takeover, the SAC was formed as a provisional administration. Since then, there have been resignations of government officials across levels, personnel changes of the administration offices, and key structural changes at the ministerial level. However, existing structures at the department, regional, district and township levels seem to have been largely maintained. This section presents key entities working for the aquaculture sector in Myanmar.

The Department of Fisheries

The DOF is the responsible government department for the development and management of the fisheries sector (that includes aquaculture) in Myanmar.

Specifically, duties of the Aquaculture Division within DOF include the following:

- Overseeing development of the aquaculture industry.
- Providing technical assistance and capacity building to the sector.
- Seeking technologies to improve the sector.
- Adapting aquaculture techniques to local climatic conditions and monitoring the impacts of climate change.
- Collecting revenue in the form of taxes.

The DOF is organized into central, regional/state, district, township, and sub-township offices. The average number of officers per township is five – which is insufficient to cover the number of aquaculture operators in the production centers. The main role of those township officers is to deliver extension on good practices and transfer technology for farmers.

The department is also responsible to enforce relevant laws. As aforementioned, the provision of aquaculture leases and licenses are under the DOF authority. It includes ability to designate aquaculture land from agricultural or VFV land for aquaculture development for no more than 10 years.

Finally, in many locations, DOF also operates government hatcheries and is responsible for the sale of fingerlings produced through breeding or artificial propagation. However, the current political context has further reduced DOF capacities to serve the aquaculture farmers.

The Environmental Conservation Department (ECD)

The Environmental Conservation Department (ECD) is responsible for environmental conservation and management under the Ministry of Natural Resources and Environmental Conservation (MONREC). The ECD was established when the Environmental Conservation Law was enforced in 2012 to strengthen national environmental management.

Regarding industrial wastewater management, the Pollution Control Division under ECD takes the lead in taking measures against water pollution and conducting environmental management activities.

The Myanmar Fisheries Federation (MFF)

The Myanmar Fishery Federation (MFF) is a non-governmental, nonprofit organization that supports and promotes the fisheries sector[5] in Myanmar. The Federation aims to improve the socio-economic conditions and livelihoods of its members and the broader fisheries community. MFF acts as an umbrella organization that consists of different related associations working in fishery sector (Box 3).

MFF provides information on relevant policies, technology, and important fisheries information to stakeholders. The Federation carries out advocacy on behalf of its membership at the local, state/regional, and national levels. It also promotes foreign investment in and export from the Myanmar fisheries industry.

Box 3: Functional associations are under the MFF

- Myanmar Shrimp Association
- Myanmar Fish Farmers Association
- Myanmar Fishery Products Processors and Exporters Association
- Myanmar Aqua Feed Association
- Myanmar Marine Fisheries Association
- Myanmar Fresh Water Capture Fishery Association
- Myanmar Crab Entrepreneurs Association
- Myanmar Eel Entrepreneurs Association
- Myanmar Ornamental Fish Entrepreneurs Association
- Myanmar Fish Paste, Dried Fish, Fish Sauce Entrepreneurs Association.

[5] *The fisheries sector of Myanmar is divided into marine and freshwater fisheries sub-sectors. While marine fisheries sub-sector includes inshore and offshore, the freshwater fisheries sub-sector includes aquaculture, as well as leasable and open fisheries sub-sectors.*

PART 2: YANGON – AYEYARWADY AQUACULTURE CORRIDOR

NGA-MYANMAR TARGET TOWNSHIPS

The socio-economic status of Twantay Township, Maubin Township, Pantanaw Township and Nyaungdone Township are collected from different secondary sources, like the Myanmar Population and Housing Census (2014), General Administrative Department Township Report (2020) for each township, and other publications, including academic studies. Summary of the socio-economic conditions of survey locations of each township is briefly described in this section.

Twantay Township

The township area has 279.90 square miles and is 15 feet above sea level. It is situated in Yangon's Southern District, position them within a proximity to Yangon, Myanmar's most populous city and its most important commercial center. There are several rivers and creeks, and most of its territory (90 percent) is covered by flat ground with great access to water –ideal for freshwater aquaculture. Toe River and Kattiya Creek flow from north to south, the Pan Hlaing River flows from west to east, and the Twantay Canal flows from west to east.

In Twantay Township, there are four primary types of soils: lateritic soil, saline marshy and meadow gluey soil, dune forest, and beach sand. Silt and clay make up the majority (90 percent) of these soils –which is ideal for establishing earthen ponds. Over the years of 2018, 2019, and 2020, Twantay township experienced an average annual rainfall of about 2,632.96 mm, with an average yearly number of wet days of 91 days. In the years 2018, 2019, and 2020, the average annual temperature for the summer was 41.54 °C, while for the winter, it was 16.38 °C.

Total population in Twantay Township is 235,347 persons (51% female). Total households in this township are 57,250 households, 39.7% of them uses water for drinking from improved sources (tap water/ piped, tube well/ borehole, protected well/ spring and bottled water/ water purifier) while some 60.3% of the households rely on unimproved sources, especially rivers or streams –highlight the importance of environmental sustainability to protect water ecosystems.

Twantay Township is an agricultural area where both summer and monsoon paddy are farmed. Black grams and green grams are widely grown as annual crops, while long-term rubber plantations are also grown. In terms of land use, 119,802 acres of the land is for agricultural. Other uses are for pastureland (2,681 acres), industrial area (104 acres), residential in both urban and rural areas (3,456 acres), protected forest area (868 acres) and fallow land (887 acres), uncultivated lands (57,579 acres) and other lands (54,019 acres) respectively. The data shows that over the period of 2019 and 2020, there were 3,692 ponds totaling 34,198 acres in the township, with the total fish production of 164,908.95 viss (2,267.50 metric tons). A total of 72,215 people rely on agriculture for their living, with the aquaculture industry coming in second livelihood sector with 40,890 people engage.

Maubin Township

Located in the Ayeyarwady Region, the township area of Maubin is 515.380 square miles and situated at 13.62 feet elevation above sea level. The slope is modest. With lengths of 46 miles and 25 miles, respectively, the two most well-known rivers are Toe and Yazutaing. Freshwater is the predominant type of local water resource utilized for drinking and agriculture. The soil of Maubin Township is gleisoil based on the Food and

Agriculture Organization (FAO) soil classification system. Gleisoil is formed under waterlogged conditions produced by rising groundwater.

The average annual rainfall of Maubin Township was around 2,220.93 mm, and the average annual rainy days was 107 days from the period of 2016 to 2020. The average annual temperature in the summer season was 38.9 °C, and that in the winter season was 13.08 °C, over the period of 2016 to 2020.

Total population in Maubin Township is 322,260 persons (51% female). Total conventional households in this township are 39,388 households. 30.1% of households use water for drinking from improved sources (tap water/ piped, tube well/ borehole, protected well/ spring and bottled water/ water purifier) while 69.9% use water from unimproved sources.

The agricultural sector employed 45,947 people, followed by casual workers with 42,594 people and merchant 34,750 people. Only 957 numbers of people reported to work in aquaculture sector –this number seems to be an underreported figure (i.e., it is very likely that casual workers work in both agriculture and aquaculture).

The 2020 data shows that there were 213,890 acres of agricultural area, 5,373 acres of pastureland, 631 acres of industrial area, 8,263 acres of residential area of urban and rural, 2,250 acres of fallow land, and 99,439 acres of uncultivated lands. The main crops produced are paddy (summer and monsoon), groundnut, sesame, sunflower, green grams, black grams, and corns respectively. Over the period of 2019 and 2020, there were 1,389 ponds (53,929.58 acres), with total fish production of 131,792 viss (1,812.14 metric tons).

Pantanaw Township

Pantanaw Township is in the Ayeyarwady Region with an area of 498.52 square miles and situated at 17.91 feet above sea level. The township is composed of rivers, creeks, inns, lakes, man-made embankments, and low land. The most well-known creek is Pantanaw Creek, flowing to the Ayeyarwady River. Soils in Pantanaw Township are formed from the parent material of young and old alluvium deposited by rivers and creeks. Meadows with swampy clay soils and meadows with alluvial medium loamy soils are predominant in this township.

From the period of 2017 to 2020, the average annual rainfall of Pantanaw township was around 2,029.46 mm, and the average annual rainy days was 86 days. Over the same period, the average annual temperature in the summer season was 32.95°C and that in the winter season was 21.05°C. The climate of Pantanaw Township is influenced by its geographical location and the periodical shifting of monsoon winds.

The entire population of Pantanaw Township is 277,610 people (51% female). There are 61,762 conventional households, whereby 64.1% of them use improved sources of water for drinking (tap water, piped water, tube wells, boreholes, protected wells, springs, bottled water, and water purifiers), compared to 35.9% of households who use unimproved sources.

The township statistics (2020) reports that there were 4,523 acres of urban and rural residential area, 9,845 acres of fallow land, and 54,805 acres of uncultivated land. In addition, 213,725 acres of land were for agriculture, 18,100 acres for pastureland, 56 acres for industrial area, and 4,523 acres for residential area. Paddy (summer and monsoon), groundnut, sesame, sunflower, green gram, black gram, corn, and sugarcane are the main crops grown in Maubin Township.

Between 2019 and 2020, there were 351 registered ponds, accounted for 17,967.38 acres. During that period, Pantanaw Township has a total fish production of 51,164 viss (703.51 metric tons). A total of 45,974 individuals depends on agriculture for their livelihood, followed by 23,975 casual workers and 13,275 merchants. Only 780 individuals rely on aquaculture as their main livelihood.

Nyaungdone Township

The township area of Nyaungdone is 348.23 square miles and situated at 20 feet elevation above sea level. Nyaungdon is also part of Ayeyarwady Region, and mostly a flat land in delta area. The township is composed of river, creeks, and lakes. Ayeyarwady river with the length of 16 miles flows from north to south and Pan Hlaing River with 14 miles length flows from north to east.

Most of the soil found in Nyaungdone Township is sandy loam, clay loam, clay and silty.

The average annual rainfall of Nyaungdone township was around 2,044.38 mm, and the average annual rainy days was 106 days from the period of 2017 to 2020. The average annual temperature in the summer season was 37.5°C, and that in the winter season was 16.75°C, over the same period.

There are 230,772 people living in Nyaungdone Township (51% female), with 52,617 households. 32.7% of families obtain their drinking water from improved sources (tap water/piped, tube well/borehole, protected well/spring, and bottled water/water purifier), while the rest do so from unimproved sources.

In this township, there are 131,057 acres agriculture land, 7,506 acres pastureland, 201 acres industrial land, 8,263, acres residential areas, and 78,254 acres other lands. The top 10 crops grown in Nyaungdone Township, like those in other townships are paddy (summer and monsoon), groundnut, sesame, sunflower, green gram, black gram, corn, and sugarcane.

With 1,321 ponds and 29,924.74 acres of fisheries, Nyaungdone Township has a total fish production of 13,451.84 viss (184.96 metric tons), between 2019 and 2020. A total of 57,599 persons makes their living as merchants. Aquaculture is next, employing 15,575 people, while agriculture employs 16,680 people.

STUDY LOCATIONS

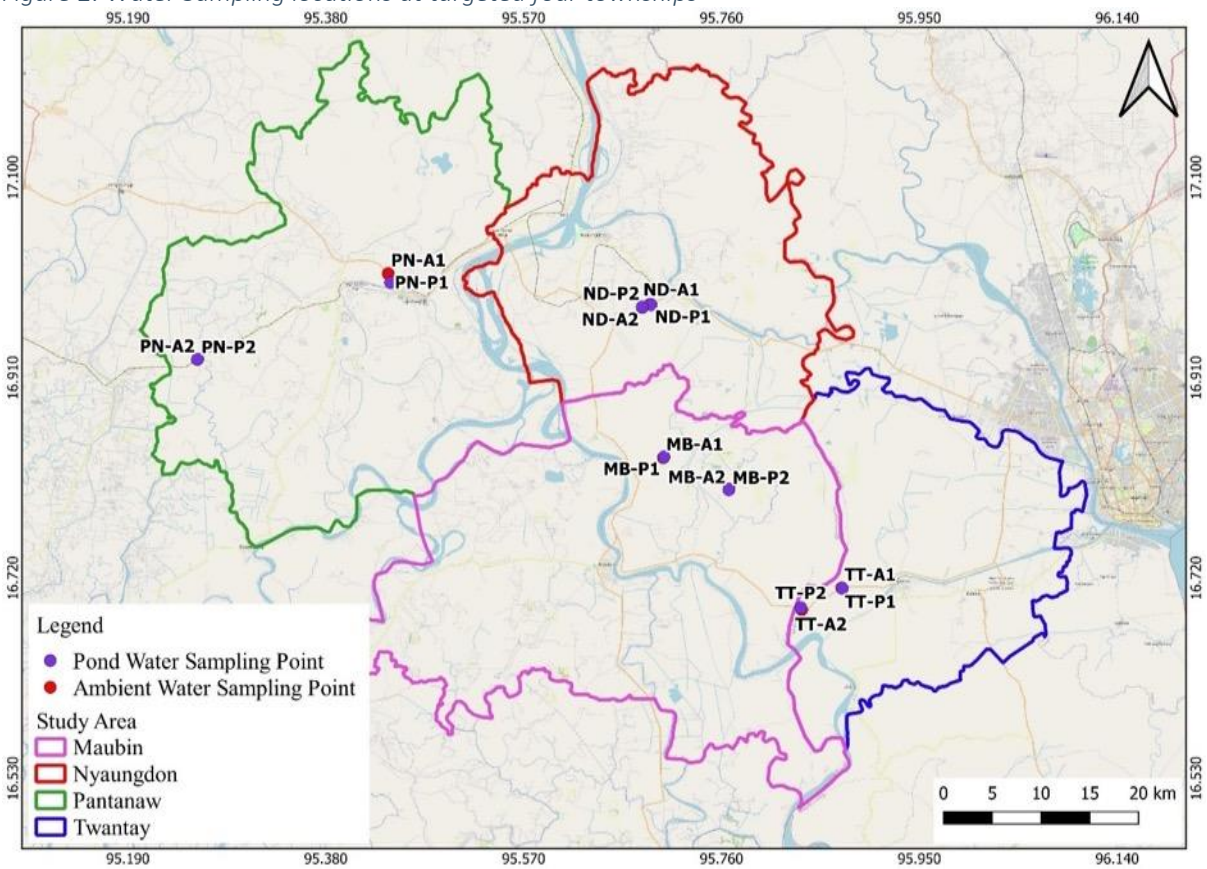
In Myanmar, inland aquaculture production cycle usually begins in early to mid-monsoon season (from June to August). Most production cycle ends during dry season (months of November to April), when water availability is low and demand for freshwater products in markets is high. Generally, a full pond harvest (i.e., as opposed to a partial harvest) is accomplished by draining the pond. Pond is also drained in any emergency cases like a disease outbreak, etc. Drained water consists of effluent that would impact water quality at streams.

Preliminary Site Visit

Before selecting the study locations in each township, preliminary survey was conducted on 27 and 28 June 2022. During the preliminary survey, the following activities were carried out:

- Observing streams and water gates near the fishponds.
- Discussing with pond owners/operators and asking for permission to collect water samples.

Figure 2: Water Sampling locations at targeted four townships



Source: Myanmar Koei International Ltd. (MKI)

The study locations were selected to be representative of appropriate place within and around the fishpond based on the following considerations:

- Farm type: fish hatchery, fish farm, or integrated poultry-fish farm.
- Size of farm: over 100 acres or less than 100 acres).

- Type of feed: farm-made feed or commercial feed.
- Type of feeding methods: spread, spot feeding or other.
- Presence of good management and locations of inlet/outlet of pond water.

Based on those considerations, the following ponds are selected.

Table 2: Outline of water quality field survey

Period	Locations	Points	GPS	Items	Parameters
13 July 2022	Twantay (Yangon)	TT-P1	16°42'36.82"N, 95°52'34.02"E	Pond water	<u>On-site measurement:</u> Water temperature, pH, Dissolved Oxygen, Turbidity, Total Suspended Solid <u>Laboratory analysis:</u> Nitrate, Ammonia, Total Nitrogen, Orthophosphate, Total Phosphorous
		TT-A1	16°42'38.67"N, 95°52'32.04"E	Ambient	
		TT-P2	16°41'31.40"N, 95°50'9.93"E	Pond water	
		TT-A2	16°41'24.02"N, 95°50'13.73"E	Ambient	
14 July 2022	Maubin (Ayeyarwady)	MB-P1	16°50'6.09"N, 95°42'17.48"E	Pond water	
		MB-A1	16°50'3.51"N, 95°42'15.02"E	Ambient	
		MB-P2	16°48'14.03"N, 95°46'1.27"E	Pond water	
		MB-A2	16°48'15.87"N, 95°46'2.54"E	Ambient	
15 July 2022	Pantanaw (Ayeyarwady)	PN-P1	17° 0'1.46"N, 95°26'31.85"E	Pond water	
		PN-A1	17° 0'32.39"N, 95°26'23.83"E	Ambient	
		PN-P2	16°55'40.02"N, 95°15'25.09"E	Pond water	
		PN-A2	16°55'38.62"N, 95°15'24.38"E	Ambient	
16 July 2022	Nyaungdone (Ayeyarwady)	ND-P1	16°58'45.69"N, 95°41'32.92"E	Pond water	
		ND-A1	16°58'47.52"N, 95°41'30.13"E	Ambient water	
		ND-P2	16°58'38.52"N, 95°41'1.93"E	Pond water	
		ND-A2	16°58'36.79"N, 95°41'2.12"E	Ambient	

Source: Myanmar Koei International Ltd. (MKI)

Selected Study Locations

Water quality sampling was carried out at 16 locations (4 locations of each township, consisted of 8 ponds and 8 ambient). It was not possible to collect effluent water from the surveyed ponds because the study was carried out during a grow-out period, whereby none of sampled ponds discharging their effluent to streams. In the absence of pond water effluent, samples of pond water and ambient water (surface water of nearby streams) were collected to measure water quality.

NGA-Myanmar can complement this study by collecting and measuring effluent water during full harvest period.

Those 8 ponds were also used to collect data and information to calculate carbon emissions and to understand the current aquaculture practices.

Twantay Pond #1 (TT-P1) and Twantay Ambient #1 (TT-A1)

TT-P1 and its respective TT-A1 are located in Twantay Township. TT-P1 farm carries out farming both for commercial hatchery as well as grow-out (polyculture). This farm uses farm-made feed. The total pond area is 80 acres, whereby samples were collected from an area over 13 acres.

The type of pond is an earthen one. The water is received from the diversion channel of the Twantay Canal, directly pumped into the pond without treatment, except screen installation to prevent invasive species to enter the ponds. When the pH level is adjusted or the water level drops during the dry season, this pond uses groundwater to supplement the required water.

Usually the farm use partial harvesting method. When the pond is harvested, the water from the pond is directly discharged to the near channel using diesel pump. The water in the pond is five to six feet deep. The farm-made feed, rice bran, and soybean cake are fed to the fish by spreading method. Lime is mostly used for pond upkeep and to maintain desired pH level. The owner/operator uses test kit to check water quality. This farm experienced bacteria infestations. Pond maintenance is carried out every three years.

Figure 3: TT-P1 pond and sampling process in TT-P1 and TT-A1

Source: Myanmar Koei International Ltd. (MKI)

Figure 4: TT-P2 pond and sampling process in TT-P2 and TT-A2

Source: Myanmar Koei International Ltd. (MKI)

Twantay Pond #2 (TT-P2) and Twantay Ambient #2 (TT-A2)

TT-P2 and TT-A2 are also located in Twantay Township. TT-P2 farm is for commercial growth-out by using polyculture system. The pond is an earthen pond, with a total area of 20 acres. The water samples were collected from an area covering around 2 acres of the pond. This farm mostly uses farm-made feed –a mix of rice bran and soybean cake. Spot feeding method is used.

This fishpond uses diverted water from the Pan Hlaing River. The water from the channel is directly pumped into the pond without treatment, except screen installation for preventing invasive species to enter. Partial harvesting practices are commonly used. The water from the pond is drained into the nearby channel without any treatment. A diesel generator is used for pumping activities, and electricity is used only for lighting purposes. The water depth of the pond is six feet. Lime is mostly used to maintain water quality.

Maubin Pond #1 (MB-P1) and Maubin Ambient #1 (MB-A1)

The pond and its ambient water are in Maubin Township. The MB-P1 ponds are an earthen type with a total acreage of 1,019.23, whereby samples are collected from different points within an area of 51 acres. Polyculture system is used with water sourced from diverted channel of Toe River. The water from the channel is directly pumped in pond without treatment, except screen installation for preventing invasive species.

Partial harvesting method is commonly used in this farm. Full harvesting is applied around three years when the pond maintenance is performed. The water depth of the pond is six feet. Each month, the quality of the water is examined by employing a permanent technician, who specializes in this. Floating commercial pellets is used by spread feeding application. For keeping the water quality at the desirable level, only lime is utilized. This farm is connected to the national grid, but only for lighting purpose. A diesel generator is used for all pumping activities.

Figure 5: MB-P1 pond and sampling process in MB-P1 and MB-A1

Source: Myanmar Koei International Ltd. (MKI)

Figure 6: MB-P2 pond and sampling process in MB-P2 and MB-A2

Source: Myanmar Koei International Ltd. (MKI)

Maubin Pond #2 (MB-P2) and Maubin Ambient #2 (MB-A2)

They are in Maubin Township. The MB-P2 pond is an earthen type. The water depth of the pond is six feet. The Pa Pin Creek, which is a tributary of the Toe River, is the source of water for the pond. The water from the creek is directly pumped into the pond without treatment, except screen installation for prevention of entering the invasive species. The total area of the farm is 145 acres, whereby water samples were collected from an area totaling 70 acres.

Polyculture practice is applied in this farm and partial harvesting is usually applied. A full harvesting is done when pond maintenance is required. Following observation of the pond water quality, tests are conducted sporadically as needed. The water is directly pumped out to the nearby creek without treatment. A diesel generator is used for pumping activities. For feeding purposes, spot feeding is employed. Fish are fed a proportionate mixture of peanut cake and rice bran. To keep the pond water quality, lime and molasses are utilized.

Pantanaw Pond #1 (PN-P1) and Pantanaw Ambient #1 (PN-A1)

They are in Pantanaw Township. The pond is of the earthen type and is combined with chicken raising. The size of the pond is 15.5 acres, whereby samples were collected from an area of 1.5 acres within the pond. The polyculture method is used in this pond.

