MYANMAR

AYEYARWADY ***DELTA***

Bio-Based value chain Analysis

For Sustainable Mangrove Restoration

Acknowledgment

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Acronyms & Abbreviations

BCR	Benefit to Cost Ratio
CCVFV	Central Committee for the Management of Vacant, Fallow and Virgin Lands
CF	Community Forest
CFEs	Community Forest Enterprises
CFI	Community Forestry Instructions
CFUG	Community Forest User Group
DPP	Discounted Payback Period
FABs	Farmland Administration Bodies
FAO	Food and Agriculture Organization
GAD	General Administration Departments
GIZ	La Deutsche Gesellschaft für Internationale Zusammenarbeit
ICF	Intensive Crab Fattening
ILO	International Labour Organization
INDCs	Intended Nationally Determined Contributions
ITC	International Trade Centre
LUC	Land Use Certificates
MMK	Myanmar Kyat
MoALI	Ministry of Agriculture, Livestock and Irrigation
MoNREC	Ministry of Natural Resources and Environmental Conservation
MSDP	Myanmar Sustainable Development Plan
MSMEs	Micro, Small, and Medium Enterprises
MYSAP	Myanmar Sustainable Aquaculture Program
NAPA	National Adaptation Programme of Action
NCF	Natural Crab Fattening
NDCs	Nationally Determined Contributions
NORAD	Norwegian Agency for Development Cooperation
NPV	Net Present Value
NRRP	National Reforestation and Forest Rehabilitation Program
NTFPs	Non-Timber Forest Products
SDD	Solar Dome Dryer
SLRD	Settlement and Land Records Department
SOBA	Ayeyarwady State of the Basin Assessment
SWOT	Strengths, Weaknesses, Opportunities and Threats
USD	United States Dollar
VFV	Vacant, Fallow, Virgin
WB	World Bank
WHH	Welhungerhilfe

Executive Summary

The mangrove forests of the Ayeyarwady Delta have sustained one of the highest deforestation rates in Myanmar. The cause of this loss has been primarily anthropogenic in nature, including agricultural land expansion and the harvesting of wood for fuel and construction purposes. The effects of deforestation have negatively affected the stock of natural resources in the Delta. They have also resulted in lowering the capacity of mangrove forests to effectively act as a buffer against waves and storms surges. For this, the Government of Myanmar has set the objective to increase the resilience of mangroves and coastal communities. Unfortunately, mangrove forest conservation efforts in Myanmar face barriers such as weak governance, lack of technical capacity, and lack of financial resources. It has been identified that mangrove restoration process requires a decrease in the level of disturbance from economic activities based on wood. This does not mean that efforts for restoration should focus on heavily extracting other commodities. On the contrary, and considering the Ayeyarwady landscape, the development of responsible business models and the improvement in value chains represent a sustainable opportunity to fulfill the economic income from mangrove wood-based activities. Two bio-based value chains are recommended to be improved as a complement for mangrove restoration and conservation efforts. Considering the institutional landscape of Myanmar, they represent an opportunity to be developed by community forest user groups.

This work analyzes two bio-based value chains: hard-shell mud crab and dried food products. It maps the functional value chain activities; identifies the strengths, weaknesses, opportunities, and threats; and assesses various financial models which support recommendations for improvements in the selected value chains. The main findings are the following:

Institutional landscape framework:

- Current land use regulations limit the use of land for other economically attractive practices in the region like aquaculture.
- There are inconsistences in the legal framework that overshadow the development of value chains related to aquaculture.
- Sustainable practices for crab and other fishery resources are weakly controlled in the region.

Business and investment models:

- Mud crabs represent an opportunity for economic development for different stakeholders in the region. They also represent an opportunity for mangrove restoration and an adaptation mechanism for climate change.
- The future and viability of mud crab production, as well as other fishery activities may be at risk if no proper and sustainable management practices are implemented.
- The implementation of solar-dome dryers represents an opportunity to decrease mangrove fuelwood consumption and a mechanism to improve communities' income.

Access to capital:

- Lack of access to formal financing is identified as a major issue for economic actors in the region.
- Access to financial resources is required in order to improve farmers' operational activities.

01. Introduction & Objective

Objective

The main objective of this report is to analyze potential improvements in value chains that can support mangrove restoration efforts while improving the livelihoods of smallholder farmers, fishers, and foragers in sustainable bio-based production systems in the Ayeyarwady Region, Myanmar. For this purpose, the report presents a functional analysis of identified value chains to be improved and presents a financial analysis that supports the suggested recommendations. The value chains selected shall complement the restoration and conservation of the mangrove forest efforts in the Ayeyarwady Delta region.