The Pantanaw River provides water for the ponds. The water from the canal is directly pumped into the pond without treatment, except screen installation for preventing invasive species to enter the pond. Additionally, groundwater is used to replenish the pond water level and maintain the pH level. The partial harvesting method is applied with full harvesting is done when pond maintenance is done. A diesel generator is used for all pumping activities. Commercial pellets are used for fish feed, and the spread feeding method is applied. Lime is utilized to keep the pond's water quality and maintain the pond.

Figure 7: PN-P1 pond and sampling process in PN-P1 and PN-A1

Source: Myanmar Koei International Ltd. (MKI)

Pantanaw Pond #2 (PN-P2) and Pantanaw Ambient #2 (PN-A2)

The fishpond PN-P2 and Ambient PN-A1 are in Pantanaw Township. The PN-P1 pond is an earthen type and is integrated with raising chickens. This farm has a total area of 100 acres. The water samples were collected from different points within 1.5 acres of the farm. Polyculture practice is employed. The pond varies from a five-to-six-foot depth of water. The Thoungkhwa River provides the water for fishponds in this location.

The water from the canal is directly pumped into the pond without treatment, except screen installation for prevention of entering the invasive species. According to the survey, it was discovered that the neighborhood utilizes water from the Thoungkhawa River for agriculture, residential usage, and drinking. However, the pond discharged its water into a nearby channel without treatment.

A partial harvesting method is commonly applied, and a full harvesting is carried out only when the pond maintenance is carried out. Pond maintenance is generally done about once every three years. A diesel generator is used for pumping activities. Rice bran is used as feed and provided with a floating technique. Lime is used for pond maintenance.

Figure 8: PN-P2 pond and sampling process in PN-P2 and PN-A2

Source: Myanmar Koei International Ltd. (MKI)

Figure 9: ND-P1 pond and sampling process in ND-P1 and ND-A1

Source: Myanmar Koei International Ltd. (MKI)

Figure 10: ND-P2 pond and sampling process in PN-P2 and PN-A2

Source: Myanmar Koei International Ltd. (MKI)

Nyaungdon Pond #1 (ND-P1) and Nyaungdon Ambient #1 (ND-A1)

The fishpond ND-P1 is located in Nyaungdone Township. The pond is an earthen type. This farm has a total area of 600 acres, whereby water samples were collected from different points within an area of 30 acres. This pond practices polyculture method.

Fishponds receive water from Sarmalauk Creek. The water from the canal is directly pumped into the pond without treatment, except the use of screen for preventing from invasive species. The maximum water depth of the pond is five to six feet. Floating commercial feed (pellets) is used for feeding by spot method. Lime is used for pond maintenance purposes. Partial harvesting method is applied with full harvesting method is only done every 3 years to drain and maintain the pond. When draining, the pond water is directly discharged to the nearby channel without treatment. Though the electricity is connected to the pond area, pumping operations use a diesel generator. Its surrounding community uses the Sarmalauk Creek for irrigation purposes.

Nyaungdon Pond #2 (ND-P2) and Nyaungdon Ambient #2 (ND-A2)

The fishpond ND-P2 and its ambient ND-A2 are located in Nyaungdone Township. The pond is an earthen type. The fishpond receives water from the Sarmalauk Creek. The water from the canal is directly pumped into the pond without treatment, except screen installation for preventing invasive species to enter the pond. The maximum depth of the pond is five to six feet. The total size of the pond is 340 acres whereby the team selected samples from within the pond in an area of 23 acres.

Polyculture practices are employed in this pond. Sinking commercial feed (pellets) is provided by spreading method. Due to the application of polyculture practice, partial harvesting method is used with full harvesting is done every 3 years when pond maintenance is required. A diesel generator is used for pumping. The Sarmalauk creek is used as a source for irrigation by the community. Lime is used to maintain the water quality.

CURRENT AQUACULTURE PRACTICES

Over the period from 2006 to 2016, the size of aquaculture farm in Myanmar, especially in Yangon and Ayeyarwady regions, increased significantly. However, the farming technologies and practices appear to have changed marginally. This section discusses aquaculture farm characteristics commonly found in Yangon – Ayeyarwady aquaculture corridor.

Culturing Methods

The aquaculture culturing methods currently used in Myanmar and NGA-Myanmar target townships can be categorized broadly as follow:

Extensive

Extensive culture systems depend largely on a single input, the seed, and there are no or very few supplemental inputs used, and consequently, such systems heavily depend upon the natural feed produced in the ponds or brought in by water in-flow. Productivity is small as this system totally relies on the natural system. The amount of nutrients in the water body is limited due to minimum input, although this method has been contributing to the mangrove deforestation, especially in the past. It has lower levels of risk of disease infestations than intensive ones. In the Small-Scale Fish Farming Guidebook for Rural People in Myanmar, the pond size employed in the extensive culturing system ranges from 2 acres to 5 acres. However, to dealt with the rising price of fish feed and other inputs, ponds larger than 2 acres – 5 acres has also been transitioning to this culturing method.

Semi-intensive

Semi-intensive culture systems also depend largely on naturally produced feed. However, the production of natural feed is enhanced by the application of organic or inorganic manure or a combination of both. At this level, the practices are known as low-cost semi-intensive systems. Further intensification in these systems is attained by increasing the stocking density and supplementing natural feed with commercial feed (produced by feed producers) or farm-made feed (made from agricultural byproducts, like rice bran and various types of vegetable de-oiled cakes). This system supplies water to the ponds either manually (using gravity) or mechanically. Since supplemental nutrients are provided in addition to natural feeds, its productivity tends to be larger than extensive systems. On the other hand, feed wastes, fish disease, eutrophication, etc. could occur, if ponds are not well-managed. In NGA-Myanmar target townships, this method is widely used due to its low-cost feed and higher yield.

Intensive

Intensive culture systems are high-input, high-output-based systems which require infrastructure facilities, large investment, and adequate managerial skill. This system depends largely on complete and commercially available feed, oxygenation of the system, exchange or circulation of water, etc. The primary impact of feeds and feeding methods utilized in intensive aquaculture is hyper nutrification, with inorganic phosphate and nitrogen. They eventually cause the water to become contaminated, and hazardous waste builds up at the bottom of the ponds. The habitat and growth circumstances of cultured organisms are stressed by toxic waste. The investment cost is high in intensive culturing, but the return profit from the fish yield is high if there is no occurrence of fish diseases. The transition into a more intensive systems in NGA-Myanmar target areas has been hampered by skyrocketing prices of commercial feed and other inputs due to tenacious market disturbances impacted by COVID-19 pandemic and the political and socio-economic events following the 1 February 2021 government takeover by the military.

In terms of business type, most of farms use their ponds to grow fish (and therefore known as grow-out pond). Meanwhile some others will use their ponds as hatchery to produce fingerlings or as nursery to grow fingerlings to a certain size before they go to grow-out ponds. Some farms do combinations of the three businesses. Out of the 8 surveyed farms, 3 were also running hatchery ponds.

Ponds that integrate fish with chicken production were found in Pantanaw Township. Among the 8 surveyed ponds, 2 ponds were used the integrated system.

Box 4: Monoculture vs Polyculture

Based on the number of species being cultured in a pond, aquaculture is classified into two, monoculture and polyculture.

Monoculture

〉 Single species in a pond or tank
〉 The culture of tilapia, catfish, carps are typical
〉 Monoculture of high value, market-oriented fish species is commonly done through intensive system

Advantages:

〉 Easy to feed
〉 Permits great control over size, age, and sex
〉 Easy to operate
〉 Selective harvest of marketable fish can be employed
〉 Suitable for farmers having limited land resources

Disadvantages:

〉 Natural productivity of pond is not fully utilized
〉 Available space in water column is not utilized
〉 More chances of epizootic disease and parasites
〉 More risk of water quality problem like dissolved oxygen depletion

Polyculture

〉 Culturing more than one species of aquatic organism in the same pond
〉 Rely on synergism and available food

Principal/Biological Basis

〉 Maximizing resources based on a combination of species having different food habits
〉 Better utilization of available natural food produced in a pond at different depths
〉 As a result, higher yield is obtained

Requirements characteristics of fish

〉 Having different feeding habits
〉 Occupying different ecological niches
〉 Attaining marketable size at the same time
〉 Tolerating (non-predatory) each other

Seed and Cultured Species

There are two main annual peaks in stocking seed, (i) in June to July at the onset of the monsoon, and (ii) during late-monsoon in October. Seed for operations are produced in nursery ponds on-farm for own use or sourced from off-farm such as buying from fingerling traders, private hatcheries, or government hatcheries. Larger farms are more likely to nurse their own seeds. Specialized commercial nurseries are present in virtually every village where there are clusters of grow-out ponds. Specialized nurseries tend to be smaller than grow-out farms. Nurseries also have shorter production cycles than grow-out farms and require less start-up and operating capital.

Rohu and Catla are the most cultured species in Myanmar. In these late decades, the grass carp, silver carp, black carp and bighead carp are also grown when the polyculture system[6] becomes quite common.

Table 3: Commonly grown freshwater aquaculture species in Myanmar

Local Name	English Name	Scientific Name	Status
Ngamyit Chin	Rohu	*Lebeo rohita*	Native[7]
Ngagayung Pwa	Catla	*Catla catla*	Native
Ngagyin Phyu	Mrigal	*Cirrhinus mrigala*	Native
Ngagyin	Common carp	*Cyprinus carpio*	Introduced[8]
Ngagyin	Black carp	*Labeo calabasu*	Unknown[9]
Myatsar Ngagyin	Brass carp	*Ctenopharyngodon idellus*	Introduced
Ngweyaung Ngagyin	Silver carp	*Hypopthelmicthys molitrix*	Introduced
Gaunggyi Ngagyin	Bighead carp	*Aristichthys nobilis*	Introduced
Tilapia	Tilapia	*Oreochromis spp*	Introduced
Yaungsone Ngagyin	Colour carp	*Carrasius spp*	Unknown
Ngakhu	Catfish	*Clarias batrechus*	Native
Ngatan	Striped catfish	*Pangasius sutchi*	Native
Ngaphan Ma	Rhotees	*Osteobrama alfredianus*	Native
Yaycho Ngamote	Pacu/Freshwater Pomfret	*Piaractus brachypomus*	Not established[10]
Thai Ngakhone Ma	Tarpian/Silver barb	*Puntius gonionotus*	Unknown
Yaycho Pazun Tokekyi	Freshwater prawn	*Macrobrachium rosenbergii*	Native

Source: Small Scale Fish Farming Guidebook for Rural People in Myanmar

Among above species list, Ngamyit Chin, Ngagaung Pwa, Ngagyin Phyu and Ngagyin Shwe Wah are the most popular one in NGA-Myanmar townships along with Tilapia, Ngaknoe Ma, Myat Sar and Ngatan.

During the SEA, among the surveyed ponds, they all used polyculture system. Rohu was cultured in all surveyed ponds. Catla and Mrigal were also popular, that was then followed by common carp, tilapia, striped catfish, and grass carp.

[6] Polyculture is the culture of two or more fish species together in a pond.

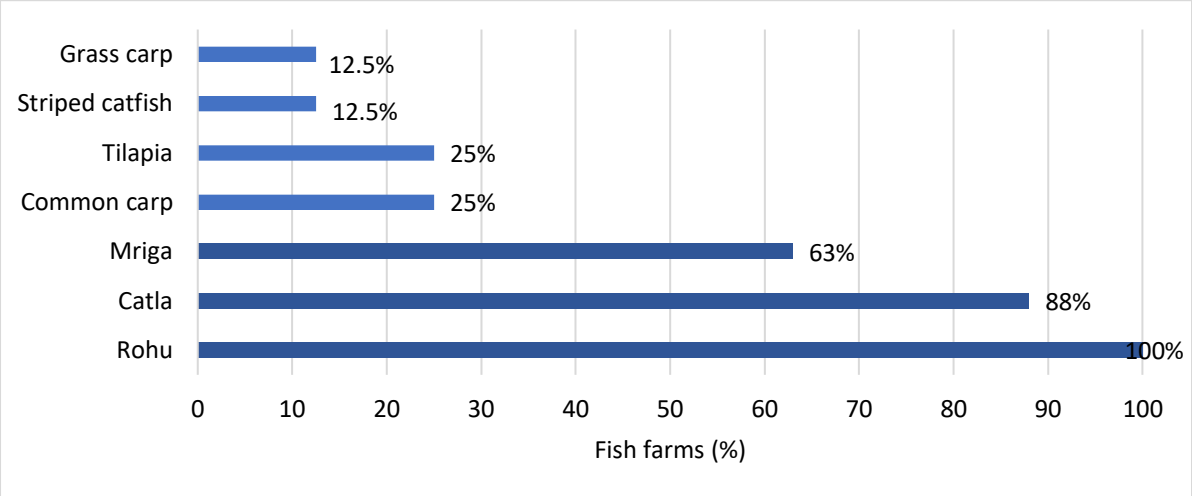
[7] Native means species present in its natural range or in its potential range (that is, it can occupy area without human intervention). Usually, it lives there and reproduces itself even without the intervention of man. If it extends because of the modification of the environment by man, it always remains considered autochthonous.

[8] Introduced or non-native or invasive means species brought into an area where it does not naturally occur but is able to survive and reproduce there.

[9] Unknown means the species are not found in the reference website for the status identification.

[10] Not established means non-native species which are not established yet in Myanmar.

Figure 11: Cultured species in the surveyed fishponds



Source: Myanmar Koei International Ltd. (MKI)

Feed and Non-Feed Inputs

Feed and feeding effect the productivity of aquaculture ponds as they provide main nutrient input for fish. Fish feed can be categorized into natural feed (those presence in the pond) and supplementary feed (those add to pond to supplement natural feed). From supplementary feed, the main products released to the natural waters are solids, and nutrients such as phosphorus and nitrogen. When feed is not consumed all, the uneaten feed settle to sediment that will result in flux of ammonia and phosphates to overlying water layer and changes the structure of benthic population. This kind of environmental issues is common from any aquaculture operations when unresponsible feeding is done and water treatment is inexistence.

Natural Feed vs Supplementary Feeds

The phytoplankton, zooplankton, detritus snails, worms, insects and insect larvae, small plants like duckweeds and various other weeds and grasses that naturally occurred in the ponds are the natural feed for fish. In extensive and semi-intensive systems reliance to natural feed is high. Natural feed is considered friendlier to the nature.

Supplementary feed can be categorized into farm-made feed and commercial feed. In the 8 study locations, both commercial feeds and farm-made feeds were used. As aforementioned, some ponds are also integrated with livestock (principally chicken production) whereby the animal manure acts as supplemental feed for the fish. Farm-made supplementary feed are mostly agriculture byproducts such as rice bran, oilcakes, brewery waste, etc. Farm-made feed is more popular than commercial one, as it is perceived to be cheaper. Common farm-made feeds applied at the NGA targeted township are raw rice bran alone, or a mixture of rice bran and ground nut oilcake or soybean cake. A mixture of rice bran and ground nut oilcake or soybean cake are produced by boiling the raw materials[11], and after that, they are made into solid-balls shape for feeding fish.

These external feeds are mostly pelleted, and either as floating or sinking feeds. Floating feeds are generally more easily digestible than sinking feeds, and they facilitate more effective feed management as overfeeding can be avoided. They generally have more efficient feed conversion ratio (FCR) than sinking feeds but are more expensive. The commercial pellets can be bought from local markets. There are now 27 commercial pellet production plants in Myanmar, 7 of which produce only freshwater fish feed. The name and the daily production rate of these 7 factories are as follow:

[11] *In the surveyed ponds, proportions of used raw materials are different among ponds.*

Table 4: Commercial freshwater fish feed producers

Fish feed production plants	Fish feed produced per day (tons)
Livestook Feed Stuff and Milk Product Enterprise	250
Htoo Thit	200
Shwe Taung Ngwe Taung	150
Phyo Ayer	120
Myan Swan Htet	70
Shwe Myanmar	60
Ngwe Pin Lae	60

Source: Strengthening R&D Mechanisms to Advocate Effective Feed Management in Aquaculture and Reduce Dependence on Fish Meal: Impact on Myanmar Fisheries.

Due to the increased prices of both readily-use commercial feeds and raw materials to make home-made feeds, the surveyed farms reduced the use of supplementary feeds and relied more on natural feeds, with supplementary feeds provided only when the harvesting time is close to meet targeted weight.

Feeding Methods and Feed Conversion Ratio (FCR)

In the surveyed locations, feeding was mostly done by hands, either through spread feeding (feeding by spreading feed over the surface water directly) or spot feeding (feeding by placing feed inside a floating bamboo or feeding rings which are attached to the bottom of the pond. From environmental perspective, spot feeding is better than spreading method because fish would need to come to specific locations so that pond operator can better control amount of feed and check health condition of fish briefly. As a result, spot feeding produces less feed waste, reducing water pollution. However, among the 8 surveyed ponds, only 2 applied spot feeding method.

Among the 8 surveyed farms, farms in Nyaungdon Township (ND-P1 and ND-P2), one in Pantanaw Township (PN-P1), and another in Maubin Township (MB-P1) used commercial pellets with 1:2 FCR. Meanwhile all the remaining farms used farm-made feeds with 1:4 to 1:5 FCR. While operators seem to have a good understanding that commercial pellets are better for fish growth due to its systematic composition for different species, but the farm-made feed is still popular due to its cheaper price.

The main factor contributing to improve profitability and resource efficiency in aquaculture operations in NGA-Myanmar target locations is efficient feed management because fish feed accounts for 70% of operating costs. Farm management includes the regulations of (i) the amount of feed according to the size of biomass and age composition, and (ii) intervals of feeding according to environmental conditions. To avoid wastes and feed spillage, feeding can be regulated according to daily variations in the weather conditions. By using such adjusted feeding procedures, feed conversion efficiency and thus quality of effluent water discharged into waterways could be increased. In the content of Myanmar and NGA targeted townships, many fish farm owners receive little extension advice or training related with farm-management and culturing operation. There is a strong need to promote improved management practices especially from the point of view of improving environmental performance of fish farms.

Non-Feed Inputs

Several chemicals and other substances such as lime, salt, fertilizers, antibiotics, and other agro-chemicals are used as non-feed inputs for improving soil and water conditions and controlling biological issues like phytoplankton blooms, aquatic plant infestations, disease vectors, and the proliferation of invasive species. Over usage of agro-chemicals can cause imbalance in pond chemistry, causing algae to grow more quickly and causing pond to become cloudy or discolored. Chemical residues in cultured aquatic products can pose potential risks to humans, including allergy, toxicity, and antibiotic resistance.

- Lime (calcium hydroxide or CaCO3) is used primarily to neutralize acidity in bottom soil and water to increase the total alkalinity of water.
- Molasses (locally called as *Tin Lae Yay*), a byproduct of sugar processing used in organic fertilizer production, are applied to get a desirable water quality level.
- Fertilizers, especially urea and triple superphosphate are used to increase the production of the natural food organisms to be eaten by fish.
- Pesticides are sometimes used prior to stocking fingerlings to remove any unwanted wild fish that might predate upon stocked seed.
- Salt is also used to treat parasite infections in fish.
- Antibiotics are used in aquaculture to treat diseases caused by bacteria. Sometimes antibiotics are used to treat diseases, but more commonly antibiotics are used to prevent diseases by treating the water or fish before disease occurs.

All surveyed ponds were reported to use lime. The use of molasses was observed in one farm in Maubin Township (MB P2). During the last season, there was no usage of fertilizers except the two integrated fishponds in Pantanaw Township. During the last and ongoing seasons, fertilizers were not used due to its expensive price as well as supply disruptions.

Production

Farm Management

Fish production cycle usually begins in the early to mid-monsoon season (June-August) and end in the dry season months of November-April, coinciding with diminishing availability of water and scarcity of wild freshwater fish in the market. Nonetheless, the production cycle can be different for each farm based on the cultured species and the market demand. Duration of one production cycle is determined by many factors, including farm size, species being grown, and whether it is monoculture or polyculture. Through monoculture system, production of a single species may be done at once to meet market demand. Being cultured only one species, this method is easier to feed and monitor fish status, and permits great control over size, age, and size. However, it has a greater chance of yield loss in case of disease outbreaks and fish growth is highly affected if there is a shortage of feed supply.

In polyculture, more fish can be cultivated and produced within a small water body pond. Nonetheless, this system requires a more complex management and can be rather expensive and riskier due to the probability of different diseases related to different cultured species. However, if done properly, polyculture can be seen as one way to optimize feed circularity. In this way the natural food produced in the culture environment is utilized to a greater extent through compatible or complementary feeding habits of species which do not compete one to each other.

In terms of energy sources, among the 8 ponds, only 2 were using the electricity from national grid line, while the rest were using diesel generators. Electricity is only used for the lightning purpose while diesel generators were mainly used to pump water in/out of the ponds. In terms of renewable energy, only one pond was using solar energy, but only for lighting purpose.

Harvesting

Harvesting is the most labor-intensive operation on an aquaculture farm, apart from pond construction or rehabilitation. As such, there have been attempts to introduce as much mechanization as possible to reduce labor. Depending on the fish culturing methods (whether monoculture or polyculture), harvesting methods are different. In monoculture, only one full harvesting method is employed due to the culturing of one species. For polyculture ponds, partial harvesting method will be done before the final harvest, whereby fishes are captured by using the appropriate fish net (purse seine) without draining the water. During a full/final harvest, water is drained out from pond, either using or not using water pump. When drained,

usually ponds are also being maintained. Maintenance includes digging pond sediments, clear out predators, dry out pond bottom, liming and/or fertilizing to improve soil conditions, and filling pond with water, etc. The 8 studied farms were all using polyculture, which is the common practice in NGA target townships. As such, a combination between partial and full harvesting is widely practiced.

Harvested fish are mostly sold to fish traders and sent to the wholesale markets, San Pya and Shwe Padauk, in Yangon, and very few went to retailers, factories or cold storage facilities.

Application of Good Practices

The surveyed pond operators were assessed against five key good practices as details out in the Table 4. Among the 8 farms, spraying lime is the most used practices during pond preparation. On the other hand, it was found that only 2 farms reported of carrying out proper feeding, and only 1 doing regular soil testing.

Table 5: Usage of good practices

Good Practices	Number of farms
Soil test during the pond preparation	1
Drying the soil during the pond preparation	4
Spraying the $CaCO_3$ during the pond preparation	6
Proper feeding	2
Regular pond water quality test	3

Source: Myanmar Koei International Ltd. (MKI)

When asked about key challenges, 2 farms in Twantay Township and 1 farm in Nyaungdone Township mentioned about facing poor water quality and number of invasive species entering the ponds (especially suckermouth catfish, *Hypostomus plecostomus*). To prevent the entering of invasive species, screen was used when water was filled into the pond. Nonetheless, screen could not prevent entering of tiny eggs of those invasive species along the water. During the interviews, these operators mentioned that the reproduction rate of the invasive species is faster than the cultured species, leading to economic losses.

In addition, one farm in Pantanaw Township and another in Maubin Township highlighted fish diseases as main challenge for them. Infestations with *Lernaea* (anchor worm) are most prevalent in the summer months and occur more commonly in stagnant or slow-moving water bodies.

During the field survey, good management practices are observed more when farm is directly managed by the pond owner or an experienced manager. However, overall, it was observed that all farm operators possessed little awareness on the negative impacts of ponds effluent to its surrounding environment and communities. For example, in Twantay Township, one farm used groundwater, to supplement pond water, although ground water is scarce in that township. Meanwhile, the use of nutrient-rich pond bottom sediment is used only as a layer on pond embankment.

PART 3: WATER QUALITY PARAMETERS AND ON-FARM EMISSIONS

WATER QUALITY PARAMETERS

Water quality indicators are important parameters to assess impacts of aquaculture operations to its surrounding environment. As such this SEA collected and tested water quality parameters both at pond level as well as at water stream (ambient) level. This section presents the results of water quality assessment of key parameters.

Water Quality Survey Methods

All water samples were collected and analyzed by the analytic methods shown in Table 5. All samples were kept in iced boxes at 2-4 °C and were transported to the laboratory. Among the parameters, water temperature, pH, DO, and turbidity were measured on-site by using Horiba U-52 instrument. While water discharge level was also conducted on site by using JFE Digital Current Meter.

Table 6: Analytic methods for water quality

Parameter	Method
Temperature	Instrument Analysis Method (Horiba, U-52, Multi Water Quality Checker)
pH	Instrument Analysis Method (Horiba, U-52, Multi Water Quality Checker)
Dissolved Oxygen	Instrument Analysis Method (Horiba, U-52, Multi Water Quality Checker)
Turbidity	Instrument Analysis Method (Horiba, U-52, Multi Water Quality Checker)
Water Discharge Level	Detection of Electromagnetic Elements (Real-time measurement by AEM 213-D Digital Current Meters)
Total Suspended Solids	2540D Total Suspended Solids Dried at 103-105°C
Nitrate	Hach DR 3900 Spectrophotometer, Cadmium Reduction Method
Ammonia	Spectro Direct Methods
Total Nitrogen	Hach DR 3900 Spectrophotometer, Persulfate Digestion Method
Orthophosphate	SM 4500-PD+ Stannous Chloride
Total Phosphorus	SM 4500-PB+E Per sulfate + Ascorbic

Source: Myanmar Koei International Ltd. (MKI), Pro-Lab and Goshu A1 Business Economy Company Ltd.

Water Quality Survey Results

Results of pond water and ambient water quality survey from targeted townships are summarized in Table 6 and Table 7.

Pond Level

Water quality analysis reports from the Laboratory are described in Annex 3. Pond water quality results were compared with the value of effluent water quality (for aquaculture) discharged to water body stipulated in the National Environmental Quality (Emission) Guidelines (NEQG) in Myanmar. In addition, the results were also compared with the permissible level of pond water in aquaculture (Boyd C. E. 1990).

At the present, there has no surface (ambient) water quality standards in Myanmar. Therefore, to evaluate ambient water quality in this survey, Vietnamese environmental standard (A2-for domestic water supply)[12] was used as reference because Myanmar and Vietnam are neighboring countries and water quality characteristics in both countries are closed.

Table 7: Pond water quality survey results of four targeted townships

Township	Unit	Twantay		Nyaungdone		Pantanaw		Maubin		NEQG Guideline Value	Permissible Level
Date		13 July 2022		14 July 2022		14 July 2022		15 July 2022			
Point		TT-P1	TT-P2	ND-P1	ND-P2	PN-P1	PN-P2	MB-P1	MB-P2		
Time		10:14	11:20	09:44	10:33	12:12	14:33	09:27	11:55		
Temperature	°C	29	29	27	26	28	28	27	29	<36	26-32*
pH	-	6.5	6.6	7.8	7.3	7.9	7.3	7.6	8.0	6-9	6.5-8.5
Dissolved Oxygen	mg/L	5.50	1.12	4.31	1.56	6.68	3.70	3.29	5.67	-	4-8*
Turbidity	NTU	143	214	39	266	100	139	185	144	-	25-80
Water Discharge	m^3/s	-	-	-	-	-	-	-	-	-	-
Total Suspended Solids (TSS)	mg/L	130	80	25	170	540	100	100	80	50	200
Nitrate	mg/L	<0.1	1.6	<0.1	1.2	<0.1	8.1	<0.1	<0.1	-	0.2 – 10
Ammonia	mg/L	<0.02	<0.02	<0.02	<0.02	0.22	0.39	<0.02	<0.02	-	0-0.5
Total Nitrogen (TN)	mg/L	<2	<2	<2	9	5	<2	6	<2	10	0.5-4.5ppm
Ortho-phosphate	mg/L	<0.25	<0.25	<0.25	<0.25	<0.25	<0.25	<0.25	<0.25	-	-
Total Phosphorus (TP)	mg/L	<0.15	<0.15	<0.15	<0.15	<0.15	<0.15	<0.15	<0.15	2	0.1 -0.5

**Species dependent*
***The value in red color shows the value which is higher than pond water quality (permissible level)*
Source: Myanmar Koei International Ltd. (MKI)

The temperatures of all water samples were not significantly different, at around 26 - 29˚C during the survey period (rainy season) that was under the permissible range for aquaculture (26 - 32˚C) as well as NEQG value.

The pH of the pond water varied from 6.5 to 8.0 among the 8 ponds and that was within the range of the requirement of fish cultivation and complied with NEQG effluent guideline value. The pH values of studied water were neutral to slightly acidic, which was also suitable for the fish production as the standard pH value for fish culture is 6.5 to 8.5. Based on the in-depth interview results, pond owners/ operator used lime to prevent low pH that is harmful to fish.

As for DO, results at TT-P2, ND-P2, PN-P2, MB-P1 were lower than 4 mg/L. Although DO can change dramatically over a 24-hour period in pond, even the strongest fish may suffocate if DO levels decrease to about 3-4 mg/L. Maintaining good levels of DO in the water is essential for successful production since oxygen (O_2) has a direct influence on feed intake, disease resistance and metabolism. It is therefore important to keep DO at optimum levels of above 4.0 mg/L. Critically low DO occurs in ponds specifically when algal blooms crash and bacterial decomposition of the dead algae cells. It also noted that each type of fish living in the water requires a different amount of DO to live. Healthy water should generally have DO concentration above 6.5-8 mg/L. If DO is high, it can be reduced by removing some of animals from the system and organic materials in the water, as well as by replacing water partially. It is necessary to avoid over application of fertilizers and organic manure to manage DO level.

[12] *Vietnamese national technical regulations on surface water quality (A2 Class: for domestic water supply) (QCVN 08- MT 2015/ BTNMT) (Vietnam Environment Administration (VEA)- Ministry of Natural Resources and Environment (MONRE)-Vietnam*

The result of turbidity at all sampling point was beyond the permissible level for aquaculture except ND-P1. A possible reason is that excessive turbidity pond water can be caused by nutrient imbalance, increase of ammonia and nitrites, suspended waste particles. Even uneaten fish feed, fecal matter of rapidly growing fish, and seasonal plant decay can also increase turbidity rates.

As for TSS, results at all points were exceeded NEQG guideline values but was under the permissible level of pond water quality except PN-P1. TSS are a significant factor in observing water clarity. The more solids present in the water, the less clear the water will be. During the survey period, there were very high TSS concentrations in PN-P1. One of the causes is that the pond just received water from a river or stream, and during the rainy season, TSS levels are high in this water.

The results of ammonia at all points were within the range of the permissible level of pond water. However, ammonia can easily rise (through accumulation of overfeeding, protein rich, excess feed wastes) to dangerously high levels. Ammonia level will depend on the temperature of pond water and its pH.

Total phosphorous (TP) values in the water among the eight ponds was under the NEQG effluent values for aquaculture and that was also within the range of the requirement for the fish cultivation. Total nitrogen (TN) in the sample ranged from <2 to 9 which was under the NEQG effluent values but TN results at ND-P2, PN-P1 and MB-P1 was beyond the permissible limit.

Ambient Level

The ambient water quality results were compared with Vietnam Surface Water Standard. The temperatures of all ambient water samples were not significantly different, at 26 - 29°C. These temperatures were also relatively similar with the pond level data.

Table 8: Ambient water quality survey results of four targeted townships

Township	Unit	Twantay		Nyaungdone		Pantanaw		Maubin		Vietnamese Environmental Standard for surface water
Date		13 July 2022		14 July 2022		14 July 2022		15 July 2022		
Point		TT-A1	TT-A2	ND-A1	ND-A2	PN-A1	PN-A2	MB-A1	MB-A2	
Time		09:48	11:46	09:15	10:56	12:56	14:07	09:06	11:23	
Temperature	°C	28	29	26	26	27	27	27	28	-
pH	-	6.4	6.7	6.6	6.5	6.7	6.7	7.1	7.0	6-8.5
Dissolved Oxygen	mg/L	1.30	0.74	1.44	1.31	0.00	0.55	2.09	1.33	≥ 5
Turbidity	NTU	69	38	37	123	22	20	60	88	-
Water Discharge	m^3/s	2.41	0.14	0.58	0.62	0.14	0.20	1.85	0.72	-
Total Suspended Solids (TSS)	mg/L	50	40	20	100	10	15	33.33	80	30
Nitrate	mg/L	0.4	3.5	2.6	<0.1	2.3	1.2	1.6	<0.1	5
Ammonia	mg/L	0.16	<0.02	<0.02	0.16	0.26	0.1	0.14	<0.02	-
Total Nitrogen (TN)	mg/L	<2	<2	2	3	3	<2	5	4	-
Ortho-phosphate	mg/L	<0.25	<0.25	<0.25	<0.25	<0.25	<0.25	<0.25	<0.25	-
Total Phosphorus (TP)	mg/L	<0.15	0.18	<0.15	<0.15	0.78	<0.15	<0.15	<0.15	-

**The value in red color shows the value which is higher than Vietnam Surface water standard (A2 Class). Vietnam national technical regulations on surface water quality (A2 Class: for domestic water supply) (QCVN 08- MT 2015/ BTNMT)*
Source: Myanmar Koei International Ltd. (MKI)

The pH of the ambient water varied from 6.4 to 7.1 among the 8 sampled locations and that was within the Vietnam Surface Water Standard (A2 Class – domestic water supply). pH is an important parameter for evaluating toxicity of an aquatic system. High acidity (a low pH) can convert insoluble metal sulfides to

soluble forms, which increases the bioavailability. A high pH can also cause ammonia toxicity. The pH measurements from all points showed that these sampling points were within the standard value for domestic water supply.

The DO of the ambient water varied from 0 – 2 mg/L among the 8 ambient locations and that were lower than Vietnam Surface Water Standard. DO refers to the amount of oxygen dissolved in water. When DO levels become too low, aquatic organisms cannot survive, and water quality is affected.

As for TSS, results at TT-A1, TT-A2, ND-A2, MB-A1, MB-A2 were exceeded Vietnam Surface Water Standard. The more solids present in the water, the less clear the water will be. In terms of water quality, high levels of TSS will increase water temperatures and decreases DO levels. If the speed or direction of the water current increases, particulate matter from bottom sediments may be resuspended.

Nitrate values in the water sample ranged from < 0.1 to 3.5 which were under the Vietnamese environment standard of 5 mg/L).

In conclusion, pH and nitrate results of all sampling points were under the Vietnam Surface Water Standard. However, TSS results of five sampling points are higher than the standard. DO of the ambient water for all points is lower than standard values. It might be due to the water turbidity is high and it will cause DO level decrease. Thus, it is concluded that the ambient water condition of some points is poor even in the rainy season as it may be low rain fall and flow periods.

Water quality Index (WQI)

WQI assesses the quality of water through a single numerical value, calculated based on individual parameters. This number represents a relative scale to justify the quality of water in categories ranging from very poor to excellent. The weighted arithmetic water quality index approach (Brown et al., 1970) is employed to assess the quality state of the ambient water (surface water) of NGA targeted townships. As Myanmar does not have an ambient surface water standard, the Vietnam Surface Water Standard (A2 Class) was used in this WQI computation. However, since Vietnam Surface Water Standard only covers pH, dissolved oxygen, total suspended particles, and nitrates, therefore, only these parameters were used to evaluate the WQI. Methodology being used to calculate the WQI is attached as Annex 5.

Table 9 shows the results of Water Quality Index (WQI) of the ambient water quality status of the studied area. 3 ambient water samples (TT-A1, PN-A2, MB-A2) have the good water quality while the other 5 samples (TT-A2, ND-A1, ND-A2, PN-A1, MB-A1) have the poor water quality based on the estimated four parameters.

Table 9: Results of Water Quality Index (WQI) of eight ambient water samples

	TT-A1	TT-A2	ND-A1	ND-A2	PN-A1	PN-A2	MB-A1	MB-A2
WQI	47.5378	59.44693	53.61065	51.0521	51.61614	45.5699177	53.14383	43.73521
Status	Good	Poor	Poor	Poor	Poor	Good	Poor	Good

Source: Myanmar Koei International Ltd. (MKI)

ON-FARM AQUACULTURE EMISSIONS

Aquaculture contributes to the greenhouse gas emissions including by producing nitrous oxide (N_2O), carbon dioxide (CO_2), and methane (CH_4). Nitrous oxide mainly comes from microbial transformation of nitrogenous compounds derived from feed and fertilizer in aquaculture ponds. Carbon dioxide emissions come from pre-farm energy use to produce and transport feed and other inputs, and on-farm energy use, like fuel and electricity consumptions for operations. Methane emissions are released mainly from the anaerobic decomposition of organic matter. This section presents calculated carbon footprints released during the lifecycle of aquaculture farming in the target areas of NGA-Myanmar.

The contribution of aquaculture to carbon footprint was calculated from the operation of the previous fish-farming cycle in the 8 ponds. The fish species cultured in each pond are shown in Table 10.

Table 10: Production of different fish species by pond type

Aquaculture pond	Type of fish species							
	Ngamyit chin	Ngagaung pwa	Ngagyin phyu	Ngagyin shwe-wah	Tilapia	Ngakone-ma	Myat-sar	Nga-tan
TT-P1	✓	✓		✓	✓			
TT-P2	✓	✓						
MB-P1	✓	✓	✓	✓				
MB-P2	✓	✓	✓					
PN-P1	✓	✓			✓			
PN-P2	✓	✓						
ND-P1	✓	✓		✓		✓	✓	
ND-P2	✓		✓					✓

Source: Myanmar Koei International Ltd. (MKI)

It focuses on the areas of four production phases: (i) production of feed raw materials, (ii) on-farm energy use, (iii) aquatic N2O production, and (iv) fertilizer use. The emission sources occurred in these phases are considered in the calculations of carbon footprint.

Table 11: Emission sources included in the calculations

Name	Description
Feed: fertilizer production	Emissions released from the production of synthetic fertilizers applied to crops
Feed: crop N_2O	Direct and indirect nitrous oxide from the application of N (synthetic and organic) to crops and crop residue management
Feed: crop energy use	CO_2 from energy use in field operations, feed transport and processing
Feed: crop LUC	CO_2 from land use change arising from soybean cultivation
Feed: rice CH_4	Methane arising from rice cultivation
Feed: fishmeal	CO_2 from energy use in the production of fishmeal
Feed: Animal by-products	CO_2 from energy use in the production of animal by-products
Feed: other materials	Emissions from the production of a small number of “other” feeds (including animal by-products, lime, and synthetic amino acids)

Name	Description
Feed: blending & transport	CO_2 from energy use in the production and distribution of compound feed
Pond fertilizer production	Emissions arising from the production of synthetic fertilizers applied to increase aquatic primary productivity
On-farm fuel use	Emissions arising from the use of fuel on fish farm
Pond N_2O	N_2O from the microbial transformation of nitrogenous materials (fertilizers, excreted N and uneaten feed) in the fish farm water body

Source: Myanmar Koei International Ltd. (MKI)

Emission from feed materials

Commercial feeds and farm-made feeds were used by the surveyed ponds. They made farm-made feeds from locally available ingredients such as rice byproducts, groundnut meal and oilseed meal. Some farm owners have used commercial feeds which are manufactured by feed mills such as Htoo Thit company. Although there is no reliable data of feed formula in the production of feed pellets by private feed mills, it is estimated that it includes mixture of 60% rice bran, 10% oilseed meal, 10% wheat flour, and 20% soybean[13]. Table 11 shows total fish production and total weight of feed consumption for the last harvesting period.

The emissions of feed material were calculated using the below equation:

$$\boldsymbol{Emissions = Amount\ of\ feed\ material\ x\ Emission\ FactorFactor}$$

All emissions of feed materials are calculated through the FISH-e tool (FISH-e) developed by Food and Agricultural Organization (FAO). FISH-e calculates the emission from feed materials, energy, and fertilizer consumption. Emission factors for feed materials were based on the values derived using the Global Livestock Environmental Assessment Model (GLEAM, FAO 2017b).

Total emissions from the production of feed ingredients contributed for 2,616.62 tons CO_2e, with the highest proportion of crop fertilizer production and crop N_2O ranging for 567.82 tons and 538.36 tons, respectively.

Table 12: Total fish production and feed consumption for last harvesting period

Pond	Total Fish production (kgLW)	Total feed consumption (kg feed/last harvesting year)	Last harvesting period	Fish harvesting pond area (acre)	Feed type
TT-P1	73,481.85	8,164.65	February, 2021	70	Farm-made feed
TT-P2	24,493.95	2,612.69	February, 2022	7	Farm-made feed
MB-P1	489,879.00	104,507.52	May, 2022	30	Commercial feed
MB-P2	163,293.00	26,126.72	2020	138	Farm-made feed
PN-P1	11,430.51	5,878.55	March, 2022	4	Commercial feed
PN-P2	3,265.86	2,204.46	June, 2022	10.5	Farm-made feed
ND-P1	130,634.40	52,253.76	March, 2021	250	Commercial feed
ND-P2	-	-	June, 2022	52	Commercial feed

Source: Myanmar Koei International Ltd. (MKI)

[13] *Khin et, al. 2011. Strengthening R&D Mechanisms to Advocate Effective Feed Management in Aquaculture and Reduce Dependence on Fish Meal: Impact on Myanmar Fisheries.*

Table 13: Emissions from feed materials

Ponds	Emissions (tons CO_2 e)									Total
	Fertilizer production	N_2O	Energy use	LUC	Rice CH_4	Fishmeal	Animal by-products	Blending/ transport	Others	
TT-P1	46.54	44.13	31.98	47.15	8.16	7.74	2.28	9.36	17.14	214.48
TT-P2	15.51	14.71	10.66	15.72	2.72	2.58	0.76	3.12	5.71	71.49
MB-P1	310.29	294.19	213.21	314.35	54.37	51.58	15.21	62.38	114.28	1,429.85
MB-P2	103.43	98.06	71.07	104.78	18.12	17.20	5.07	20.79	38.09	476.62
PN-P1	7.24	6.86	4.98	7.34	1.27	1.20	0.36	1.46	2.67	33.36
PN-P2	2.07	1.96	1.42	2.10	0.36	0.34	0.10	0.42	0.76	9.53
ND-P1	82.74	78.45	56.86	83.83	14.50	13.76	4.06	16.63	30.47	381.29
ND-P2	-	-	-	-	-	-	-	-	-	-
Total	**567.82**	**538.36**	**390.18**	**575.25**	**99.50**	**94.40**	**27.83**	**114.15**	**209.13**	**2,616.62**

Note: Emissions from feed materials at ND-P2 could not be calculated due to unavailability of data.
Source: Myanmar Koei International Ltd. (MKI)

Emissions from on-farm energy use

Aquaculture uses energy for a variety of purposes, especially for pumping, lighting, and powering vehicles. The proportions of diesel used in the fish-farming are considered to calculate the emissions from the consumption of energy required to produce fishes. Emission is calculated by multiplying of the rates of diesel used in the previous fish-farming cycle with emission factor (EF), as shown in the below equation. In this calculation, emission factor for diesel use (3.2 kg CO_2/liter) was applied from UK BEIS (2016).

$$\boldsymbol{Emissions = Energy\ Usage\ Amount\ x\ Emission\ Factor}$$

The use of energy has been contributed with the total amount of 34.60 tons of emissions to the atmosphere from the eight-fishing ponds for a last harvesting cycle. The detail emission rate for each fishing pond is shown in the following Table 14.

Table 14: Emissions from on-farm energy use in eight ponds

Pond	Amount of diesel use (liter)	Emission factors (kg CO_2/liter)	Emissions (tons)
TT-P1	946	3.2	3.03
TT-P2	568		1.82
MB-P1	946		3.03
MB-P2	973		3.11
PN-P1	946		3.03
PN-P2	1,893		6.06
ND-P1	757		2.42
ND-P2	3,785		12.11
Total			**34.60**

Source: Myanmar Koei International Ltd. (MKI)

Emissions from aquatic N_2O

Nitrous oxide (N_2O) emissions are released from nitrifying and denitrifying bacteria through autotrophic aerobic nitrification and anaerobic denitrification within the water body on the fish farm, because these bacteria utilize ammonia which is released from the degradation of the uneaten protein-rich aquafeed and fecal excreta of fishes. N_2O emissions are influenced by environmental factors, such as DO, pH, salinity and

water temperature that can change seasonally. Emissions for aquatic N_2O was calculated as shown in below equation. Emission factor from Macleod et al. (2019) was applied for N_2O (0.79 kg CO_2e/kg LW production).

$$\boldsymbol{Emissions = Fish\ Production\ Amount\ x\ Emission\ Factor}$$

Aquatic N_2O contributed with the total emission amount of 708.22 tons from the eight-fishing ponds. The emissions from each pond are described in the table below.