This report complements GGGI's work on the Economic Appraisal of the Ayeyarwady Mangrove Forest. Both reports are part of GGGI's Investment Case for Coastal Landscape Mangrove Restoration in Myanmar, with the overall objective to support enabling policy environment, analyze potential natural capital value-chain returns, and assess potential benefit-sharing mechanisms and financing needs.

Ayeyarwady Delta

The Ayeyarwady Delta, at the mouth of the Ayeyarwady River, is an important alluvial floodplain of Myanmar that supports the largest tracts of mangroves in the country. The landscape is characterized by mangroves, mixed water-covers (freshwater, blackish water and sea water) and land-cover, largely rice farmland, and rural dwellings. The Ayeyarwady Delta is rich in resources and one of the most populous regions in Myanmar (Population, 2015). The region has been the major rice producer for domestic consumption and, to a small extent, for exporting to international markets. The area is also an important source of fresh and processed fishery produce.

The Delta's ecosystem hosts some of the most diverse mangroves in the world, plus more than 30 species of endangered fauna (Webb et al, 2014). The mangroves hold a substantial store of belowground carbon, a feature of great interest towards the mitigation of climate change. The mangrove ecosystem has provided coastal protection services to the Ayeyarwady Delta region, playing an important role of protecting coastal lands, settlements, and infrastructure against cyclones. Multiple events have shown Myanmar's vulnerability against extreme weather events. To date, cyclones have caused an estimated of 150,000 deaths and resulted in damage costs of approximately Kyat 20 trillion (USD 20 billion). The economic losses from Cyclone Nargis in 2008 were estimated at 2.7 percent of the national GDP (FAO, 2017).

Figure 1: Map of Ayeyarwady Delta Located in the South of Myanmar

Source: Nauta, T. (2014). Delft3D model of the Ayeyarwady Delta. Myanmar. Delft University of Technology.

The mangrove forests of the Ayeyarwady Delta have sustained one of the highest deforestation rates in Myanmar. A mangrove assessment conducted in 2014 found that the Ayeyarwady Delta mangrove forests shrank by 64.2 percent between 1978 and 2011, from 262,300 hectares to 93,800 hectares. Around 3 percent of the forests were lost every year during this period (Webb et al, 2014). The cause of this loss was primarily anthropogenic in nature, including agricultural land expansion, aquaculture development, and the harvesting of wood for fuel and construction purposes. The effects of deforestation have resulted in lowering the capacity of mangrove forests to effectively act as a buffer against waves and storms surges (FAO, 2017). Mangrove forest conservation efforts in Myanmar face barriers such as weak governance, and lack of financial resources.

To overcome these barriers, it is proposed that selected bio-based value chains are developed to complement mangrove restoration and conservation efforts.

This report addresses such proposed activities that can complement mangrove restoration to improve the livelihoods of farmers, fishers, and foragers in the Ayeyarwady region. The report is structured as follows: Section 1, Introduction; Section 2 describes the institutional landscape relevant to land governance, agriculture and aquaculture sectors; Section 3 presents a review of selected literature; Section 4 is a description of the applied methodology; Section 5 consists of analyses of the selected value chains and discussions; and Section 6 presents conclusions and recommendations.

02. Institutional Landscape

The institutional framework in a country defines the basis that allows for the success or failure of potential efforts aiming towards economic activity development. Considering the main objective of the report, the following section presents an overview of the institutional landscape in Myanmar that frames the economic activities involved in the discussed value chains.

Following the 2008 Constitution and elections in Myanmar, the Government had undertaken a restructuring process of the land institutional and legal framework. However, the land-administration structure remained complex. An FAO Institutional Assessment in Myanmar reported that by 2015, the land sector was governed by an estimated 70 ambiguous and overlapping laws and regulations with inconsistent and discretional application of policies (FAO, 2016).

Myanmar's natural resource assets such as land, forestry, and fisheries are all state owned. The rights to access and manage these assets are governed under various government departments (WB, 2019a). Responsibilities are distributed among 10 different government entities. The Ministry of Home Affairs (through its General Administration Departments – GAD) and the Ministry of Agriculture, Livestock and Irrigation – MoALI (through its Settlement and Land Records Department – SLRD), play the major role in all levels of non-forest land administration. The Ministry of Natural Resources and Environmental Conservation (MoNREC) assumes primary responsibility in areas designated as forest. The GAD has branches at the township and state levels and acts as the central government's representative at these levels. The SLRD is responsible for maintaining land registry and cadastral maps. It also has branches at the state, district, and township levels. (Srinivas and U, 2015).