Table 15: Emissions for aquatic N_2O in eight ponds

Pond	Total Fish production (kg LW)	Emission factors (kg CO_2e/kg LW production)	Emissions (tons CO_2e)
TT-P1	73,481.85	0.79	58.05
TT-P2	24,493.95		19.35
MB-P1	489,879.00		387.00
MB-P2	163,293.00		129.00
PN-P1	11,430.51		9.03
PN-P2	3,265.86		2.58
ND-P1	130,634.40		103.20
ND-P2	-		-
Total			**708.22**

Note: Some data for ND-P2 are not available.
Source: Myanmar Koei International Ltd. (MKI)

Emissions from fertilizer usage

Lime is mainly used in these fish farming ponds to increase productivity because it acts as a buffer maintaining the pH level. The emissions from lime were calculated using the following equation. Emission factor of lime is 0.074 kg CO2 e/ kg CaCO3 derived from LCI data for the calculation tool Feed print for greenhouse gas emissions of feed production and utilization (2012).

$$\boldsymbol{Emission = Fertilizer\ Usage\ Amount\ x\ Emission\ Factor}$$

The total emissions from the application of lime in the fishing ponds accounted for small proportion with the amount of 3.55 tons. The emissions from fertilizer application in each pond are described in the following table.

Table 16: Emissions from fertilizers in eight ponds

Pond	Type of fertilizer	Fertilizer usage amount (tonne)	Emission factors (kg CO_2e/kg $CaCO_3$)	Emissions (tonne CO_2e)
TT-P1	$CaCO_3$	15.00	0.074	1.05
TT-P2		6.00		0.42
MB-P1		18.75		1.31
MB-P2		6.53		0.46
PN-P1		0.18		0.01
PN-P2		0.525		0.04
ND-P1		2.12		0.15
ND-P2		1.56		0.11
Total				**3.55**

Source: Myanmar Koei International Ltd. (MKI)

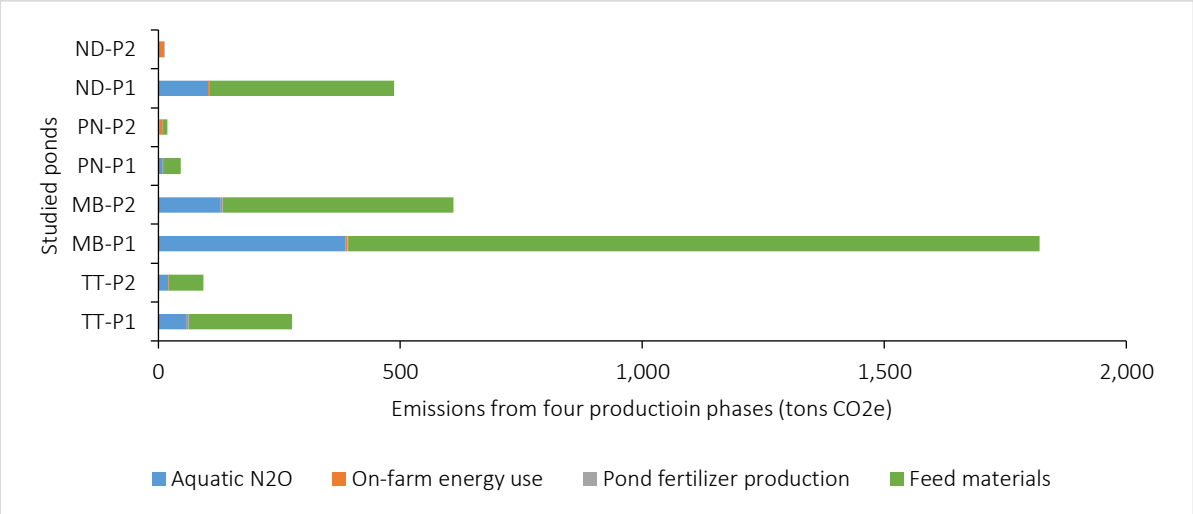
Total emissions from aquaculture

The total emissions from the eight ponds with the total fish harvesting area of 561.5 acre are 3,362.99 tons CO_2e. These are for the year of previous fish-farming cycle and represent 8 species groups with 896,478.57 kg LW of fish production and 50.67 tons of lime use. The average emission amount released from an area of acre is 5.99 tones of CO_2e.

Production of feed materials contributed 78% of the total emissions and this was the largest proportion of emissions of the four phases. Aquatic N_2O was also the critical source of emissions, contributing 21% of the total. Emissions from on-farm energy use accounted for only 1% of GHG emissions while emissions from fertilizer utilization was contributing less than 1%.

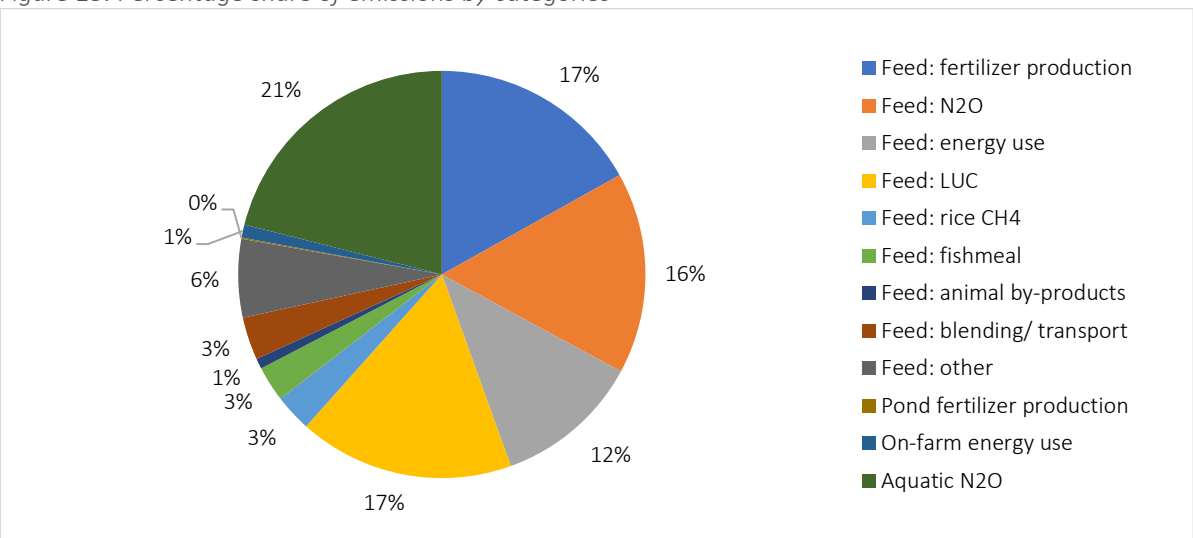
Emissions from feed production are composed with nine component processes. Of those nine processes, crop fertilizer production accounted for 17%, crop N_2O (16%), crop energy use (12%), crop LUC (17%), CH_4 from rice production (3%), fishmeal (3%), animal by-products (1%), blending/ transport (3%), and other materials (6%), respectively.

Figure 12: Emissions from four production phases (tons CO_2e)



Source: Myanmar Koei International Ltd. (MKI)

Figure 13: Percentage share of emissions by categories



Source: Myanmar Koei International Ltd. (MKI)

Limitation of the Analysis

The emissions could only be calculated for the fish species on the previous fish-farming cycle of the 8 ponds due to the difficulty to receive the data from the operators/owners. Moreover, the emissions from production of feed materials at ND-P2 could not be calculated due to the unavailability of information on the proportions of commercial feed materials and fish production amount.

Operators/owners have not been kept the records on the utilization of feed raw materials, fish production amount, and energy usage amount that are essential in the calculation of emissions from aquaculture ponds. Therefore, this analysis relies on the estimated data provided by the operators/owners.

While some fish-farming ponds have used generators with the diesel supply for water pumping, lighting, some are relying on the national grid electricity for the operation. However, the emissions released from the electricity use could not be considered due to the unavailability of electricity data.

The emissions arising from the post-harvest are also not considered in the analyses, although significant emissions can arise depending on the post-harvest supply chain (e.g., mode of transport, distance transported, storage conditions).

Proposed Measures to Reduce Emissions from Aquaculture

Although emission contribution of aquaculture and related supply chain are smaller than other sectors, appropriate mitigation measures should be developed to improve aquaculture sustainability. Emissions associated with aquaculture could be reduced from the energy consumption, feed material use, feeding efficiency, management of chemical fertilizer usage, and other supply chain components.

Operators/owners should adopt some common approaches to reducing emissions from on-farm energy and fuel use including shifting to low-emissions energy sources. In addition, reuse of materials will have significant potential to reduce emissions. The reduction of nutrient inputs and waste can also contribute to avoid environmental issues. Good production practices and operating conditions, such as appropriate pH and temperature, sufficient DO, etc. should also be taken to reduce emissions from aquaculture.

The following measures should also be developed to eliminate the contribution of aquaculture to carbon footprint:

- Effective and efficient application of fertilizers and feed materials (or feed) to maximize utilization and prevent over-application, considering predicted consumption rates.
- Avoid the use of fertilizers containing ammonia or ammonium in water with pH of 8 or above to avoid the formation of toxic unionized ammonia (NH_3).
- Grow organic fertilizer (e.g., natural grass) in the pond basin to reduce the use of chemical fertilizer.
- Choose the appropriate pellet size to the species' life-cycle stage to reduce the unconsumed fraction (e.g., smaller pellets should be fed to fry or juvenile fishes)
- Monitor and keep record of feed uptake regularly to determine whether it is being consumed and adjust feeding rates accordingly. Feed may be wasted due to overfeeding or not feeding at the right time of day.

PART 4: ASSESSMENT OF THE ENVIRONMENTAL IMPACTS AND KEY RECOMMENDATIONS

ASSESSMENT OF ENVIRONMENTAL IMPACTS

Environmental and social impacts of aquaculture are often related to lack of good management and may occur because of inappropriate design, site selection, construction, farm operations, and processing and other supply chain activities. Key drivers of environmental impacts from aquaculture operations are related to species being farmed, intensity of production, and farm location. As such the environmental impacts can be minimized by applying greener practices, including through physical and biological treatments of the effluent.

Assessment Process

Significance of the potential environmental impact can be determined in a number of ways, including expert judgements, the use of thresholds, reference to legislation, and consultation with stakeholders. In this study, the assessment of significance is determined based on the probability of the impact occurring by expert judgement. The criteria for the assessment of significance are described as follows:

Table 17: Significance Criteria for Assessment

Impact Character	Symbol	Description
Probability	VP	Impact very likely to occur
	P	Impact likely to occur
Scale	++	Large positive impact
	+	Positive impact
	0	No impact
	--	Negative impact
	----	Large negative impact
Direct/ Indirect	I	Indirect impact
	D	Direct impact
Frequency/ duration	LT	Long term
	ST	Short term

Source: Myanmar Koei International Ltd. (MKI)

Water Quality

Aquaculture units can generate considerable amounts of effluents containing a variety of substances, such as particulate materials mainly resulting from uneaten feed and fecal material, dissolved metabolites from excretion via gills and kidneys, and various forms of chemicals (e.g., fertilizers, heavy metals), with undesirable environmental consequences. The magnitude of these impacts depends mainly on farm location, species, culture type, stocking densities, feed digestibility, and on other husbandry factors, such as feeding practices and disease. The water itself can affect the health of the organism as well as contribute to the accumulation of substances or pathogens toxic to consumers. Potential environmental effects on aquaculture development may have on water quality include:

- Increased oxygen demand
- Organic waste decomposition and accumulation (feed and feces/ pseudo feces)

- Disruption to nitrogen cycling
- Increased algal growth

Based on the field measurement results presented in previous section, while the values of pH, temperature, ammonia, and TP were within the standards, however, the values of DO, TSS, turbidity, total nitrogen (TN) in some ponds do not meet the standards – with one out of 8 assessed ponds indicate eutrophication, a serious environmental concern. In addition, the WQI calculation, suggests that five out of eight ambient water samples have poor water quality, based on the estimated four parameters.

Table 18: Impacts on water quality and proposed mitigations

Potential Environmental Impacts	Impacts	Proposed Mitigation Measures
❭ A negative impact is expected if the effluent discharged to the adjacent water bodies without treatment, depending on the effluent composition. ❭ The extent of leaching of total nitrogen (TN) content and total phosphorous (TP) from the feed to the environment is high. ❭ The discharge of unused and unmetabolized nutrients and organic matter can cause eutrophication and other ecological changes in receiving waters. ❭ Shortage of proper drainage system also one of the main reasons of environmental impact caused by aquaculture.	VP -- D ST	❭ Prevent pond effluent from entering surrounding water bodies; and ❭ Treat the effluent before its release into the receiving waters to reduce contaminant levels. ❭ Discharge of effluents through settling basins or wetland where possible. ❭ Apply water reuse and recirculation to minimize effluent volume ❭ Frequent water monitoring to determine the level of pollution and contamination. ❭ Check drainage system around the fish farming to minimize the environmental impact.
❭ Another risk is when fish farms use chemicals and pesticides to kill pathogens or predatory species when preparing ponds before stocking. This may contaminate the water body with discharges of pond water. ❭ The use of fertilizers, chemicals, and hormones as well as fish feeds and excretes in aquaculture will be relatively high and may result in contaminations to the local water bodies.	P -- I ST	❭ Ensure appropriate use of right chemicals and hormones. ❭ Reduce input of nutrients and organic matter into ponds through better fertilization and feeding practices. ❭ Treatment of such water by ensuring adequate time for biodegradation of the chemicals used. ❭ Minimize the use of antibiotics and other chemicals for disease control and to focus on reduction in stress as a major feature of aquatic animal health management.
❭ The extraction of water from ground water may result in changes to the natural water regime, potentially effect on the availability and quality of ground water.	P -- I LT	❭ Limit water exchange. ❭ Providing storage for rain and runoff water.

Source: Myanmar Koei International Ltd. (MKI)

Overfeeding and inefficient feed conversion leads to low water quality, increased turbidity, and sedimentation. Good water quality management in ponds can be a powerful tool in reducing the volume and enhancing the quality of pond effluents to minimize adverse environmental effects. While treatment methods are available for improving the quality of effluents before their final discharge from aquaculture

operations, it is important to take steps to minimize the pathways through which those pollutants enter aquaculture ponds in the first place. Effluents from intensive production systems, with a large feed input, typically have greater negative impacts than effluents from semi-intensive or extensive systems with little or no feed addition. Therefore, an aquaculture activity where supplementary feed is required should be in an area of reasonable depth and current flows to ensure that nutrients resulting from uneaten feed and feces are adequately dispersed. However, none of studied ponds indicate of using appropriate water treatment system.

Water resources used in aquaculture may include the sea, estuaries, rivers, lakes, and groundwater. The extraction of water from these resources may result in changes to the natural water regime, potentially affecting fish stocks, or the availability and quality of groundwater. Based on the in-depth interview results, 7 farms rely on the surrounding water bodies such as creeks and irrigation canals connected with rivers, and one farm from Pantanaw Township uses the groundwater as water sources because of the water scarcity in dry season.

Bottom Sediment

The impacts on bottom sediments are the most obvious form of pollution resulting from aquaculture activities, the reduction of the wastes and effluents amount released into the environment is crucial. Not all the nutrients given as feed are assimilated or consumed by the fish and other aquatic animal products in the production process. A large proportion is excreted either as dissolved nutrients that increase their concentration in the water column or as feces that settle to the sediment. Moreover, sediment produced internally by biological activity and management procedures. within the ecosystem Organic sediment in ponds originates primarily from plankton. Other sources are manure applications, uneaten feed, aquatic animal feces, and higher aquatic vegetation.

Excess pellets settle to the sediments where they may be consumed by wild fish, consumed by benthic organisms or breakdown into nutrients by benthic assimilation. The level of nutrient release is greatly influenced by feed quality, feeding strategy, over-feeding, and type of feed (pellet, trash fish, farm-made feeds).

The pond system relies mainly on internal processes, where solid wastes settle at the bottom of the pond and accumulate over time. If the settled waste has accumulated over time, any natural activities, such as erosion, can cause mixing of the highly nutritious pond bottom and may lead to algal blooms.

Table 19: Impacts of bottom sediments and proposed mitigations

Potential Environmental Impacts	Symbols	Proposed Mitigation Measures
〉 The major sources of bottom sediment in aquaculture ponds are suspended soil particles in inflowing water, manures and feed added to ponds to promote aquatic animal production. 〉 Poor aquacultural management or harvesting practices can result in high amounts of sediment deposition.	P -- I LT/ST	〉 Choose the appropriate feeds during the production cycle 〉 Pay attention to the feeding methods and the resulting solids production can greatly reduce the wastes. 〉 Use filtration systems and settling basins to remove larger (settleable) solids. 〉 Use constructed wetland to remove smaller suspended solids. 〉 Reduce erosion and eliminate scour which can be an important source of suspended solids 〉 Regular monitoring the pond bottom sediments during pond harvesting time.

Source: Myanmar Koei International Ltd. (MKI)

Solid Waste

Aquaculture, like any other animal production activity, produces wastes in the form of particulate (mainly the uneaten feed and feces) and soluble substances (excreta) which increase biochemical oxygen demand, nitrates, and phosphates in receiving waters. Some of the feed is in the form of dust that is too small to be eaten by the fish, some feed gets lost through over feeding of the fish, or if the feed pellets are the wrong size for the fish.

Table 20: Impacts of solid waste and proposed mitigations

Potential Environmental Impacts	Symbols	Proposed Mitigation Measures
〉 The two major sources of solid wastes in aquaculture are uneaten feed and undigested substances, which are passed through as fecal waste. 〉 Fish produce waste, and their waste has the potential to build up in the surrounding area. This can deplete the water of oxygen, creating algal blooms and dead zones.	P -- I ST	〉 Feed and feeding systems can effectively reduce wastes resulting from the fish feed through proper management of the inputs into the culture system. 〉 Uniformity in size of fish is very important for them to accept the same size of pellet. 〉 The feed should be sieved to remove dust and broken pellet before being fed. 〉 The feed must be fed effectively to ensure little, or no waste resulted from the uneaten feed. 〉 Removal of solid waste from the pond bottom is typically done after two or more fish production cycles. 〉 Solid waste collection system should include those generated by aquaculture in freshwater such as: uneaten feeds, cage materials (poles, bamboos, nets, etc.), feed bags, human waste and dead fish.

Source: Myanmar Koei International Ltd. (MKI)

As aforementioned, both commercial pellets and farm-made feed are used in NGA-Myanmar target areas. Fish cannot digest all feed, and some are wasted. For example, out of 100 units of feed fed to fish, typically 40 to 50 percent is wasted: 0 to 5 units of feed are uneaten (wasted), fish produce 10 – 15 units of solid waste and 30-35 units of liquid waste. If some feed wastes are left to remain in the aquaculture system, their aerobic bacterial activity will increase the biochemical oxygen demand (BOD) and deplete oxygen. As low DO and high TSS results in some ponds was observed, it can be assumed that some feed wastes are left to remain in the aquaculture system and become waste. To decide whether those ponds have overfeeding or not, it should be measured BOD of water quality. However, the effect of waste production may vary depends on feed types, nutrient composition, ratio of feed size to fish size, quantity of feed per unit time, feeding method and storage time.

Moreover, the risk of negative impacts of aquaculture wastes is greatest in enclosed waters or sites with poor water exchange rates such as in slow moving rivers, lakes, and shallow bays. In these conditions, aquaculture production can lead to a buildup of organic sediments and addition of nutrients to the water column. This, in turn, can lead to secondary effects such as eutrophication, algal blooms and low dissolved oxygen levels.

Hazardous Materials

The aquaculture sector may involve the handling and use of hazardous materials (e.g., oil, fertilizers, and other chemicals). The overuse and misuse of chemicals and fertilizers in aquaculture operations is a reason for contamination on the aquatic environment. Moreover, metals present in artificial feeds (e.g., copper, zinc, cobalt, cadmium, lead and mercury) represent a risk, both to the environment and to the aquatic living organisms. In addition, antibiotics used to prevent and fight infectious diseases in aquatic organisms cultivated on a commercial scale.

It was observed that CaCO3 used in all fishponds as it has fair price. There was no usage of chemical fertilizers, but a little usage of molasses (*Tin Lae Yay*) was observed. While it is expected the risk of hazardous materials in the surveyed ponds to be low, it is necessary to follow the regulatory guidelines of chemical usages. Although further research is required on the environmental effects of these compounds, particularly for long-term and multiple source impacts. Recommendations for the safe storage, handling, and use of hazardous materials, including guidance on oil spills and containment must be followed. The effect of these chemical wastes upon these natural water systems depends on the concentration of chemicals used, the farm size and the size of receiving water bodies.

Table 21: Impacts of hazardous materials and proposed mitigations

Potential Environmental Impacts	Symbols	Proposed Mitigation Measures
〉 The overuse and misuse of chemicals in aquaculture operations is a reason for contamination on the aquatic environment. 〉 Metals present in artificial feeds (e.g., copper, zinc, cobalt, cadmium, lead and mercury) represent a risk, both to the environment and to the aquatic living organisms	P -- I ST	〉 Ban of hazardous chemicals in the aquaculture in the fish farms in accordance with its self-adherence to the aquaculture product quality standards implemented. 〉 Reduce disease problems through preventative management, not chemicals. 〉 Implement preventative health management strategies. 〉 Minimize leakage from oil, petrol. 〉 Minimize usage of antifouling agents

Source: Myanmar Koei International Ltd. (MKI)

Biodiversity

Aquaculture could greatly impact biodiversity as well if not carefully managed. These impacts on biodiversity can resonate through multiple trophic levels and can completely change the natural environment. The greatest impacts of aquaculture on biodiversity are the possible invasion of escapees, the degradation of the environment, particularly through eutrophication, and the greater risk of harm caused to a wild population. Species that escape from aquaculture can become invasive in areas where they are nonnative and aquaculture species may consume increasingly scarce fish meal, and aquaculture species may transmit diseases to wild fish. In the study area, the sucker fish species are the most common invasive species found in aquaculture ponds and ambient surface water. Potential loss of genetic resources may be occurred due to potential release of artificially propagated seed into the wild, sustainability of fish meal and fish oil ingredients for fish; and development of antibiotic resistance in pathogenic bacteria that can then spread from farms to wild stock. When wild fish migration ways pass nearly fish farms, wild fish can become infested with parasites and can leads to the loss of native species.