GAD, SLRD, and the Forest Department are responsible for protecting the land under their jurisdiction against encroachment and squatters. Requests for transfer of tenancy rights and change of land use must be initiated at the village tract level to eventually be endorsed and approved at the state level. Currently, little information on State-held land is publicly available as regional governments and departments lack data on the amounts of State land under their control. Civil Society Organizations have claimed that government awarded land leases in a nontransparent manner. This has led to concession holders exploiting land without consideration for long-term sustainability. This practice has also left the rural communities with few opportunities to participate in revenue streams from those resources (Srinivas, 2015).

Table 1: Key Land Use Classifications and Trustee Authorities

LAND USE	DELEGATED GOVERNMENT TRUSTEE AUTHORITIES
Reserved Forest Land	Department of Forestry (Department within MoNREC)
Protected Area System	
Protected Public Forest Land	
Public Forest Land (Virgin Land)	Department of Forestry (Department within MoNREC) Ministry of Agriculture, Livestock and Irrigation (MoALI) Central Committee for the Management of Vacant, Fallow and Virgin Lands (CCVFV) Settlement and Land Records Department (Department within MoALI) General Administration Department
Vacant and Fallow Land	Ministry of Agriculture, Livestock and Irrigation (MoALI) Settlement and Land Records Department (Department within MoALI) Central Committee for the Management of Vacant, Fallow and Virgin Lands (CCVFV) General Administration Department
Farmland	Ministry of Agriculture, Livestock and Irrigation (MoALI) Settlement and Land Records Department (Department within MoALI) General Administration Department Farmland Administration Body
Inland fishery / Aquaculture	Department of Fisheries (Department within MoALI) General Administration Department

Source: Legal Review of Recently Enacted Farmland Law and VFV Land Law (Oberndorf, 2012) & Fisheries Sector Report (WB, Fishery Sector Report Myanmar, 2019).

Policies and Legal Framework

Myanmar has been engaged in designing and implementing required policies, governance, and programming instruments to address socio-economic development and play its part in mitigating global climate change. With the Nationally Determined Contributions (NDCs), Myanmar has confirmed its commitment to climate change mitigation, by pursuing the correct balance between socio-economic development and environmental sustainability.

Myanmar has identified mitigation actions and policies in the primary areas of forestry and energy, complemented by supporting policies in other sectors. Adaptation actions in agriculture, forestry, water, infrastructure and biodiversity, among others, are currently under implementation; while reducing the risk of disasters remains a main program and policy focus. Considering the report's interest in the Ayeyarwady Delta, the government objective of increasing the resilience of mangroves and coastal communities is highlighted. For this, the intended implementation plan mentions the development of a coastal zone management plan to effectively conserve terrestrial and under water resources, including mangrove forests (NDC Registry, 2019).

In alignment with the Intended Nationally Determined Contributions (INDCs), tackling the drivers of mangrove degradation and loss, as well as encouraging restoration, are part of the Government's national priorities: the Biodiversity Strategy and Action Plan, Climate Change Strategy and Action Plan, the National Reforestation and Forest Rehabilitation Program (NRRP), and the National Adaptation Programme of Action (NAPA). All the above are also integrated under the Myanmar Sustainable Development Plan (MSDP).

The following sub-section reviews the policies and legal framework of the agricultural, fishery and forestry sectors that currently determine the basis for exercising economic activities within the value chains under analysis.

Agricultural Sector

Land for farming is regulated under the following laws: The Farmland Law (2012) and the Vacant, Fallow, Virgin (VFV) Lands Management Law (2012). The former placed a system of securing rural land tenure through a land use certificate and registration system. The latter permits VFV lands to be reclassified as farmland as determined by Farmland Administration Bodies (FABs). Under the Farmland Law, Land Use Certificates (LUC) are granted and issued to farmers by the FABs and registered by the SLRD. The Farmland Law states that 'farmland' consists of areas of land designated as paddy land, ya land, kiang land, among others. Any changes in the status of land use must be properly registered (Oberndorf, 2012). FABs, established in 2012, are responsible for reviewing request applications for the rights to use farmland and submitting them to the SLRD for registration. FABs conduct valuations of farmland for tax acquisition compensation purposes, issuing warnings, imposing penalties or revoking user rights if conditions for the use of farmland are not met, and resolve disputes that arise over the allocation and use of farmland use rights (FAO, 2016). Recently, MoALI drafted the Agricultural Development Strategy and Investment Plan (2018-2019 to 2022-2023) to improve the performance of the agricultural sector. The Plan promotes market openness, innovation, and cooperation for the agricultural sector in general and specifically for the rice sector (Myint, 2018).

Fishery Sector

The fishery sector is regulated under the following laws: the Myanmar Marine Fisheries Law (1990), the Freshwater Fisheries Law (1991) and the Aquaculture Law (1989). Decentralization under the New Constitution in 2008 allowed each state and region to draft their own freshwater fisheries legislation (WB, 2019a). The Ayeyarwady region drafted the Ayeyarwady Freshwater Fishery Law in 2012, recognizing the rights of 'flooded area fishers' (small-scale flood-plain fishers). The new Ayeyarwady Freshwater Fisheries Law issued in 2018 recognized the rights of communities to form community fisheries associations to further develop fisheries and community fisheries associations systematically. The objective is to prevent the extinction of fisheries, the depletion of fishery resources, and secure tax and revenue collection (Ayeyarwady Fresh Water Fisheries Law, 2018).

Despite the new Constitution of 2008, the Aquaculture Law of 1989 remained as a union level law. This means that states and regions cannot draft their own legislation with respect to aquaculture practices. Moreover, aquaculture development is constrained by the Farmland Law (2012) and the Vacant, Fallow, and Virgin Land Law (2012). These two laws restrict the conversion of land registered for rice cultivation for any other permanent purposes without authorization (WB, 2019a).

Forestry Sector

In the forestry sector, forest land is protected by the Forest Law (2018), encompassing forest resources including protected reserved forest land and protected public forest land. Public forest land also falls under the Vacant, Fallow and Virgin Lands Management Law (2012) (Oberndorf, 2012). The Myanmar Forest Policy (1995) and the 30-year National Forestry Master Plan (2001-2030) laid out the national target to constitute 30% of the total country's area as Reserved Forest and Protected Public Forest, and 10% as Protected Area by 2030. These national targets have been committed as NDC (NRRPM, 2016).

The Myanmar government has been promoting Community Forest (CF) programs since 1995 and issued Community Forestry Instructions (CFI) as a guide to decentralized forest management (Srinivas, 2015). The Community Forests led to the creation of Community Forest Enterprises (CFEs). The CF Strategy Action Plan, as well as the new Forestry Law (2018), provide the communities with livelihood opportunities. In theory, the communities can profit from the sale of timber, non-timber forest products (NTFPs), and other value addition activities from the CF. (WB, 2019b).

With the development goal of enhancing economic and environmental conditions, the National Reforestation and Rehabilitation Program in Myanmar (2017-2018 to 2026-2027) aims to create impact through a shift from degraded forests to better quality forests and income improvement of local communities. This program looks to reinforce efforts of rehabilitation and restoration by institutional strengthening (NRRPM, 2016). The most progressive target of the NRRP is the establishment of CF as a mechanism to provide communities the capacity to plan and manage their forest resources according to an agreed management plan (WB, 2019c).

Land Use and Issues

Following the land use regulations and policies, land in the Ayeyarwady region is mainly allocated for farming purposes. Realistically, not all land is suitable for crop production; however, current land use regulations limit other land use, such as aquaculture development in the Ayeyarwady Delta. This is despite the fact that the livelihoods of several thousand people in the coastal region are directly and indirectly involved in aquaculture activities. This policy, of preventing the conversion of farmland to other uses, is a historical legacy from previous governments that placed heavy emphasis on protecting crop cultivation to ensure national food security (TFS, 2017).

The conversion of any paddy land or other agriculture land to aquaculture is constrained by bureaucratic procedures. Further complicating this is the fact that failure to cultivate agricultural land can result in confiscation of the land. Hence, this represents a significant entry barrier for poor people to carry out livelihood activities directly related to aquaculture (Belton et al, 2015). Aside from land access and security of land tenure challenges, other barriers to optimize land use include farmers' low skills, lack of access to credit and support services, scarce availability of small land holdings, and lack of micro-credits in Myanmar's financial sector.

In the coastal areas, where mangrove forests grow, communities use mangrove wood for their daily needs and commercial purposes, such as for firewood and as building materials, while simultaneously degrading the mangrove forests in the process. The degradation of the mangrove forests has resulted in more frequent and intense flooding, less wood for the community's needs, as well as a reduction of the natural stock of fish, shrimp and crabs found in the mangrove estuaries and swamps. As the country's mangrove forests become increasingly deforested, wild fishery catch and stock is depleted. Fish abundance in some coastal areas is estimated to have fallen by 10 percent between 1979 and 2016 (GIZ, 2017). Despite regulatory and policy barriers to use land for aquaculture purposes, the Ayeyarwady State of the Basin Assessment (SOBA) presents the number of fish, shrimp, and crab farm areas in the Ayeyarwady region. It highlights that fish and shrimp farming dominated the landscape, with more than 4,500 fish farmers, and shrimp farmers totaled over 2,000 (Joffre, O., 2017).