Table 22: Impacts on biodiversity and proposed mitigations

Potential Environmental Impacts	Symbols	Proposed Mitigation Measures
〉 Escape of aquatic crops and their potential hazard as invasive species. 〉 The relationships among effluents, eutrophication of water bodies, and changes in the fauna of receiving waters. 〉 The transmission of diseases or parasites from farmed animals to wild fish stocks. 〉 Pollution of local waters that supply aquaculture systems threatens aquaculture itself as well as biodiversity.	P -- I ST	〉 Installation and maintenance of screens with a mesh that is small enough to prevent the entry and potential escape of aquatic species in the drainage channels. 〉 When necessary, consider chemical treatment of water released from hatcheries (e.g., with chlorine at acceptable concentrations for the receiving waters) to destroy escaping larvae or juveniles. 〉 Installation of gravel filtration on pond discharge structures. 〉 Use of settling ponds to remove oysters and suspended materials from water before its discharge.

Source: Myanmar Koei International Ltd. (MKI)

Community Health

Most of aquaculture ponds in NGA-Myanmar townships relies on water from streams where its surrounding communities are also relying on as their main source of water. During the dry season, some ponds are also relying on groundwater to replenish their pond water level. Excessive pumping lowers the groundwater table and contributes to the saline water intrusion that has been an issue in the Ayeyarwady delta.

Furthermore, the use of farm-made feed and commercial feed as well as agrochemicals has enriched streams with nitrogen, phosphorus, and potassium that increases health risk, including cancer and other serious illnesses – especially if water is consumed in a long run.

When nutrient-rich sediments are removed from ponds either manually or mechanically during harvest and used to enhance embankment, the loose sediments from the raised embankment will be carried along with run-off water in the rainy season. They will clog drainages and irrigation canals that worsen seasonal floods.

Table 23: Impacts on community health and proposed mitigations

Potential Environmental Impacts	Symbols	Proposed Mitigation Measures
〉 Nitrogen percolation contamination of groundwater, which may pose a carcinogenic risk 〉 Seawater intrusion as a result of excessive groundwater extraction for pond dilution.	P -- I LT	〉 Create a community-led groundwater quality monitoring system for a tube well in a neighboring community. 〉 Build ponds on soils with adequate clay content to avoid seepage into the groundwater and surface water 〉 Regular monitoring the pond bottom sediments during pond harvesting time.

Source: Myanmar Koei International Ltd. (MKI)

Climate Change

As presented in the Section 3, aquaculture operations emit GHGs into the atmosphere that contributes to climate change. On the other hand, climate change both directly and indirectly impacts the aquaculture sector. Short-term climate change impacts on aquaculture can include losses of production and infrastructure arising from extreme events such as floods, increased risks of diseases, parasites, and harmful algal blooms. Long-term impacts can include reduced availability of wild seed as well as reduced precipitation leading to increasing competition for freshwater. Climate change may also bring increased risks for animal health, for example by changing the occurrence and virulence of pathogens or the susceptibility of the organisms being cultured to pathogens and infections.

Table 24: Contributions to climate change and proposed mitigations

Potential Environmental Impacts	Symbols	Proposed Mitigation Measures
〉 Aquaculture activities such as power input, transport and feed production are considered the main pathways of the sector's contribution to GHGs. 〉 Feed production in aquaculture is particularly seen as the sector's major contributor to GHG emissions.	P -- I & D LT & ST	〉 Use renewable energy, such as wind, solar and tidal power instead of fuel usage 〉 Reduce fuel usage and substitute high emission intensity fuels with low emission intensity alternatives 〉 Improve efficiency of feeding 〉 Use feed with lower associated emissions 〉 Improve feed management that targets reducing uneaten feed

Source: Myanmar Koei International Ltd. (MKI)

KEY RECOMMENDATIONS

In Myanmar, aquaculture will continue to be key sector that will be relied upon for food, income, and employment. With proper management, and by applying greener solutions as well as the effluent guidelines for aquaculture already available, the sector has high potential to balance between aquaculture development and environmental integrity.

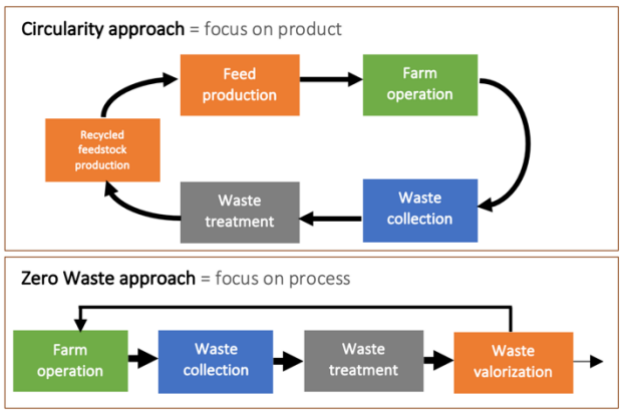
Promoting Appropriate Green Aquaculture Practices

Myanmar has a large number of freshwater sites of high ecological value, but improper disposal of polluted water from aquaculture ponds has contributed to the degradation of aquatic resources, causing biodiversity losses and threatening the capacity of those resources to support livelihoods in the future. Unfortunately, with the current political, social, and economic crises, the development and implementation of effective legal frameworks will very likely be absence. Therefore, the voluntary adoption of environmentally friendly practices and technologies in the aquaculture sector should be strengthened to contribute to its sustainability. For that very reason, relevant program like NGA-Myanmar should continue its endeavors to explore and promote low-cost and appropriate green practices and technologies.

Generally, aquaculture MSMEs in Myanmar spend approximately twice as much per acre on fuel as large farms, while large farms spent roughly twice as much per acre on fertilizers, lime, and pesticides as MSMEs. This suggests several possibilities: MSMEs may be unable to afford or access inputs used in farm management, they may lack knowledge of how to use them efficiently, and/or they may seek for low-risk systems to be less prone to poor water quality and disease. This provides an opportunity to introduce green practices and technologies that promote resource efficiency that reduce environmental degradation, while ensuring improved economic returns from productivity improvement and lower production costs.

Resource efficiency in aquaculture can be achieved by promoting circular economy in the sector. Circularity in aquaculture can be achieved by considering, but not limited to, biological flows within its production systems. Given its specific dimension in addressing the nutrient flow mass and looking at the impacts of recirculating them from one biological species to another, or capturing them to be recirculated as new feed, the circular economy in aquaculture can also be defined and described as a circular bioeconomy. The objective of circular economy in aquaculture is to make the value of the products, materials, and resources last within the economy for as long as possible, which aims to minimize waste generation (zero waste approach) and to produce renewable biological resources, facilitating a conversion of these resources and waste streams into value added products, such as food, feed, biobased products, and bioenergy (circularity approach).

Figure 14: Circularity and zero waste pathways



Source: iFishIENCi

Feed is considered as the single most important input in increasing aquaculture production and profits. Success or failure in augmenting yield in aquaculture production depends, to a large extent, on the quality of the diet and feeding management. In addition, feed production, both commercial

and home-made --where protein-rich ingredients are required to meet its quality, is a critical area of the overall environmental impact of the aquaculture sector. Moreover, unsustainable feeding practices results in dirty effluent water and sludge that worsen ecosystem in surrounding aquaculture operations. Therefore, it is recommended that NGA-Myanmar will focus on promoting circular economy by increasing circularity in feed production and valorization of aquaculture wastes, both effluent and sludge.

Table 23: Recommended circular bioeconomy by using both circularity and zero waste pathways.

What	How
Improved feed formulations & circularity of feed ingredients	〉 Improved feed formulations, both for home-made production and commercial one, incorporating resource efficiency principles in the manufacturing process: novel energy-intensive process, bad locations, etc. 〉 Production of 'green water' rich in natural feed (i.e., plankton, mostly microalgae), especially for micro/small operators in extensive production system 〉 Reduce the use of 'linear' ingredients in feed production, for example replacing soybean meal with alternative protein feed ingredients (i.e., black army fly produced using sludge from ponds).
Resource efficiency of feeding	〉 Monitor FCR and make improvement to minimize nutrient excretion 〉 Promote 'smart-feeding' technology for medium/large operators.
Circularity of waste	〉 Integrated aquaculture systems, either polyculture or integrated aquaculture-agriculture systems.

Source: Myanmar Koei International Ltd. (MKI)

To complement the circular bioeconomy practices, the use of relevant good practices can also be promoted. For example, maintaining moderate fish densities can be done to mitigate problems of sludge and poor water quality in fishpond. Safe and proper use of inputs (such as lime to manage pH) as well as pond aeration will also help improve pond water quality. Furthermore, agricultural irrigation (for integrated aquaculture-agriculture systems), created wetlands, settling basins, and biological filters are also practical methods for improving quality of effluents from ponds. In that case, if space is available and construction costs are manageable, settling basins are suggested for fishponds while constructed wetlands can be used as an alternative to settling basins.

Furthermore, to protect the environment, the discharge of sludge, any solid waste (farm, human, animals) and chemicals into receiving waterbodies or ecosystems, should be prohibited. Any waste must be disposed of in accordance with the label instructions and any applicable national regulations to mitigate the environmental impacts related solid water released from fish farms. Fish farms should take the responsibilities for cleaning up trash, such as glass bottles, polystyrene cartons, broken nets, and feedbags to mitigate the impacts on surrounding environments. The use of designated waste receptacles is recommended. These should be maintained by the fish farms and, when it's technologically possible, waste separation and recycling should be encouraged.

Recirculating Aquaculture Systems (RAS) could be promoted in intensive fishponds by large operators or in hatcheries. While expensive, the use of this systems can reduce the number of effluents because 90% of the water is recycled within the system. In addition, certification system for green aquaculture practices, with strong internal control system and external audit mechanism, is also an approach which can contribute to the adoption of green practices, when incentivize with access to higher-value markets.

The following table presents other mitigation measures and practices for specific issues that can be promoted in NGA-Myanmar target areas.

Table 24: Other mitigation measures and practices.

Issues	Mitigation Measures
Destructions of natural habitats	〉 Promote environmentally production systems, such as mangrove friendly aquaculture 〉 Not expanding ponds by destroying natural habitats.
Improper waste disposal	〉 Disposal of waste according to label instructions and relevant regulations 〉 Composting and reuse as fertilizers (e.g., sludge) 〉 Incineration of biological waste.
Leakage of oil and fuel (i.e., from generators)	〉 Keeping all gasoline and oil-containing machinery and equipment well above high water level and water-proof flooring system 〉 Regularly maintenance of all utilized machinery and equipment.
Hygiene	〉 Develop protocols that specifies cleaning activities 〉 Feed shall be handled and stored in a safe, clean and dry manner, clearly separated from any sources of potential contamination and pests such as insects and rodents.
Carbon footprint	〉 Recycling of waste materials and use of recycled products 〉 Use of renewable energy for pumping and other facilities (e.g., solar, wind and water energy) if possible 〉 Planting trees/vegetation on the farm without having negative impacts to the fishponds 〉 Efficient use of water resources and efficient feeding (feeding amount and feed conversion ratio should be recorded and documented.) 〉 To be able to mitigate GHG emission, the following activities and variables should be recorded: Energy usage amount and type of energy; Fertilization usage amount, type of fertilizer; Feeding (feed type, feed conversion ratio and feed consumption), and Harvesting (total production amount, time)
Erosion and sediment accumulation in ponds	〉 Planting the appropriate vegetation on dykes and banks 〉 Where planting vegetation on dykes and banks is difficult, gravel/stone shall be used. If neither planting nor the use of gravel is feasible, plastic lining may be used. 〉 Broken dykes should be repaired prior to next stocking.

Source: Myanmar Koei International Ltd. (MKI)

Water Quality Monitoring

Most of the surveyed fish farms do not use systematic monitoring practices for water quality of fishponds. Monitoring is also nonexistence outside the ponds, like the rivers or irrigation canals where these ponds being connected into.

In the National Environmental (Emission) Quality Guideline (NEQG), the effluent guideline values from the aquaculture activities have been described. However, awareness on the guideline is very limited. While the potential impacts of fish farms effluent to the environment are also not well-studied, aquaculture pond operators are also not recording properly their inputs use and other key information to assess their environmental impacts.

While it was not mentioned much during the interviews, based on the surveyors' observation it was noted that supplemental feeds, fertilizers, and antibiotics were used. Furthermore, none of surveyed ponds were having water treatment facility. From the interviews, it was also learned that awareness of aquaculture operators on the negative impacts of aquaculture on the environment was also very limited. It was,

therefore, not surprising that the water quality tests at ambient water resulted in many of them having poor quality.

Unfortunately, in the studied townships, the surrounding communities of aquaculture production centers utilize those poor-quality ambient water streams for their daily needs. Considering the rapid growth of aquaculture sector in the Yangon-Ayeyarwady aquaculture corridor, the degradation of ambient water quality in the long-term should be expected, if no environmental safeguard is implemented. Thus, the implementation of water quality monitoring and keeping the data record is important.

NGA-Myanmar should consider providing capacity building to its targeted MSMSEs on pond water quality management, including monitoring process. When the water quality monitoring system is considered, it is vital to select the monitoring methods that are fitted with local context. Low-cost in-situ measurement would be more effective than the laboratory measurement method, which time consumption and laborious. In addition, given the ineffective government operations at the moment, the program can also design and implement a low-cost participatory water quality monitoring for the targeted communities.

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ANNEXES

Annex-1. Excerpt from the relevant laws and regulations of aquaculture

No.	Relevant Laws and Regulations related to aquaculture and environmental conservation	Brief Explanation
National Laws		
1.	Law amending the law relating to the fishing rights of foreign fishing vessels (1993)	This Law, which consists of four Sections, lays down some amendments and addenda to the Law relating to the Fishing Rights of Foreign Fishing Vessels (hereinafter the "basic Law"). Section 2 contains new Section 35 A, to be inserted under Section 35 of the basic Law, within Chapter IX. The latter sets out specific prohibitions. As per new Section 35A, no public servant exercising any of the duties and powers entrusted under the basic Law shall: (a) replace another person for the offender or conceal the offender without taking any action; (b) cause to disappear, alter by wrongful means, substitute or misuse an exhibit involved in an offence. Sections 38 to 44 of the basic Law, which set forth offences and establish related penalties to be applied, are replaced by the provisions laid down in Section 3 of the present Law. Lastly, Section 4 of this Law adds Section 55 A to the basic Law, dealing with proceedings that may be instituted against any public servant under Section 43 of the basic Law. In such event, the prior sanction of the Ministry shall be required.
2.	Aquaculture Law (1989)	This Law is divided into the following 10 Chapters: Title and Definition (1); Application for Lease or License (2); Payment of Duties and Fees (3); Powers of the Department and the Director General (4); Cancellation of the Lease License (5); Inspection and Action to be taken (6); Appeals (7); Prohibitions (8); Offences and Penalties (9); Miscellaneous (10). The exercise of aquaculture in aquaculture lands or fishery areas which are not connected to any of the Government Departments or special fishery areas is subject to the issuance of a lease grant. The sale of fish seeds produced through artificial propagation, or the breeding of aquarium fish are subject to the issuance of a license. License holders shall pay a grant fee or a license fee, according to the procedure set out by the DOF, which shall determine the duration of permits and licenses, as well. The Department may designate aquaculture land from agricultural and virgin land for the development of aquaculture, for not more than 10 years and at the conditions listed in article 13 (among others, purpose of aquaculture, time limits for the implementation of aquaculture activities, etc.). Person(s) who intend to exercise aquaculture at Fishery Areas connected with one of the Government Department, shall apply for the issuance of a license in accordance with the regulations of the Department, provided the person has prior agreement with the Department concerned. Further provisions concern (a) the

		powers of the Director General in matter of licenses and permits; (b) the conditions for the cancellation of the lease or the license; powers and duties of inspectors; (c) penalties to be inflicted in case of violation of the provisions of the present Law.
3.	Myanmar Marine Fisheries Law (1991)	The Myanmar marine fisheries law has its provisions mainly focused on the system establishment of (i) marine fisheries operations (ii) collection of marine fisheries product for sale (iii) operation of fisheries related activities and (iv) commercial sport fishing. Due to the marine fisheries law none of the fishery's activities could be established without license, which basically is granted by the DOF.
4.	Freshwater Fisheries Law (1991)	The Freshwater Fisheries Law, promulgated on 4 March 1991, is the primary legislation in the Union of Myanmar which governs the freshwater fisheries, the most significant fisheries sector in the Union. The Freshwater Fisheries Law which has its origins dating back to the early 1900s, was designed primarily to provide a framework for commercial exploitation of the fisheries. The specific objectives of the law are spelt out in Chapter II, Section 3 of the Law as follows: to further develop the fisheries; to prevent the extinction of fish; to safeguard and prevent the destruction of freshwater fisheries waters; to obtain duties and fees payable to the State; to manage the fisheries and to take action in accordance with the Law
5.	Law amending the Myanmar Marine Fisheries Law (1993)	This Law has been enacted to amend and supplement certain provisions of the Myanmar Marine Fisheries Law (hereinafter the "basic Law"). The amendments mainly concern the prohibitions set forth in the basic Law as well as offences and related penalties established therein. In accordance with new sub-section (b) of Section 42, at the time of inspection of any fishery no person shall conceal or, without the permission of the Inspector, dispose of fish, fishing implement or other material and money.
6.	Law amending the law relating to the fishing rights of foreign fishing vessel (1993)	This Law, which consists of four Sections, lays down some amendments and addenda to the Law relating to the Fishing Rights of Foreign Fishing Vessels (hereinafter the "basic Law"). Section 2 contains new Section 35 A, to be inserted under Section 35 of the basic Law, within Chapter IX. The latter sets out specific prohibitions. As per new Section 35A, no public servant exercising any of the duties and powers entrusted under the basic Law shall: (a) replace another person for the offender or conceal the offender without taking any action; (b) cause to disappear, alter by wrongful means, substitute or misuse an exhibit involved in an offence. Sections 38 to 44 of the basic Law, which set forth offences and establish related penalties to be applied, are replaced by the provisions laid down in Section 3 of the present Law. Lastly, Section 4 of this Law adds Section 55 A to the basic Law, dealing with proceedings that may be instituted against any public servant under Section 43 of the basic Law. In such event, the prior sanction of the Ministry shall be required
7.	Environmental Conservation Law (2012)	The Environmental Conservation Law (ECL) was enacted in March 2012. This law is the fundamental law of environmental

		management and environmental conservation in Myanmar prepared by MONREC. This Law has eight objectives, including conserving natural and cultural heritage for the benefit of current and future generations, reclaiming ecosystems starting to degenerate and disappear, and promoting international, regional and bilateral co-operation focused on environmental conservation. The law enables the formation of an Environment Conservation Committee and the establishment of an Environmental Management Fund to enable environmental conservation works. The law also identifies several duties and powers of the Ministry of Environmental Conservation and Forestry, one of which is to create guidance related to mitigation and adaptation of climate change. Others include stipulating environmental quality standards (e.g., noise, water quality, solid waste) and establishing monitoring programs for the conservation and enhancement of the environment.
8.	Environmental Conservation Rules (2014)	The Environmental Conservation Rules (ECRs) were enacted in June 2014 as the detailed enforcement regulations for ECL. The project proponent shall adhere to the following policies based on ECL: To treat, emit, discharge, and deposit the substance which causes pollution in the environment in accordance with stipulated environmental standard (Article 14 in ECL). To be responsible to carry out activities that contribute to generated cash or in-kind to the relevant combined scheme for the environmental conservation including the management and treatment of waste including liquid, emission, solid (Article 16 (a) in ECL)
9.	National Environmental Policy (2019)	The new National Environmental Policy provides long-term, strategic guidance for achieving a sustainable future for Myanmar. It requires the mainstreaming of environmental protection into planning and decision-making at all levels of government and in all sectors. The Government of the Republic of the Union of Myanmar has responded to these challenges by adopting this new National Environmental Policy with the aim of mainstreaming environmental considerations into economic and social development. The Policy will provide long-term guidance for government organizations, civil society, the private sector and development partners on the achievement of environmental protection and sustainable development objectives in Myanmar. Along with this Policy, the Government emphasizes the importance of placing environmental considerations at the center of efforts to promote economic and social development, reduce poverty, mitigate and adapt to climate change, and minimize natural disaster risks.
10.	National Environmental Quality (Emission) Guidelines (NEQG) (2015)	MONREC formulated the National Environmental Quality (Emission) Guidelines (NEQG) in coordination with ADB in December 2015. The NEQG determines the guideline values for general emission such as air emissions, wastewater, noise levels, odor, and those for sector-specific emission such as emission from forestry, agribusiness/feed production, aquaculture, chemicals, oil and gas, infrastructure, general manufacturing, mining, and power.