Along with the lack of diversification of production, observed in an overdependence of a single species, the rohu fish (*Labeo rohita*), a growing importance in the commercialization of mud crabs has been observed in recent years (Belton at al, 2015). Mud crabs (*Scylla spp.*) are widely distributed in the Ayeyarwady Delta area, breeding at the roots of the mangroves. Collecting mud crabs has been gaining popularity among the Delta community of Myanmar. It has emerged as an important livelihood activity due to the high export market potential. Thousands of poor fishers, traders and transporters are directly or indirectly dependent on mud crab fishery activities in the Ayeyarwady Delta area. Unfortunately, population dynamics and stock assessments of mud crab in the Ayeyarwady Delta have confirmed an over-exploitation of these resources, highlighting high fishing pressure and the need to reduce it for future sustainability (Thein H., K. M. 2016).

Table 2: Total Number of Fish, Shrimp, Crab Pond Farmers and Farm Area in Ayeyarwady Division in 2017-2018 Fiscal Year

NO	DISTRICT/ TOWNSHIP/ SUB-TOWNSHIP	FISH FARM		SHRIMP FARM		CRAB FARM		TOTAL		
		Number of farmers	Area (Acre)	Number of farmers	Area (Acre)	Number of farmers	Area (Acre)	Number of farmers	Area (Acre)	Area (ha)*
(i)	Pathein District	275	4551.75	1551	19215.15	1	8.57	1827	23775.500	9622
(ii)	Hinthada District	604	2049.447	2	9.000	0	0	606	2058.447	833
(iii)	Myangmya District	315	4669.690	8	42.080	0	0	323	4711.770	1907
(iv)	Labutta District	109	840.660	320	29760.080	7	192.44	436	30793.180	12462
(v)	Maubin District	3282	106352.693	49	4589.520	0	0	3331	110942.213	44898
(vi)	Pyapon District	156	3346.270	123	7264.520	1	15.000	280	10625.790	4300
	Total	4741	121810.510	2053	60880.380	9	216.010	6803	182906.9	74021

* 2.471 acre = 1 ha

Source: The Ayeyarwady State of the Basin Assessment Report 2017 (Joffre, 2017).

Community Forest

Mangrove cover in the Ayeyarwady Delta recorded a 64 percent decrease between 1978 and 2011, mainly due to agricultural expansion (Webb et al, 2014). After the devastation caused by Cyclone Nargis, mangrove forests were further degraded due to overuse by the local population as the villagers used small timber to rebuild houses, as fuelwood, and traded mangrove wood as a source of income (Feurer et al, 2018).

Given that land tenure is still an unresolved issue in many parts of Myanmar, CFs are seen as one possibility for the local population to receive secured access, management and use rights over forested land for a certain time period. A CF certificate allows only for a 30-year use and does not give formal ownership. After the 30-year period, the Community Forest User Group (CFUG) can apply for an additional 30-year extension (Feurer et al, 2018).

In 2001, to develop CFs, the Myanmar government set a target of 919,000 ha under CF management by 2030. However, progress has been slow and as of 2016, only 12 percent of the target had been achieved (RECOFTC, 2016). To ensure the support from local communities, CF management plans included the establishment of mangrove plantations as outlined in the Community Forestry Instruction (CFI) (Tint et al, 2011).

The CFUGs' members have their own plots within the plantation area. They decide on the mangrove species and manage the plantations for a period of 30 years.

When trees are mature, they will benefit from the sale of the timber. This opportunity presents the most significant, as well as the most favorable regulatory environment through the recently revised CFI. Only CFUG members are promised the full benefit of the timber while all other mangrove products, including fuelwood and other NTFPs can be freely used by any other person (CF members and non-members alike) for subsistence and commercial purposes. Everyone else can collect unlimited amounts of fuel wood for subsistence and other NTFPs, irrespective of whether they own forest plots or not. Hence, the mangrove plantations are likely to be overused. Most households in the Ayeyarwady region (91%) use traditional stoves for cooking, utilizing mostly wood from the mangrove forest area. This demand makes fuelwood one of the most important mangrove products for subsistence and commercialization (Feurer et al, 2018).

Overall, the mangrove forests in the Ayeyarwady Delta have undergone dramatic changes over the past decades. Thirty years ago, mangrove forests were abundant, and were mainly used for charcoal production. Fifteen years ago, mangrove forests were deforested, and the land was used for rice production, but later flooded and rendered unproductive. Nowadays, mangroves are used for different purposes, mostly related to the marketing opportunities that mangrove products can provide (Feurer et al, 2018).

03. Review of Selected Literature

The following section reviews the findings that add to the knowledge platform that allows building the case for the selection of value chains and subsequent discussion presented later in this report.