Compliance to International Laws		
1.	Code of Conduct for Responsible Fisheries	Fisheries, including aquaculture, provide a vital source of feed, employment, recreation, trade and economic well-being for people throughout the world, both for present and future generations and should therefore be conducted in a responsible manner. This Code sets out principles and international standards of behaviour for responsible practices with a view to ensuring the effective conservation, management and development of living aquatic resources, with due respect for the ecosystem and biodiversity. The Code recognizes the nutritional, economic, social, environmental and cultural importance of fisheries and the interests of all those concerned with the fishery sector. The Code takes into account the biological characteristics of the resources and their environment and the interests of consumers and other users. States and all those involved in fisheries are encouraged to apply the Code and give effect to it.
2.	International Plan of Action-Illegal, Unreported and Unregulated (IPOA –IUU) Fishing	The IPOA-IUU is a voluntary instrument that applies to all States and entities and to all fishers. Following the IPOA's introduction, the nature and scope of IUU fishing is addressed. This is followed by the IPOA's objective and principles and the implementation of measures to prevent, deter and eliminate IUU fishing. These measures focus on all State responsibilities, flag State responsibilities, coastal State measures, port State measures, internationally agreed market-related measures, research and regional fisheries management organizations. Special requirements of developing countries are then considered, followed by reporting requirements and the role of FAO.
3.	Port State Measure Agreement (2009)	The Agreement on Port State Measures (PSMA) is the first binding international agreement to specifically target illegal, unreported and unregulated (IUU) fishing. Its objective is to prevent, deter and eliminate IUU fishing by preventing vessels engaged in IUU fishing from using ports and landing their catches. In this way, the PSMA reduces the incentive of such vessels to continue to operate while it also blocks fishery products derived from IUU fishing from reaching national and international markets. The effective implementation of the PSMA ultimately contributes to the long-term conservation and sustainable use of living marine resources and marine ecosystems. The provisions of the PSMA apply to fishing vessels seeking entry into a designated port of a State which is different to their flag State.
4.	European Union (EU) regulation No. 1005/2008 and 1010/2009	This Regulation sets out detailed rules for implementing Council Regulation No. 1005/2008 establishing a European Community system to prevent, deter and eliminate illegal, unreported and unregulated fishing. These rules cover in particular inspections of third country vessels in Member States ports, the catch certification scheme for importation and exportation of fishery products and sightings. This Regulation is implemented by a set of other instruments and further amended by three regulations. For the full list of EU legislation and official documents pertaining to Illegal, Unreported and Unregulated Fishing,
5.	Regional Plan of Action-IUU (RPOA –IUU)	This Regional Plan of Action to Prevent, Deter and Eliminate Illegal, Unreported and Unregulated (IUU) fishing (RPOA-IUU)

		recognizes the negative impacts of IUU fishing on the marine environment, the economic development and the social well-being of coastal communities in the WECAFC area of competence. This (RPOA-IUU) has been developed by the joint Regional Working Group on IUU fishing (RWG-IUU) of WECAFC which includes two sub-regional organizations, the Caribbean Regional Fisheries Mechanism (CRFM) and the Organization for Fisheries and Aquaculture of Central America (OSPESCA), and was presented at the 17th Session of WECAFC in July 2019 for review, endorsement and implementation at national and regional levels.
6.	ASEAN Regional Plan of Action for Managing Fishing Capacity –RPOA Capacity (2017)	The overall objective of the RPOA-Capacity would be to serve as guide for the management of fishing capacity in an ASEAN perspective and also to support the ASEAN Member States in the development and implementation of their respective NPOA-Capacity (SEAFDEC, 2006). The RPOA-Capacity is also meant to support the need to enhance regional cooperation on fisheries management and/or management of fishing capacity in sub-regional areas such as the Andaman Sea, Gulf of Thailand, South China Sea and Sulu-Sulawesi Seas. Strengthened regional and sub-regional cooperation on the management and control of fishing capacity would provide an effective platform for the AMSs to support efforts to combat IUU fishing. The RPOA-Capacity contain four parts: Part 1 as an introduction part includes rationale, problems on the sustainable fisheries management, and the needs for RPOA-Capacity; Part 2 include the goals and objectives of the RPOA-Capacity; Part 3 refers to the guiding principle in developing the RPOA-Capacity. Part 4 is the main part of the Plan of Action for Managing Fishing Capacity and this part comprises of 5 Sessions as follows: 1) Assessment of Fishing Capacity; 2) Preparation and Implementation of National Plans; 3) International Consideration; 4) Required Urgent Measures for Regional Fisheries Management; and 5) Mechanisms to Promote of the Implementation.
7.	ASEAN Guidelines for Preventing the Entry of Fish and Fisheries Products from IUU Fishing Activities into Supply Chain	The Guidelines outlines the possible future actions in the ASEAN region in combating IUU fishing, in accordance with the ASEAN-SEAFDEC Resolution and Plan of Action on Sustainable Fisheries for Feed Security for the ASEAN Region towards 2020 adopted in 2011. The Guidelines comprises three main parts. The Introduction as Part 1 includes the objective of ensuring that fish and fishery products in the supply chain do not come from IUU fishing activities. The introduction part also includes the objectives, nature and scope, guiding principle, and definition of terminologies for better understanding of the basic elements and focus of the Guidelines; Part 2 deals with the forms of IUU fishing activities found in the Southeast Asian region; Finally, Part 3 which is the most important part of the Guidelines provides guidance on preventing the entry of fish and fishery products from IUU fishing activities into the supply chain based on the root cause of IUU fishing activities that occur in the region. These Guidelines should be reviewed regularly and update, when necessary, as proposed by AMS.

Annex-2. Interview Questionnaire Form

			Date	:	
Business Name	:		Location	:	
Responded by	:		Designation	:	
Type of Business	:	☐ Hatchery ☐ Growth out ☐ Poultry-Fish ☐ Others	Operation year	:	Starting from
Size of farm (total, in acres)	:		Average size of each pond (in acres)		
Average depth of ponds (in feet)					

No.	Request/Question	Answer
	Cultured specie (s):	☐ Nga-myit-chin (Rohu) ☐ Nga-gaung-pwa (Catla) ☐ Tilapia (Tilapia) ☐ Nga-tan (Pangasius) ☐ Nga-gyin-phyu (Mrigal) ☐ Nga-gyin-shwe-wah (Common carp) ☐ Other: _____
	Water used:	☐ Surrounding water body ☐ Rainwater ☐ Underground water
	Fertilization:	☐ Manure ☐ Calcium Carbonate ($CaCO_3$) ☐ Urea ☐ Other: _____
	Feed used:	☐ Manufactured pallets ☐ Rice bran ☐ Millet bran ☐ Feed scraps ☐ Vegetables ☐ Other: _____
	Feeding methods:	☐ Floating ☐ Sinking ☐ Other: _____
	Feed Conversion Ratio:	_____
	Harvesting methods:	☐ Partial ☐ Full
	Is water entering the ponds treated?	☐ Yes ☐ No
	Is water leaving the ponds treated?	☐ Yes ☐ No
	Previous occurrences of fish diseases	☐ No ☐ If "Yes", fish diseases: _____ reasons of occurring: _____ how it was managed: _____
	Sources of energy	☐ Electricity from national grid

No.	Request/Question	Answer
		☐ Solar ☐ Diesel generators
	Estimated amount of fuel oil used for operations	Grade of diesel: _____ Amount: _____
	Presence of good practices	☐ Soil test during the pond preparation ☐ Inlet water quality test ☐ Presence of reservoirs ☐ Using organic fertilizers ☐ Proper feeding ☐ Regular Pond water quality test If "Yes", monitoring interval: _____; parameters: _____; type of test kits used: _____
	Challenges	☐ Poor inlet water quality ☐ Water scarcity ☐ Invasive species ☐ Fish diseases ☐ Other: _____

Annex-3: Lab results of water quality (Twantay, Maubin, Pantanaw and Nyaungdone Townships)

Table 1: Lab results of water quality of fish ponds surveyed in Twantay Township

Goshu-A1 Eco Business Company Limited
Plot No.19, 2nd Street, Yangon Industrial Zone, Mingalardon Township, Yangon,
Ph: +959-253685274

Water Analysis Report

Customer name: Myanmar Koei International Ltd.
Project: Yangon
Sample Name: TT-A-1
Receiving Date: 13/07/2022
Reporting Date: 22/07/2022

Sample No: 071309
Sampling Date: 13/07/2022
Analytical Date: 13-22/07/2022
Report No: ARWT 220705-02
Job No: MMA 220713

No.	Item	Result	Method	Detection Limit
1	Ortho Phosphate (mg/L as PO_4^{3-})	<0.25	*SM 4500-PD+ Stannous Chloride	0.25
2	Total Phosphorus (mg/L as P)	<0.15	*SM 4500-PB+E Persulfate+Ascorbic	0.15

*Based on Standard Methods for the Examination of Water and Wastewater (SM), APHA,AWWA, WEF
**JIS Handbook

Analyzed by: Su Wai Aung
Laboratory Technician
Goshu-A1 Laboratory

Approved by:
KOJI NAKAHASHI
MANAGING DIRECTOR
GOSHU-A1 ECO BUSINESS CO.,LTD.

REPORT RESULT IS ONLY OF THE SAMPLE SUBMITTED FOR ANALYSIS.
THIS ANALYSIS REPORT SHALL NOT BE REPRODUCED EXCEPT IN FULL, WITHOUT WRITTEN APPROVAL OF THE LABORATORY OF GOSHU-A1 ECO BUSINESS CO. LTD.

Goshu-A1 Eco Business Company Limited
Plot No.19, 2nd Street, Yangon Industrial Zone, Mingalardon Township, Yangon,
Ph: +959-253685274

Water Analysis Report

Customer name: Myanmar Koei International Ltd.
Project: Yangon
Sample Name: TT-A-2
Receiving Date: 13/07/2022
Reporting Date: 22/07/2022

Sample No: 071311
Sampling Date: 13/07/2022
Analytical Date: 13-22/07/2022
Report No: ARWT 220705-04
Job No: MMA 220713

No.	Item	Result	Method	Detection Limit
1	Ortho Phosphate (mg/L as PO_4^{3-})	<0.25	*SM 4500-PD+ Stannous Chloride	0.25
2	Total Phosphorus (mg/L as P)	0.18	*SM 4500-PB+E Persulfate+Ascorbic	0.15

*Based on Standard Methods for the Examination of Water and Wastewater (SM), APHA,AWWA, WEF
**JIS Handbook

Analyzed by: Su Wai Aung
Laboratory Technician
Goshu-A1 Laboratory

Approved by:
KOJI NAKAHASHI
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Goshu-A1 Eco Business Company Limited
Plot No.19, 2nd Street, Yangon Industrial Zone, Mingalardon Township, Yangon,
Ph: +959-253685274

Water Analysis Report

Customer name: Myanmar Koei International Ltd.
Project: Yangon
Sample Name: TT-P-1
Receiving Date: 13/07/2022
Reporting Date: 22/07/2022

Sample No: 071308
Sampling Date: 13/07/2022
Analytical Date: 13-22/07/2022
Report No: ARWT 220705-01
Job No: MMA 220713

No.	Item	Result	Method	Detection Limit
1	Ortho Phosphate (mg/L as PO_4^{3-})	<0.25	*SM 4500-PD+ Stannous Chloride	0.25
2	Total Phosphorus (mg/L as P)	<0.15	*SM 4500-PB+E Persulfate+Ascorbic	0.15

*Based on Standard Methods for the Examination of Water and Wastewater (SM), APHA,AWWA, WEF
**JIS Handbook

Analyzed by: Su Wai Aung
Laboratory Technician
Goshu-A1 Laboratory

Approved by:
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Goshu-A1 Eco Business Company Limited
Plot No.19, 2nd Street, Yangon Industrial Zone, Mingalardon Township, Yangon,
Ph: +959-253685274

Water Analysis Report

Customer name: Myanmar Koei International Ltd.
Project: Yangon
Sample Name: TT-P-2
Receiving Date: 13/07/2022
Reporting Date: 22/07/2022

Sample No: 071310
Sampling Date: 13/07/2022
Analytical Date: 13-22/07/2022
Report No: ARWT 220705-03
Job No: MMA 220713

No.	Item	Result	Method	Detection Limit
1	Ortho Phosphate (mg/L as PO_4^{3-})	<0.25	*SM 4500-PD+ Stannous Chloride	0.25
2	Total Phosphorus (mg/L as P)	<0.15	*SM 4500-PB+E Persulfate+Ascorbic	0.15

*Based on Standard Methods for the Examination of Water and Wastewater (SM), APHA,AWWA, WEF
**JIS Handbook

Analyzed by: Su Wai Aung
Laboratory Technician
Goshu-A1 Laboratory

Approved by:
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PRO LAB
ANALYTICAL LABORATORY

Myanmar Innovation Group of Co., Ltd
Address : No. (9), Sabae Housing, Pyi Htaung Su Road, (26) Ward, South Dagon Tsp, Yangon, Myanmar.
Tel : 09-893 767 424
E-mail : info@prolabmyanmar.com

LABORATORY ANALYSIS REPORT

1 Client Name : Myanmar Koei International Ltd
2 Location : No.36(A), Grand Pho Sein Condo, 3rd Floor, Phosein Road, Tamwe Township
3 Type of Sample : TT - P1
4 Sample No. : 00547/2022
5 Contact Person : Ma Sandar Maw
6 Phone No. : 09-974887018
7 Date Received : 13.07.2022
8 Date of Test Performed : 15.07.2022
9 Date of Issued : 22.07.2022
10 Result :

No.	Parameter	Result	Unit	WHO STD 2018	Method
1	Ammonia	< 0.02	mg/L	NA	SpectroDirect Methods
2	Nitrate	< 0.1	mg/L	50 mg/L	Hach DR 3900 Spectrophotometer, Cadmium Reduction Method
3	Total Nitrogen	< 2	mg/L	NA	Hach DR 3900 Spectrophotometer, Persulfate Digestion Method
4	Total Suspended Solid	130	mg/L	NA	[a] 2540D Total Suspended Solids Dried at 103-105°C

Remark:
This certificate is issued only for the receipt of the test sample.
[a] American Public Health Association, Standard Methods for the Examination of Water and Wastewater.

Tested By
Name : HTET HTET KYAW
Position : Laboratory Technician
Signature :

Approved By
Name : KYAWT KYAWT YIN
Position : Technical Consultant Manager
Signature :

LAB-FO-024-00

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Tel : 09-893 767 424
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LABORATORY ANALYSIS REPORT

1 Client Name : Myanmar Koei International Ltd
2 Location : No.36(A), Grand Pho Sein Condo, 3rd Floor, Phosein Road, Tamwe Township
3 Type of Sample : TT - A1
4 Sample No. : 00548/2022
5 Contact Person : Ma Sandar Maw
6 Phone No. : 09-974887018
7 Date Received : 13.07.2022
8 Date of Test Performed : 15.07.2022
9 Date of Issued : 22.07.2022
10 Result :

No.	Parameter	Result	Unit	WHO STD 2018	Method
1	Ammonia	0.16	mg/L	NA	SpectroDirect Methods
2	Nitrate	0.4	mg/L	50 mg/L	Hach DR 3900 Spectrophotometer, Cadmium Reduction Method
3	Total Nitrogen	< 2	mg/L	NA	Hach DR 3900 Spectrophotometer, Persulfate Digestion Method
4	Total Suspended Solid	50	mg/L	NA	[a] 2540D Total Suspended Solids Dried at 103-105°C

Remark:
This certificate is issued only for the receipt of the test sample.
[a] American Public Health Association, Standard Methods for the Examination of Water and Wastewater.

Tested By
Name : HTET HTET KYAW
Position : Laboratory Technician
Signature :

Approved By
Name : KYAWT KYAWT YIN
Position : Technical Consultant Manager
Signature :

LAB-FO-024-00

PRO LAB
ANALYTICAL LABORATORY

Myanmar Innovation Group of Co., Ltd
Address : No. (9), Sabae Housing, Pyi Htaung Su Road, (26) Ward, South Dagon Tsp, Yangon, Myanmar.
Tel : 09-893 767 424
E-mail : info@prolabmyanmar.com

LABORATORY ANALYSIS REPORT

1 Client Name : Myanmar Koei International Ltd
2 Location : No.36(A), Grand Pho Sein Condo, 3rd Floor, Phosein Road, Tamwe Township
3 Type of Sample : TT - P2
4 Sample No. : 00549/2022
5 Contact Person : Ma Sandar Maw
6 Phone No. : 09-974887018
7 Date Received : 13.07.2022
8 Date of Test Performed : 15.07.2022
9 Date of Issued : 22.07.2022
10 Result :

No.	Parameter	Result	Unit	WHO STD 2018	Method
1	Ammonia	< 0.02	mg/L	NA	SpectroDirect Methods
2	Nitrate	1.6	mg/L	50 mg/L	Hach DR 3900 Spectrophotometer, Cadmium Reduction Method
3	Total Nitrogen	< 2	mg/L	NA	Hach DR 3900 Spectrophotometer, Persulfate Digestion Method
4	Total Suspended Solid	80	mg/L	NA	[a] 2540D Total Suspended Solids Dried at 103-105°C

Remark:
This certificate is issued only for the receipt of the test sample.
[a] American Public Health Association, Standard Methods for the Examination of Water and Wastewater.

Tested By
Name : HTET HTET KYAW
Position : Laboratory Technician
Signature :

Approved By
Name : KYAWT KYAWT YIN
Position : Technical Consultant Manager
Signature :

LAB-FO-024-00

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Tel : 09-893 767 424
E-mail : info@prolabmyanmar.com

LABORATORY ANALYSIS REPORT

1 Client Name : Myanmar Koei International Ltd
2 Location : No.36(A), Grand Pho Sein Condo, 3rd Floor, Phosein Road, Tamwe Township
3 Type of Sample : TT - A2
4 Sample No. : 00550/2022
5 Contact Person : Ma Sandar Maw
6 Phone No. : 09-974887018
7 Date Received : 13.07.2022
8 Date of Test Performed : 15.07.2022
9 Date of Issued : 22.07.2022
10 Result :

No.	Parameter	Result	Unit	WHO STD 2018	Method
1	Ammonia	< 0.02	mg/L	NA	SpectroDirect Methods
2	Nitrate	3.5	mg/L	50 mg/L	Hach DR 3900 Spectrophotometer, Cadmium Reduction Method
3	Total Nitrogen	< 2	mg/L	NA	Hach DR 3900 Spectrophotometer, Persulfate Digestion Method
4	Total Suspended Solid	40	mg/L	NA	[a] 2540D Total Suspended Solids Dried at 103-105°C

Remark:
This certificate is issued only for the receipt of the test sample.
[a] American Public Health Association, Standard Methods for the Examination of Water and Wastewater.

Tested By
Name : HTET HTET KYAW
Position : Laboratory Technician
Signature :

Approved By
Name : KYAWT KYAWT YIN
Position : Technical Consultant Manager
Signature :

LAB-FO-024-00

Table2: Lab results of water quality of fish ponds surveyed in Maubin Township

Goshu-A1 Eco Business Company Limited
Plot No.19, 2nd Street, Yangon Industrial Zone, Mingalardon Township, Yangon,
Ph: +959-253685274

Water Analysis Report

Customer name: Myanmar Koei International Ltd.
Project: Yangon
Sample Name: MB-A-1
Receiving Date: 15/07/2022
Reporting Date: 26/07/2022

Sample No: 071415
Sampling Date: 15/07/2022
Analytical Date: 15-26/07/2022
Report No: ARWT 220707-10
Job No: MMA 220716

No.	Item	Result	Method	Detection Limit
1	Ortho Phosphate (mg/L as PO_4^{3-})	<0.25	*SM 4500-PD+ Stannous Chloride	0.25
2	Total Phosphorus (mg/L as P)	<0.15	*SM 4500-PB+E Persulfate+Ascorbic	0.15

*Based on Standard Methods for the Examination of Water and Wastewater (SM), APHA,AWWA, WEF
**JIS Handbook

Analyzed by:
Su Wai Aung
Laboratory Technician
Goshu-A1 Laboratory

Approved by:
KOJI NAKAHASHI
MANAGING DIRECTOR
GOSHU-A1 ECO BUSINESS CO.,LTD.

REPORT RESULT IS ONLY OF THE SAMPLE SUBMITTED FOR ANALYSIS.
THIS ANALYSIS REPORT SHALL NOT BE REPRODUCED EXCEPT IN FULL, WITHOUT WRITTEN APPROVAL OF THE LABORATORY OF GOSHU-A1 ECO BUSINESS CO. LTD.

Goshu-A1 Eco Business Company Limited
Plot No.19, 2nd Street, Yangon Industrial Zone, Mingalardon Township, Yangon,
Ph: +959-253685274

Water Analysis Report

Customer name: Myanmar Koei International Ltd.
Project: Yangon
Sample Name: MB-A-2
Receiving Date: 15/07/2022
Reporting Date: 26/07/2022

Sample No: 071417
Sampling Date: 15/07/2022
Analytical Date: 15-26/07/2022
Report No: ARWT 220707-12
Job No: MMA 220716

No.	Item	Result	Method	Detection Limit
1	Ortho Phosphate (mg/L as PO_4^{3-})	<0.25	*SM 4500-PD+ Stannous Chloride	0.25
2	Total Phosphorus (mg/L as P)	<0.15	*SM 4500-PB+E Persulfate+Ascorbic	0.15

*Based on Standard Methods for the Examination of Water and Wastewater (SM), APHA,AWWA, WEF
**JIS Handbook

Analyzed by:
Su Wai Aung
Laboratory Technician
Goshu-A1 Laboratory

Approved by:
KOJI NAKAHASHI
MANAGING DIRECTOR
GOSHU-A1 ECO BUSINESS CO.,LTD.

REPORT RESULT IS ONLY OF THE SAMPLE SUBMITTED FOR ANALYSIS.
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Goshu-A1 Eco Business Company Limited
Plot No.19, 2nd Street, Yangon Industrial Zone, Mingalardon Township, Yangon,
Ph: +959-253685274

Water Analysis Report

Customer name: Myanmar Koei International Ltd.
Project: Yangon
Sample Name: MB-P-1
Receiving Date: 15/07/2022
Reporting Date: 26/07/2022

Sample No: 071414
Sampling Date: 15/07/2022
Analytical Date: 15-26/07/2022
Report No: ARWT 220707-09
Job No: MMA 220716

No.	Item	Result	Method	Detection Limit
1	Ortho Phosphate (mg/L as PO_4^{3-})	<0.25	*SM 4500-PD+ Stannous Chloride	0.25
2	Total Phosphorus (mg/L as P)	<0.15	*SM 4500-PB+E Persulfate+Ascorbic	0.15

*Based on Standard Methods for the Examination of Water and Wastewater (SM), APHA,AWWA, WEF
**JIS Handbook

Analyzed by:
Su Wai Aung
Laboratory Technician
Goshu-A1 Laboratory

Approved by:
KOJI NAKAHASHI
MANAGING DIRECTOR
GOSHU-A1 ECO BUSINESS CO.,LTD.

REPORT RESULT IS ONLY OF THE SAMPLE SUBMITTED FOR ANALYSIS.
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Goshu-A1 Eco Business Company Limited
Plot No.19, 2nd Street, Yangon Industrial Zone, Mingalardon Township, Yangon,
Ph: +959-253685274

Water Analysis Report

Customer name: Myanmar Koei International Ltd.
Project: Yangon
Sample Name: MB-P-2
Receiving Date: 15/07/2022
Reporting Date: 26/07/2022

Sample No: 071416
Sampling Date: 15/07/2022
Analytical Date: 15-26/07/2022
Report No: ARWT 220707-11
Job No: MMA 220716

No.	Item	Result	Method	Detection Limit
1	Ortho Phosphate (mg/L as PO_4^{3-})	<0.25	*SM 4500-PD+ Stannous Chloride	0.25
2	Total Phosphorus (mg/L as P)	<0.15	*SM 4500-PB+E Persulfate+Ascorbic	0.15

*Based on Standard Methods for the Examination of Water and Wastewater (SM), APHA,AWWA, WEF
**JIS Handbook

Analyzed by:
Su Wai Aung
Laboratory Technician
Goshu-A1 Laboratory

Approved by:
KOJI NAKAHASHI
MANAGING DIRECTOR
GOSHU-A1 ECO BUSINESS CO.,LTD.