Title: Small-scale Mud Crab Fishery of Ayeyarwaddy Delta: a Case Study of Bogalay Township (2014)

Author: Khin Yadanar Oo

This study investigated the income contribution of small-scale household mud crab production to the coastal community and their awareness about the role of mangrove forests in their livelihood, especially on mud crab capture and culture. The study also explored the status of small-scale mud crab production in terms of technology, management, and government support. According to this study, two types of mud crab culture were identified, fattening and grow-out practices. Even though grow-out culture of mud crabs was proposed as a recommendation for future scenarios for various reasons, this activity was very scarce to find in the study area of Bogalay Township. Overall, the author also highlights the benefits of integrated aquaculture farming systems with mangroves as observed in Viet Nam case studies. In these cases, mangroves have played an important role in providing the habitat and feeding ground for successful capture and culture of mud crab. The results have shown an increase in juvenile mud crabs caught in stock ponds supporting plentiful seed supply for mud crab farming. The main beneficiaries have been the communities that can afford to invest in aquaculture practices but also the poor fishers that collect crab seed and food materials to sell them to farmers. Local people have recognized the positive correlation between the area of mangroves and the quantity of wild mud crab available, thereby making it easier to convince them of the importance of conserving mangroves due to their support services for mud crab farming.

Regarding the ambition of the study to investigate the potential income contribution of small-scale mud crab fishery and culture, primary and secondary data was collected from Bogalay Township, Ayeyarwady Delta, with a sampling of 75 respondents. Considering the different types of farming practices, the study focused on mud crab wild catch (73% of respondents) and mud crab fattening (26.7% of respondents). The study found that for mud crab fishers the main reasons for pursuing crab related livelihood activities were the growing demand, the lack of options of doing other livelihood activities, and the rapid returns. From the side of mud crab fatteners, the main reasons were the growing demand, the rapid returns, and low inputs required. With respect to market destination, 72% of the respondents indicated trading the mud crabs via middleman, 25% directly to Yangon and 3% to fatteners. Based on field surveys, the average amount of land owned by a crab fattener was 7.45

acres (3.015 hectares) and the largest amount owned was 20 hectares. Yet, only 16% of the villagers surveyed had their own land, the rest (84%) did not owned the land.

The report presents the findings of the economic analysis for mud crab fishers and shows that crab fishers were not getting significant profits from fishing. It was found out that for this activity, the opportunity cost of labor represented the highest cost (35.49% contribution of total cost of fishing). Analyzing the activity with and without the opportunity cost of family labor force, the author concludes that crab fishers were not having high net profit and they were just paid for their labor as opportunity cost. Following the economic analysis for mud crab fattening, the report mentions that for this activity, the highest contribution to the total cost was incurred by the crab seeds (68.8%) followed by the crab feeds (14.86%). The monthly net return for this activity, including the opportunity cost of family labor, was around 148,000 Kyat (USD 148) and the net return without family labor cost was around 200,000 Kyat (USD 200). These were reported also as the average income driven by crab fattening activities estimated by crab fatteners.

One of the major constraints for the participants in both activities, fishing and fattening, was access to financial support that will allow them to run their practices. Eighty-eight percent of the respondents mentioned that the main support they needed was capital for their investments (feed, equipment, seeds) for running and expanding their business. The report also mentions that among the five villages chosen as the study area, all of them had regular reforestation activities each year in cooperation with the forest department and NGOs in those areas. Most of the respondents were aware of the value of mangrove forests, yet, their perceptions and motivations to participate in reforestation campaigns seemed to be limited. Twenty-one among 25 respondents that had participated in reforestation activities, mentioned that their major reason was the money they expected from the program since they needed daily income for their households.

The study concludes that according to the results, mud crab aquaculture can be assumed as a suitable environmentally friendly subsistence livelihood activity for the Ayeyarwady Delta. It also mentions that mud crab fishery in the Delta is still in its infancy stages and recommends further research in the following areas: scientific support on optimum conditions for fattening, the potential of mud crab grow-out culture in mangrove forest, and the impacts of mangrove forest degradation on the wild stocks of mud crab.

Title: Socio-Economic Status of Mud Crab Collector and Value Chain Analysis in Delta Communities (2015)

Published by: Department of Fishery, MoALI

This study was implemented during October 2013 through March 2014 by DOF in three locations in the townships of Pyapon and Labutta. As the study was implemented during different seasons of the year it provides more comprehensive data of the crab collectors' activities. Subjects of the study were crab collectors, traders, and wholesalers. As indicated by the title, the study focused on crab collectors, who off load the crabs they collect and commercialize them through traders and middlemen. The report also includes data of the selling prices, prevailing at that time. Due to the nature of crab collection, the prices and quantity of crabs collected varies during summer, monsoon and winter seasons.

Crab collection, albeit lucrative and profitable, was not the main occupation of the study subjects. The majority (40%) listed fishing as their main occupation. Other occupations included farming, wood collection, labors, services, and furniture making. Only one crab collector owned land for farming in Labutta and in Pyapon. This indicated that most of crab collectors were likely landless. Based on the chart showing data of the amount of crabs collected (Kyat per day) and data on the prevailing selling prices, it was possible to estimate the average quantity of crabs collected per day. Estimates showed that during the summer season, collectors could gather one to two crabs of 200 grams, during the monsoon season around four

to six crabs, and during the winter season an average of one crab per day. Monsoon season provided collectors with the highest number of crabs, but with lower prices compared to summer and winter collecting seasons. During winter, collectors expected low catches, even though prices were higher than during the monsoon season. These estimates provided the reason as to why crab collection is practiced alongside other occupations by the collectors.

Lack of access to credit is mentioned as a major issue for most crab collectors. The study exposes that most of the subjects (70%) did not take a loan, and 30 percent did take loans -for boat, nets, bait, etc.- from the traders/middlemen at very high rates up to 20 to 30 percent per month. Sometimes the traders provided loans without any interest, but they set the selling price of the crabs, putting pressure on the earnings of the crab collectors.

The study lists the major problem faced by crab collectors to be the relatively low price received from traders or middlemen, especially if they had taken an informal loan from them. Also, crabs have to reach their final destinations alive, and the mortality rate of around 30% during transportation represents another issue for traders and middlemen. Traders are also subjected to the prevailing international market prices.

While acknowledging crab colleting as a profitable activity, the study cautions the need for proper management of crab collection, not targeting all crab sizes without regard to sustainability to ensure the future of the crab stock in the wild.

Title: Population Dynamics and Stock Assessment of Mud Crab, Scylla Olivacea in Myanmar (2015)

Author: Htun Thein, Myint Myint Kyi, et al.

The aim of this research was to develop a bio-economic model of the mud crab fishery which can be used as an initial step towards improving the management of this fishery. The report highlights that mud crab fisheries are an old livelihood practice for the local people of Myanmar that live in the delta and coastal regions. Generally, three species of mud crab can be found in Myanmar: *Scylla serrata*, *S. olivacea* and *S. tranquebarica*. However, the most dominant and abundant species in the Ayeyarwady Delta region is the *Scylla olivacea*. Consequently, the study was undertaken to estimate the key parameters of stock assessment and population dynamics of *S. olivacea* such as the asymptotic length, growth co-efficient, total mortality, natural mortality, fishing mortality, recruitment pattern, exploitation rate, length frequency distribution and the catch rate in delta regions. The study looks for providing baseline information for regulating the fishing activity over time, leading to the mud crab recovery process in order to prevent further biological and economic decline of the mud crab fishery.

The area of study for this research was the Labutta Township, southern Ayeyarwady Delta region, in which sampling sites were selected to complement major river catchments and areas of high commercial catches. The study was carried out from May 2014 to April 2015, measuring a total number of 6.966 *S. olivacea* mud crabs. The report highlights that most of fishermen catching mud crab used the same types of trap, being the fishing methods the greatest cause for crab mortality. The mortality was also strongly related to the capture of small size mud crabs. During the study, it was found that the exploitation rate was very high at 5.28 (over 0.50, the stock is generally considered to be overfished), indicating an overfishing condition of mud crab. Overall, the results clearly indicated that *S. olivacea* species are over-exploited in the Ayeyarwady Delta area. Hence, the report recommends the need for measures that minimize juvenile mud crab fisheries, such as banning the use of nets that catch juveniles and increasing community awareness of the issues of juvenile catch among the fishers. This is recommended as a way to help minimizing juvenile mud crab fisheries in Myanmar and as a measure to decrease the fishing pressure in order to obtain more sustained production.

Title: Processed Seafood and Mariculture Value Chain Analysis and Upgrading Strategy (2016)

Published by: International Labour Organization (ILO) and Norwegian Agency for Development Cooperation (NORAD)

The ILO office in Myanmar and NORAD jointly produced this report. The study was one of ILO's projects to support development of micro, small and medium enterprises (MSMEs) in Myanmar. The objectives were to identify constraints faced by MSMEs and potential upgrading of the MSMEs' value chains to have higher added values. The study locations were Yangon and Meik city and archipelago. It focused on processed seafood (shrimp and fish) and mariculture (barramundi and blood cockle) value chains. The seafood value chains selected comprised three products, shrimp paste, dried shrimp and dried fish. It was found that the products were more suited to the local/domestic markets in the short and medium terms and suggests targeting supermarkets and minimarkets in line with their rapid growth in Myanmar. These supermarkets and minimarkets require quality products, with attractive packaging and labels, to fetch higher prices compared to bulk products normally sold to wholesalers, without any label nor good packaging.