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PRO LAB
ANALYTICAL LABORATORY

Myanmar Innovation Group of Co., Ltd
Address : No. (9), Sabae Housing, Pyi Htaung Su Road, (26) Ward, South Dagon Tsp, Yangon, Myanmar.
Tel : 09-893 767 424
E-mail : info@prolabmyanmar.com

LABORATORY ANALYSIS REPORT

1 Client Name : Myanmar Koei International Ltd
2 Location : No.36(A), Grand Pho Sein Condo, 3rd Floor, Phosein Road, Tamwe Township
3 Type of Sample : MB - A1
4 Sample No. : 00576/2022
5 Contact Person : Ma Sandar Maw
6 Phone No. : 09-974887018
7 Date Received : 15.07.2022
8 Date of Test Performed : 16.07.2022
9 Date of Issued : 26.07.2022
10 Result :

No.	Parameter	Result	Unit	WHO STD 2018	Method
1	Ammonia	0.14	mg/L	NA	SpectroDirect Methods
2	Nitrate	1.6	mg/L	50 mg/L	Hach DR 3900 Spectrophotometer, Cadmium Reduction Method
3	Total Nitrogen	5	mg/L	NA	Hach DR 3900 Spectrophotometer, Persulfate Digestion Method
4	Total Suspended Solid	33.33	mg/L	NA	[a] 2540D Total Suspended Solids Dried at 103-105°C

Remark:
This certificate is issued only for the receipt of the test sample.
[a] American Public Health Association, Standard Methods for the Examination of Water and Wastewater.

Tested By
Name : HTET HTET KYAW
Position : Laboratory Technician
Signature :

Approved By
Name : KYAWT KYAWT YIN
Position : Technical Consultant Manager
Signature :

PRO LAB
ANALYTICAL LABORATORY

Myanmar Innovation Group of Co., Ltd
Address : No. (9), Sabae Housing, Pyi Htaung Su Road, (26) Ward, South Dagon Tsp, Yangon, Myanmar.
Tel : 09-893 767 424
E-mail : info@prolabmyanmar.com

LABORATORY ANALYSIS REPORT

1 Client Name : Myanmar Koei International Ltd
2 Location : No.36(A), Grand Pho Sein Condo, 3rd Floor, Phosein Road, Tamwe Township
3 Type of Sample : MB - A2
4 Sample No. : 00578/2022
5 Contact Person : Ma Sandar Maw
6 Phone No. : 09-974887018
7 Date Received : 15.07.2022
8 Date of Test Performed : 16.07.2022
9 Date of Issued : 26.07.2022
10 Result :

No.	Parameter	Result	Unit	WHO STD 2018	Method
1	Ammonia	< 0.02	mg/L	NA	SpectroDirect Methods
2	Nitrate	< 0.1	mg/L	50 mg/L	Hach DR 3900 Spectrophotometer, Cadmium Reduction Method
3	Total Nitrogen	4	mg/L	NA	Hach DR 3900 Spectrophotometer, Persulfate Digestion Method
4	Total Suspended Solid	80	mg/L	NA	[a] 2540D Total Suspended Solids Dried at 103-105°C

Remark:
This certificate is issued only for the receipt of the test sample.
[a] American Public Health Association, Standard Methods for the Examination of Water and Wastewater.

Tested By
Name : HTET HTET KYAW
Position : Laboratory Technician
Signature :

Approved By
Name : KYAWT KYAWT YIN
Position : Technical Consultant Manager
Signature :

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Tel : 09-893 767 424
E-mail : info@prolabmyanmar.com

LABORATORY ANALYSIS REPORT

1 Client Name : Myanmar Koei International Ltd
2 Location : No.36(A), Grand Pho Sein Condo, 3rd Floor, Phosein Road, Tamwe Township
3 Type of Sample : MB - P1
4 Sample No. : 00575/2022
5 Contact Person : Ma Sandar Maw
6 Phone No. : 09-974887018
7 Date Received : 15.07.2022
8 Date of Test Performed : 16.07.2022
9 Date of Issued : 26.07.2022
10 Result :

No.	Parameter	Result	Unit	WHO STD 2018	Method
1	Ammonia	< 0.02	mg/L	NA	SpectroDirect Methods
2	Nitrate	< 0.1	mg/L	50 mg/L	Hach DR 3900 Spectrophotometer, Cadmium Reduction Method
3	Total Nitrogen	6	mg/L	NA	Hach DR 3900 Spectrophotometer, Persulfate Digestion Method
4	Total Suspended Solid	100	mg/L	NA	[a] 2540D Total Suspended Solids Dried at 103-105°C

Remark:
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[a] American Public Health Association, Standard Methods for the Examination of Water and Wastewater.

Tested By
Name : HTET HTET KYAW
Position : Laboratory Technician
Signature :

Approved By
Name : KYAWT KYAWT YIN
Position : Technical Consultant Manager
Signature :

PRO LAB
ANALYTICAL LABORATORY

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Tel : 09-893 767 424
E-mail : info@prolabmyanmar.com

LABORATORY ANALYSIS REPORT

1 Client Name : Myanmar Koei International Ltd
2 Location : No.36(A), Grand Pho Sein Condo, 3rd Floor, Phosein Road, Tamwe Township
3 Type of Sample : MB - P2
4 Sample No. : 00577/2022
5 Contact Person : Ma Sandar Maw
6 Phone No. : 09-974887018
7 Date Received : 15.07.2022
8 Date of Test Performed : 16.07.2022
9 Date of Issued : 26.07.2022
10 Result :

No.	Parameter	Result	Unit	WHO STD 2018	Method
1	Ammonia	< 0.02	mg/L	NA	SpectroDirect Methods
2	Nitrate	< 0.1	mg/L	50 mg/L	Hach DR 3900 Spectrophotometer, Cadmium Reduction Method
3	Total Nitrogen	< 2	mg/L	NA	Hach DR 3900 Spectrophotometer, Persulfate Digestion Method
4	Total Suspended Solid	80	mg/L	NA	[a] 2540D Total Suspended Solids Dried at 103-105°C

Remark:
This certificate is issued only for the receipt of the test sample.
[a] American Public Health Association, Standard Methods for the Examination of Water and Wastewater.

Tested By
Name : HTET HTET KYAW
Position : Laboratory Technician
Signature :

Approved By
Name : KYAWT KYAWT YIN
Position : Technical Consultant Manager
Signature :

Table 3: Lab results of water quality of fish ponds surveyed in Pantanaw Township

Goshu-A1 Eco Business Company Limited
Plot No.19, 2nd Street, Yangon Industrial Zone, Mingalardon Township, Yangon, Ph: +959-253685274

Water Analysis Report

Customer name: Myanmar Koei International Ltd.
Project: Yangon
Sample Name: PN-A-1
Receiving Date: 15/07/2022
Reporting Date: 26/07/2022

Sample No: 071411
Sampling Date: 14/07/2022
Analytical Date: 15-26/07/2022
Report No: ARWT 220707-06
Job No: MMA 220716

No.	Item	Result	Method	Detection Limit
1	Ortho Phosphate (mg/L as PO_4^{3-})	<0.25	*SM 4500-PD+ Stannous Chloride	0.25
2	Total Phosphorus (mg/L as P)	0.78	*SM 4500-PB+E Persulfate+Ascorbic	0.15

*Based on Standard Methods for the Examination of Water and Wastewater (SM), APHA,AWWA, WEF
**JIS Handbook

Analyzed by:
Su Wai Aung
Laboratory Technician
Goshu-A1 Laboratory

Approved by:
KOJI NAKAHASHI
MANAGING DIRECTOR
GOSHU-A1 ECO BUSINESS CO.,LTD.

REPORT RESULT IS ONLY OF THE SAMPLE SUBMITTED FOR ANALYSIS.
THIS ANALYSIS REPORT SHALL NOT BE REPRODUCED EXCEPT IN FULL, WITHOUT WRITTEN APPROVAL OF THE LABORATORY OF GOSHU-A1 ECO BUSINESS CO. LTD.

Goshu-A1 Eco Business Company Limited
Plot No.19, 2nd Street, Yangon Industrial Zone, Mingalardon Township, Yangon, Ph: +959-253685274

Water Analysis Report

Customer name: Myanmar Koei International Ltd.
Project: Yangon
Sample Name: PN-A-2
Receiving Date: 15/07/2022
Reporting Date: 26/07/2022

Sample No: 071413
Sampling Date: 14/07/2022
Analytical Date: 15-26/07/2022
Report No: ARWT 220707-08
Job No: MMA 220716

No.	Item	Result	Method	Detection Limit
1	Ortho Phosphate (mg/L as PO_4^{3-})	<0.25	*SM 4500-PD+ Stannous Chloride	0.25
2	Total Phosphorus (mg/L as P)	<0.15	*SM 4500-PB+E Persulfate+Ascorbic	0.15

*Based on Standard Methods for the Examination of Water and Wastewater (SM), APHA,AWWA, WEF
**JIS Handbook

Analyzed by:
Su Wai Aung
Laboratory Technician
Goshu-A1 Laboratory

Approved by:
KOJI NAKAHASHI
MANAGING DIRECTOR
GOSHU-A1 ECO BUSINESS CO.,LTD.

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Goshu-A1 Eco Business Company Limited
Plot No.19, 2nd Street, Yangon Industrial Zone, Mingalardon Township, Yangon, Ph: +959-253685274

Water Analysis Report

Customer name: Myanmar Koei International Ltd.
Project: Yangon
Sample Name: PN-P-1
Receiving Date: 15/07/2022
Reporting Date: 26/07/2022

Sample No: 071410
Sampling Date: 14/07/2022
Analytical Date: 15-26/07/2022
Report No: ARWT 220707-05
Job No: MMA 220716

No.	Item	Result	Method	Detection Limit
1	Ortho Phosphate (mg/L as PO_4^{3-})	<0.25	*SM 4500-PD+ Stannous Chloride	0.25
2	Total Phosphorus (mg/L as P)	<0.15	*SM 4500-PB+E Persulfate+Ascorbic	0.15

*Based on Standard Methods for the Examination of Water and Wastewater (SM), APHA,AWWA, WEF
**JIS Handbook

Analyzed by:
Su Wai Aung
Laboratory Technician
Goshu-A1 Laboratory

Approved by:
KOJI NAKAHASHI
MANAGING DIRECTOR
GOSHU-A1 ECO BUSINESS CO.,LTD.

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Goshu-A1 Eco Business Company Limited
Plot No.19, 2nd Street, Yangon Industrial Zone, Mingalardon Township, Yangon, Ph: +959-253685274

Water Analysis Report

Customer name: Myanmar Koei International Ltd.
Project: Yangon
Sample Name: PN-P-2
Receiving Date: 15/07/2022
Reporting Date: 26/07/2022

Sample No: 071412
Sampling Date: 14/07/2022
Analytical Date: 15-26/07/2022
Report No: ARWT 220707-07
Job No: MMA 220716

No.	Item	Result	Method	Detection Limit
1	Ortho Phosphate (mg/L as PO_4^{3-})	<0.25	*SM 4500-PD+ Stannous Chloride	0.25
2	Total Phosphorus (mg/L as P)	<0.15	*SM 4500-PB+E Persulfate+Ascorbic	0.15

*Based on Standard Methods for the Examination of Water and Wastewater (SM), APHA,AWWA, WEF
**JIS Handbook

Analyzed by:
Su Wai Aung
Laboratory Technician
Goshu-A1 Laboratory

Approved by:
KOJI NAKAHASHI
MANAGING DIRECTOR
GOSHU-A1 ECO BUSINESS CO.,LTD.

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PRO LAB
ANALYTICAL LABORATORY

Myanmar Innovation Group of Co., Ltd
Address : No. (9), Sabae Housing, Pyi Htaung Su Road, (26) Ward, South Dagon Tsp, Yangon, Myanmar.
Tel : 09-893 767 424
E-mail : info@prolabmyanmar.com

LABORATORY ANALYSIS REPORT

1 Client Name : Myanmar Koei International Ltd
2 Location : No.36(A), Grand Pho Sein Condo, 3rd Floor, Phoscin Road, Tamwe Township
3 Type of Sample : PN - A1
4 Sample No. : 00572/2022
5 Contact Person : Ma Sandar Maw
6 Phone No. : 09-974887018
7 Date Received : 15.07.2022
8 Date of Test Performed : 16.07.2022
9 Date of Issued : 26.07.2022
10 Result :

No.	Parameter	Result	Unit	WHO STD 2018	Method
1	Ammonia	0.26	mg/L	NA	SpectroDirect Methods
2	Nitrate	2.3	mg/L	50 mg/L	Hach DR 3900 Spectrophotometer, Cadmium Reduction Method
3	Total Nitrogen	3	mg/L	NA	Hach DR 3900 Spectrophotometer, Persulfate Digestion Method
4	Total Suspended Solid	10	mg/L	NA	[a] 2540D Total Suspended Solids Dried at 103-105°C

Remark:
This certificate is issued only for the receipt of the test sample.
[a] American Public Health Association, Standard Methods for the Examination of Water and Wastewater.

Tested By
Name : HTET HTET KYAW
Position : Laboratory Technician
Signature :

Approved By
Name : KYAWT KYAWT YIN
Position : Technical Consultant Manager
Signature :

PRO LAB
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Tel : 09-893 767 424
E-mail : info@prolabmyanmar.com

LABORATORY ANALYSIS REPORT

1 Client Name : Myanmar Koei International Ltd
2 Location : No.36(A), Grand Pho Sein Condo, 3rd Floor, Phoscin Road, Tamwe Township
3 Type of Sample : PN - A2
4 Sample No. : 00574/2022
5 Contact Person : Ma Sandar Maw
6 Phone No. : 09-974887018
7 Date Received : 15.07.2022
8 Date of Test Performed : 16.07.2022
9 Date of Issued : 26.07.2022
10 Result :

No.	Parameter	Result	Unit	WHO STD 2018	Method
1	Ammonia	0.1	mg/L	NA	SpectroDirect Methods
2	Nitrate	1.2	mg/L	50 mg/L	Hach DR 3900 Spectrophotometer, Cadmium Reduction Method
3	Total Nitrogen	<2	mg/L	NA	Hach DR 3900 Spectrophotometer, Persulfate Digestion Method
4	Total Suspended Solid	15	mg/L	NA	[a] 2540D Total Suspended Solids Dried at 103-105°C

Remark:
This certificate is issued only for the receipt of the test sample.
[a] American Public Health Association, Standard Methods for the Examination of Water and Wastewater.

Tested By
Name : HTET HTET KYAW
Position : Laboratory Technician
Signature :

Approved By
Name : KYAWT KYAWT YIN
Position : Technical Consultant Manager
Signature :

LAB-FO-024-00

PRO LAB
ANALYTICAL LABORATORY

Myanmar Innovation Group of Co., Ltd
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Tel : 09-893 767 424
E-mail : info@prolabmyanmar.com

LABORATORY ANALYSIS REPORT

1 Client Name : Myanmar Koei International Ltd
2 Location : No.36(A), Grand Pho Sein Condo, 3rd Floor, Phosein Road, Tamwe Township
3 Type of Sample : PN - P1
4 Sample No. : 00571/2022
5 Contact Person : Ma Sandar Maw
6 Phone No. : 09-974887018
7 Date Received : 15.07.2022
8 Date of Test Performed : 16.07.2022
9 Date of Issued : 26.07.2022
10 Result :

No.	Parameter	Result	Unit	WHO STD 2018	Method
1	Ammonia	0.22	mg/L	NA	SpectroDirect Methods
2	Nitrate	< 0.1	mg/L	50 mg/L	Hach DR 3900 Spectrophotometer, Cadmium Reduction Method
3	Total Nitrogen	5	mg/L	NA	Hach DR 3900 Spectrophotometer, Persulfate Digestion Method
4	Total Suspended Solid	540	mg/L	NA	[a] 2540D Total Suspended Solids Dried at 103-105°C

Remark:
This certificate is issued only for the receipt of the test sample.
[a] American Public Health Association, Standard Methods for the Examination of Water and Wastewater.

Tested By
Name : HTET HTET KYAW
Position : Laboratory Technician
Signature :

Approved By
Name : KYAWT KYAWT YIN
Position : Technical Consultant Manager
Signature :

LAB-FO-024-00

PRO LAB
ANALYTICAL LABORATORY

Myanmar Innovation Group of Co., Ltd
Address : No. (9), Sabae Housing, Pyi Htaung Su Road, (26) Ward, South Dagon Tsp, Yangon, Myanmar.
Tel : 09-893 767 424
E-mail : info@prolabmyanmar.com

LABORATORY ANALYSIS REPORT

1 Client Name : Myanmar Koei International Ltd
2 Location : No.36(A), Grand Pho Sein Condo, 3rd Floor, Phosein Road, Tamwe Township
3 Type of Sample : PN - P2
4 Sample No. : 00573/2022
5 Contact Person : Ma Sandar Maw
6 Phone No. : 09-974887018
7 Date Received : 15.07.2022
8 Date of Test Performed : 16.07.2022
9 Date of Issued : 26.07.2022
10 Result :

No.	Parameter	Result	Unit	WHO STD 2018	Method
1	Ammonia	0.39	mg/L	NA	SpectroDirect Methods
2	Nitrate	8.1	mg/L	50 mg/L	Hach DR 3900 Spectrophotometer, Cadmium Reduction Method
3	Total Nitrogen	<2	mg/L	NA	Hach DR 3900 Spectrophotometer, Persulfate Digestion Method
4	Total Suspended Solid	100	mg/L	NA	[a] 2540D Total Suspended Solids Dried at 103-105°C

Remark:
This certificate is issued only for the receipt of the test sample.
[a] American Public Health Association, Standard Methods for the Examination of Water and Wastewater.

Tested By
Name : HTET HTET KYAW
Position : Laboratory Technician
Signature :

Approved By
Name : KYAWT KYAWT YIN
Position : Technical Consultant Manager
Signature :

LAB-FO-024-00

Table 4: Lab results of water quality of fish ponds surveyed in Nyaungdone Township

Goshu-A1 Eco Business Company Limited
Plot No.19, 2nd Street, Yangon Industrial Zone, Mingalardon Township, Yangon,
Ph: +959-253685274

Water Analysis Report

Customer name: Myanmar Koei International Ltd.
Project: Yangon
Sample Name: ND-A-1
Receiving Date: 15/07/2022
Reporting Date: 26/07/2022

Sample No: 071407
Sampling Date: 14/07/2022
Analytical Date: 15-26/07/2022
Report No: ARWT 220707-02
Job No: MMA 220716

No.	Item	Result	Method	Detection Limit
1	Ortho Phosphate (mg/L as PO_4^{3-})	<0.25	*SM 4500-PD+ Stannous Chloride	0.25
2	Total Phosphorus (mg/L as P)	<0.15	*SM 4500-PB+E Persulfate+Ascorbic	0.15

*Based on Standard Methods for the Examination of Water and Wastewater (SM), APHA,AWWA, WEF
**JIS Handbook

Analyzed by:
Su Wai Aung
Laboratory Technician
Goshu-A1 Laboratory

Approved by:
KOJI NAKAHASHI
MANAGING DIRECTOR
GOSHU-A1 ECO BUSINESS CO.,LTD.

REPORT RESULT IS ONLY OF THE SAMPLE SUBMITTED FOR ANALYSIS.
THIS ANALYSIS REPORT SHALL NOT BE REPRODUCED EXCEPT IN FULL, WITHOUT WRITTEN APPROVAL OF THE LABORATORY OF GOSHU-A1 ECO BUSINESS CO. LTD.

Goshu-A1 Eco Business Company Limited
Plot No.19, 2nd Street, Yangon Industrial Zone, Mingalardon Township, Yangon,
Ph: +959-253685274

Water Analysis Report

Customer name: Myanmar Koei International Ltd.
Project: Yangon
Sample Name: ND-A-2
Receiving Date: 15/07/2022
Reporting Date: 26/07/2022

Sample No: 071409
Sampling Date: 14/07/2022
Analytical Date: 15-26/07/2022
Report No: ARWT 220707-04
Job No: MMA 220716

No.	Item	Result	Method	Detection Limit
1	Ortho Phosphate (mg/L as PO_4^{3-})	<0.25	*SM 4500-PD+ Stannous Chloride	0.25
2	Total Phosphorus (mg/L as P)	<0.15	*SM 4500-PB+E Persulfate+Ascorbic	0.15

*Based on Standard Methods for the Examination of Water and Wastewater (SM), APHA,AWWA, WEF
**JIS Handbook

Analyzed by:
Su Wai Aung
Laboratory Technician
Goshu-A1 Laboratory

Approved by:
KOJI NAKAHASHI
MANAGING DIRECTOR
GOSHU-A1 ECO BUSINESS CO.,LTD.

REPORT RESULT IS ONLY OF THE SAMPLE SUBMITTED FOR ANALYSIS.
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Goshu-A1 Eco Business Company Limited
Plot No.19, 2nd Street, Yangon Industrial Zone, Mingalardon Township, Yangon,
Ph: +959-253685274

Water Analysis Report

Customer name: Myanmar Koei International Ltd.
Project: Yangon
Sample Name: ND-P-1
Receiving Date: 15/07/2022
Reporting Date: 26/07/2022

Sample No: 071406
Sampling Date: 14/07/2022
Analytical Date: 15-26/07/2022
Report No: ARWT 220707-01
Job No: MMA 220716

No.	Item	Result	Method	Detection Limit
1	Ortho Phosphate (mg/L as PO_4^{3-})	<0.25	*SM 4500-PD+ Stannous Chloride	0.25
2	Total Phosphorus (mg/L as P)	<0.15	*SM 4500-PB+E Persulfate+Ascorbic	0.15

*Based on Standard Methods for the Examination of Water and Wastewater (SM), APHA,AWWA, WEF
**JIS Handbook

Analyzed by:
Su Wai Aung
Laboratory Technician
Goshu-A1 Laboratory

Approved by:
KOJI NAKAHASHI
MANAGING DIRECTOR
GOSHU-A1 ECO BUSINESS CO.,LTD.

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Goshu-A1 Eco Business Company Limited
Plot No.19, 2nd Street, Yangon Industrial Zone, Mingalardon Township, Yangon,
Ph: +959-253685274

Water Analysis Report

Customer name: Myanmar Koei International Ltd.
Project: Yangon
Sample Name: ND-P-2
Receiving Date: 15/07/2022
Reporting Date: 26/07/2022

Sample No: 071408
Sampling Date: 14/07/2022
Analytical Date: 15-26/07/2022
Report No: ARWT 220707-03
Job No: MMA 220716

No.	Item	Result	Method	Detection Limit
1	Ortho Phosphate (mg/L as PO_4^{3-})	<0.25	*SM 4500-PD+ Stannous Chloride	0.25
2	Total Phosphorus (mg/L as P)	<0.15	*SM 4500-PB+E Persulfate+Ascorbic	0.15

*Based on Standard Methods for the Examination of Water and Wastewater (SM), APHA,AWWA, WEF
**JIS Handbook

Analyzed by:
Su Wai Aung
Laboratory Technician
Goshu-A1 Laboratory

Approved by:
KOJI NAKAHASHI
MANAGING DIRECTOR
GOSHU-A1 ECO BUSINESS CO.,LTD.

REPORT RESULT IS ONLY OF THE SAMPLE SUBMITTED FOR ANALYSIS.
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PRO LAB
ANALYTICAL LABORATORY

Myanmar Innovation Group of Co., Ltd
Address : No. (9), Sabae Housing, Pyi Htaung Su Road, (26) Ward, South Dagon Tsp, Yangon, Myanmar.
Tel : 09-893 767 424
E-mail : info@prolabmyanmar.com

LABORATORY ANALYSIS REPORT

1 Client Name : Myanmar Koei International Ltd
2 Location : No.36(A), Grand Pho Sein Condo, 3rd Floor, Phosein Road, Tamwe Township
3 Type of Sample : ND - A1
4 Sample No. : 00568/2022
5 Contact Person : Ma Sandar Maw
6 Phone No. : 09-974887018
7 Date Received : 15.07.2022
8 Date of Test Performed : 16.07.2022
9 Date of Issued : 26.07.2022
10 Result :

No.	Parameter	Result	Unit	WHO STD 2018	Method
1	Ammonia	< 0.02	mg/L	NA	SpectroDirect Methods
2	Nitrate	2.6	mg/L	50 mg/L	Hach DR 3900 Spectrophotometer, Cadmium Reduction Method
3	Total Nitrogen	2	mg/L	NA	Hach DR 3900 Spectrophotometer, Persulfate Digestion Method
4	Total Suspended Solid	20	mg/L	NA	[a] 2540D Total Suspended Solids Dried at 103-105°C

Remark:
This certificate is issued only for the receipt of the test sample.
[a] American Public Health Association, Standard Methods for the Examination of Water and Wastewater.

Tested By
Name : HTET HTET KYAW
Position : Laboratory Technician
Signature :

Approved By
Name : KYAWT KYAWT YIN
Position : Technical Consultant Manager
Signature :

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Tel : 09-893 767 424
E-mail : info@prolabmyanmar.com

LABORATORY ANALYSIS REPORT

1 Client Name : Myanmar Koei International Ltd
2 Location : No.36(A), Grand Pho Sein Condo, 3rd Floor, Phosein Road, Tamwe Township
3 Type of Sample : ND - A2
4 Sample No. : 00570/2022
5 Contact Person : Ma Sandar Maw
6 Phone No. : 09-974887018
7 Date Received : 15.07.2022
8 Date of Test Performed : 16.07.2022
9 Date of Issued : 26.07.2022
10 Result :

No.	Parameter	Result	Unit	WHO STD 2018	Method
1	Ammonia	0.16	mg/L	NA	SpectroDirect Methods
2	Nitrate	< 0.1	mg/L	50 mg/L	Hach DR 3900 Spectrophotometer, Cadmium Reduction Method
3	Total Nitrogen	3	mg/L	NA	Hach DR 3900 Spectrophotometer, Persulfate Digestion Method
4	Total Suspended Solid	100	mg/L	NA	[a] 2540D Total Suspended Solids Dried at 103-105°C

Remark:
This certificate is issued only for the receipt of the test sample.
[a] American Public Health Association, Standard Methods for the Examination of Water and Wastewater.

Tested By
Name : HTET HTET KYAW
Position : Laboratory Technician
Signature :

Approved By
Name : KYAWT KYAWT YIN
Position : Technical Consultant Manager
Signature :

LAB-FO-024-00

PRO LAB
ANALYTICAL LABORATORY

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Address : No. (9), Sabae Housing, Pyi Htaung Su Road, (26) Ward, South Dagon Tsp, Yangon, Myanmar.
Tel : 09-893 767 424
E-mail : info@prolabmyanmar.com

LABORATORY ANALYSIS REPORT

1 Client Name : Myanmar Koei International Ltd
2 Location : No.36(A), Grand Pho Sein Condo, 3rd Floor, Phosein Road, Tamwe Township
3 Type of Sample : ND - P1
4 Sample No. : 00567/2022
5 Contact Person : Ma Sandar Maw
6 Phone No. : 09-974887018
7 Date Received : 15.07.2022
8 Date of Test Performed : 16.07.2022
9 Date of Issued : 26.07.2022
10 Result :

No.	Parameter	Result	Unit	WHO STD 2018	Method
1	Ammonia	< 0.02	mg/L	NA	SpectroDirect Methods
2	Nitrate	< 0.1	mg/L	50 mg/L	Hach DR 3900 Spectrophotometer, Cadmium Reduction Method
3	Total Nitrogen	< 2	mg/L	NA	Hach DR 3900 Spectrophotometer, Persulfate Digestion Method
4	Total Suspended Solid	25	mg/L	NA	[a] 2540D Total Suspended Solids Dried at 103-105°C

Remark:
This certificate is issued only for the receipt of the test sample.
[a] American Public Health Association, Standard Methods for the Examination of Water and Wastewater.

Tested By
Name : HTET HTET KYAW
Position : Laboratory Technician
Signature :

Approved By
Name : KYAWT KYAWT YIN
Position : Technical Consultant Manager
Signature :

LAB-FO-024-00

PRO LAB
ANALYTICAL LABORATORY

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Address : No. (9), Sabae Housing, Pyi Htaung Su Road, (26) Ward, South Dagon Tsp, Yangon, Myanmar.
Tel : 09-893 767 424
E-mail : info@prolabmyanmar.com

LABORATORY ANALYSIS REPORT

1 Client Name : Myanmar Koei International Ltd
2 Location : No.36(A), Grand Pho Sein Condo, 3rd Floor, Phosein Road, Tamwe Township
3 Type of Sample : ND - P2
4 Sample No. : 00569/2022
5 Contact Person : Ma Sandar Maw
6 Phone No. : 09-974887018
7 Date Received : 15.07.2022
8 Date of Test Performed : 16.07.2022
9 Date of Issued : 26.07.2022
10 Result :

No.	Parameter	Result	Unit	WHO STD 2018	Method
1	Ammonia	< 0.02	mg/L	NA	SpectroDirect Methods
2	Nitrate	1.2	mg/L	50 mg/L	Hach DR 3900 Spectrophotometer, Cadmium Reduction Method
3	Total Nitrogen	9	mg/L	NA	Hach DR 3900 Spectrophotometer, Persulfate Digestion Method
4	Total Suspended Solid	170	mg/L	NA	[a] 2540D Total Suspended Solids Dried at 103-105°C

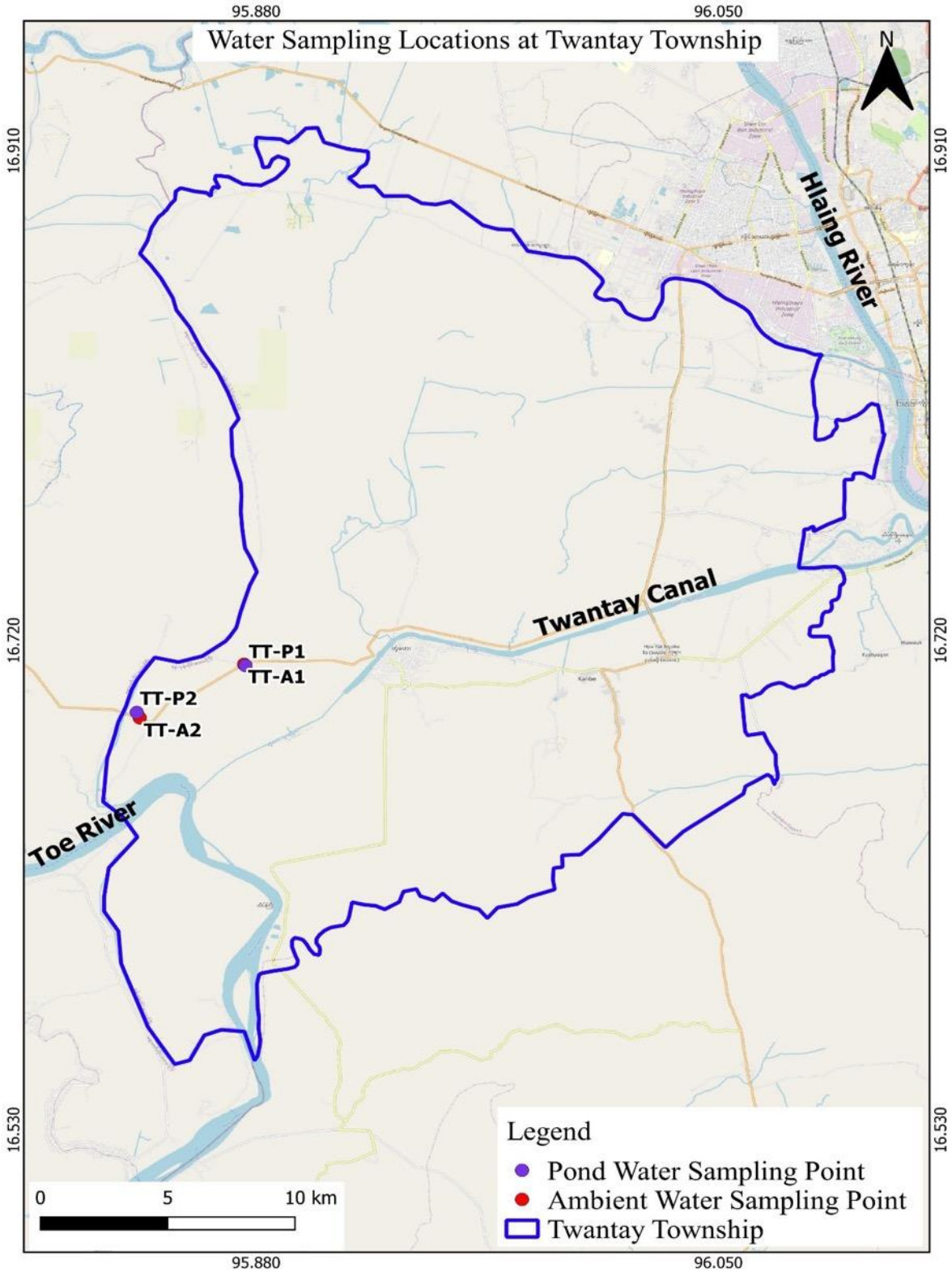
Remark:
This certificate is issued only for the receipt of the test sample.
[a] American Public Health Association, Standard Methods for the Examination of Water and Wastewater.

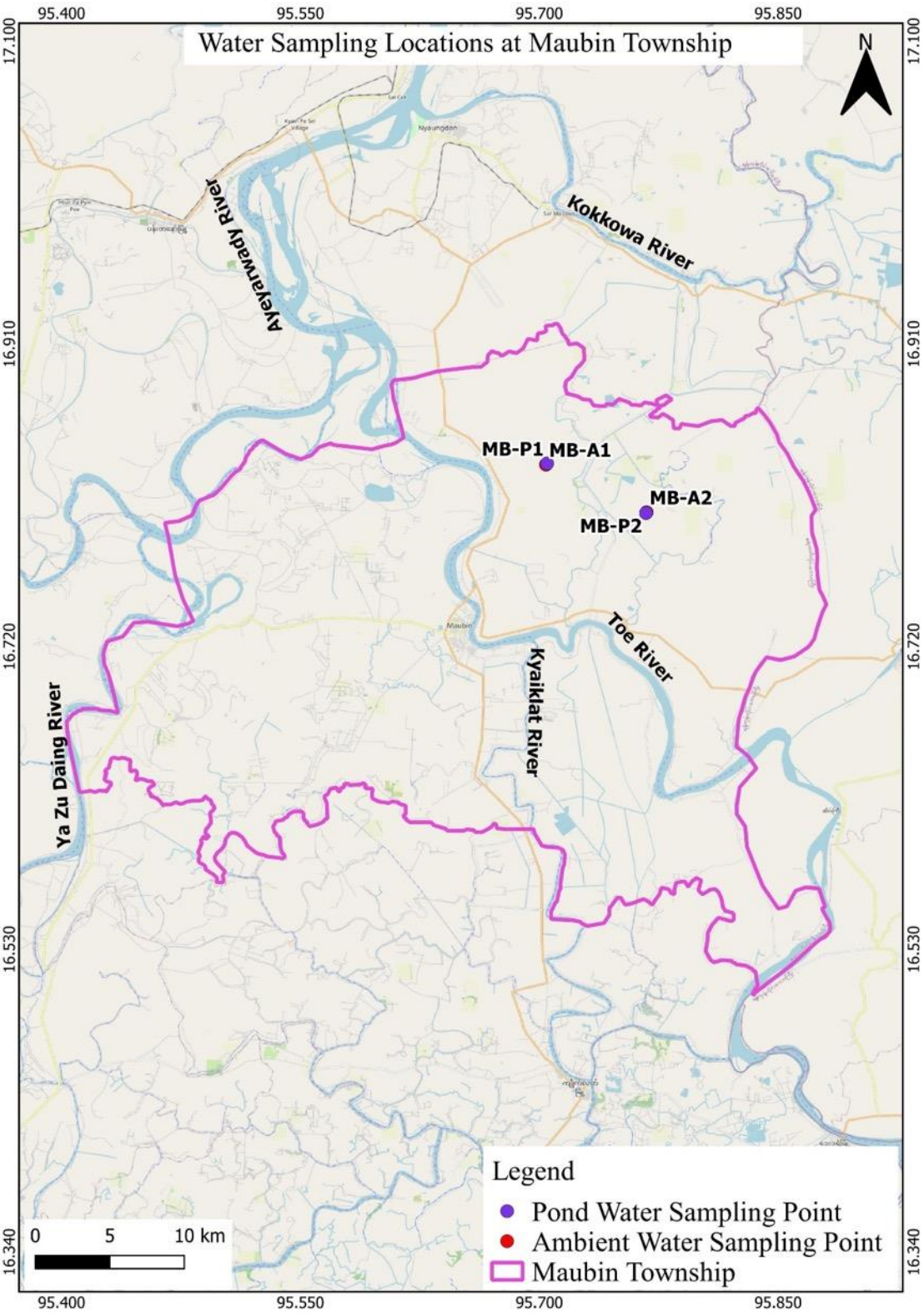
Tested By
Name : HTET HTET KYAW
Position : Laboratory Technician
Signature :

Approved By
Name : KYAWT KYAWT YIN
Position : Technical Consultant Manager
Signature :

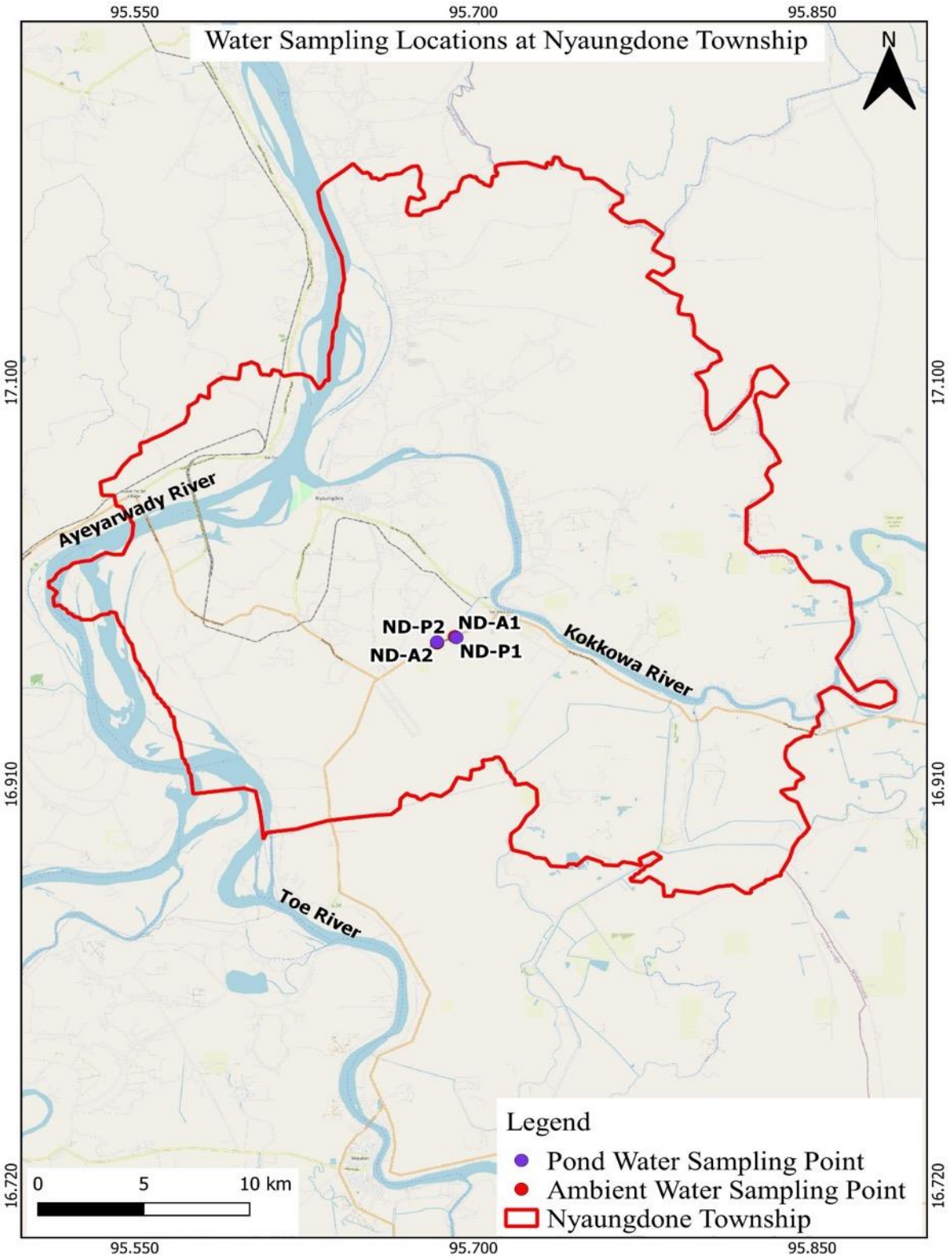
LAB-FO-024-00

Annex-4: NGA-Targeted Townships and Water Sampling Locations Maps




Water Sampling Locations at Maubin Township
N
95.400
95.550
95.700
95.850
17.100
16.910
16.720
16.530
16.340
Ayeyarwady River
Kokkowa River
MB-P1 MB-A1
MB-A2
MB-P2
Toe River
Kyaiklat River
Ya Zu Daing River
0
5
10 km
Legend
Pond Water Sampling Point
Ambient Water Sampling Point
Maubin Township


Water Sampling Locations at Pantanaw Township
N
95.250
95.400
95.550
17.100
16.910
16.720
PN-A1
PN-P1
PN-P2 PN-A2
Toe River
Ayeyarwady River
Ya Zu Daing River
Shwe Laung River
Legend
Pond Water Sampling Point
Ambient Water Sampling Point
Pantanaw Township
0
5
10 km


Water Sampling Locations at Nyaungdone Township
N
95.550
95.700
95.850
17.100
16.910
16.720
Ayeyarwady River
Kokkowa River
Toe River
ND-P2
ND-A1
ND-A2
ND-P1
0
5
10 km
Legend
Pond Water Sampling Point
Ambient Water Sampling Point
Nyaungdone Township

Annex 5: WQI Calculation Method

A general water quality index (WQI) is calculated by the following four steps:

- Selection the water quality parameters to be included.
- Transformation of the raw parameter data onto a common scale.[14]
- Decision on the relative weights to be allocated to the index components.
- Specification of the aggregation function, including, where possible, controlling for the sampling design of the water quality monitoring data.

Weighted Arithmetic Water Quality Index Method classifies the water quality according to the degree of purity by using the most commonly measured water quality variables. The calculation of WQI was made by the following equation:

$$\boldsymbol{WQI = \sum QiWi / \sum wi}$$

The quality of rating scale (Qi) for each parameter is calculated by using this expression:

$$Qi = 100\ [\ (Vi - Vo\ /Si - V0)]$$

Vi is estimated concentration of i^{th} parameter in the analyzed water
V0 is the ideal value of this parameter in pure water
V0=0 (except pH=7.0 and dissolved oxygen = 14.6 mg/L)
Si is recommended standard value of i^{th} parameter

The unit weight (Wi) for each water quality parameter is calculated by using the following formula.

$$Wi = K/Si$$

Where K= proportionality constant and can also be calculated by using the following equation:

$$K = 1/\sum(1/Si)$$

The scale rating of water quality according to Weight Arithmetic Water Quality Index (WAWQI) is given in the following Table.

Weight Arithmetic water Quality Index (WAWQI)	
WQI Value	Rating of Water Quality
0-25	Excellent water quality
26-50	Good water quality
51-75	Poor Water quality
76-100	Very poor water quality
Above 100	Unsuitable for drinking purpose

[14] Vietnam Surface Water Standard (Class II) is for domestic water supply purposes but must apply suitable treatment technology or use purposes such as Class B1 and B2. This standard is adopted as the local people in the study area may use that water for general purpose (e.g., bathing).

CONTACT

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About Mercy Corps

Mercy Corps is a leading global organization powered by the belief that a better world is possible. In disaster, in hardship, in more than 40 countries around the world, we partner to put bold solutions into action — helping people triumph over adversity and build stronger communities from within. Now, and for the future.

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