The report highlights that shrimp paste and dried shrimp are among the most popular items in almost all of Myanmar's diet and cooking. They are used in sauces and as cooking ingredients in many of Myanmar's local cuisine and delicacies. Thus, the demand is large and growing in line with population growth. As more of the Myanmar population become urbanites, the growth of supermarkets and minimarkets will follow. Improved and more hygienic shrimp processing will produce better quality products which can fetch higher prices. Selected seafood value chains, dried shrimp and dried fish, can be considered for value chain development in the Ayeyarwady Delta region. The study indicates that dried shrimp from the Ayeyarwady region naturally have more red color and straighter physical structure. These are qualities that make them to be in high demand in Yangon. It also concludes that improved practices are required to prevent unsustainable use of mangroves. This could either involve the use of alternative energy sources to power the drying process during the rainy season, or management practices to ensure the sustainable use of mangroves.

Title: Aquaculture in Myanmar – Fish Farm Technology, Production Economics and Management (2017)

Author: Belton et al.

This report provides comprehensive information about Myanmar's inland aquaculture based on data collected from 1,120 households in four townships, two of them in Yangon, in Kayan and Twantay , and another two in the Ayeyarwady region, in Maubin and Nyaungdon. The data of ponds were sourced from satellite pictures, allowing for a more accurate accounting of the number of ponds in the study areas. The study reveals that aquaculture provided a higher income compared to agriculture. The average gross margin of aquaculture farms was found to be as much as 7 times higher compared to paddy grown during monsoon season and four times higher than paddy grown during the monsoon and dry seasons.

Aquaculture farming was also found to be more equitable with regards to the gender wage gap. Women in aquaculture earn 75 percent of men's wages compared to two third of men's wage in crop growing. The study samples were grouped according to small, medium and large size ponds to get more accurate information regarding farm operation costs. Feed accounted for about 70 percent of overall operating farm costs, making it the largest component for operations of aquaculture farms. Large farms had better access to feed financing than

medium and small farms. Large farms also used more expensive feed such as pellets, which contained nutrients most suited for fish growing purposes. Their size allowed them to secure supplier financing. Small farms on the other hand almost never used expensive pellets as feed, using instead mostly rice brand, which cost about half that of pellets. To compensate, small farms bought larger fish seeds (fingerlings) to shorten the grow out period, shortening the feeding period as well, for quicker harvesting. Rohu fish continued to dominate as the fish species chosen by fish farmers, although small farms sometimes also grew large freshwater prawns which fetched high prices compared to fish.

Aside from aquaculture farming to grow fish, there were also nursery farms operated by independent farmers, i.e. non-government/private nursery, producing fish fingerlings for fish farmers. Based on the findings, the study recommended aquaculture development to stimulate development and growth in the rural areas in order to improve livelihoods and as a policy tool to reduce poverty. The development of aquaculture in coastal regions can be harmonized with coastal mangrove restoration where restoration is needed.

Title: Ayeyarwady Aquaculture Value Chain Analysis (2018)

Author: Fitzsimmons, K. (Myanmar Sustainable Aquaculture Programme)

The Author was assigned as a consultant to analyze both the shrimp (*P. monodon* and *L. vannamei*) and mud-crab value chains. The study locations were the Rakhine and Ayeyarwady regions with priority focus placed on extensive shrimp farming. However, donors directed the study to be implemented only in the Ayeyarwady region with a field assessment during July to August 2018. The study focused on three districts in Ayeyarwady, namely Pyapon, Labutta and Pathein. The consultant found that statistical information on shrimps and mud-crabs were very limitedly available in Myanmar. The data available was mainly in the form of revenue collection recorded by the Department of Fisheries. In addition to poor records, or the lack of records, the study had to deal with the locals' practice of memorizing their harvest by approximating from the sales income in Myanmar Kyat (MMK), e.g., 500,000 MMK for one tide cycle. Thus, the consultant team faced difficulties in obtaining accurate data related to the price and volume of production. From the field survey, it was found that adult live crab trading accounted for 80 percent of the crab trading while the remaining 20 percent was allocated to soft shell-production, comprising smaller sized crabs of less than 100 grams. The study found that the price of crabs sold in Labutta was slightly higher than in Pyapon. The crab size grouping was different in the two districts.

Employing diagnostic surveys for the shrimp sector, the team found that the abandonment of shrimp farms was significant. The assessment showed that a decline in the availability and accessibility of wild seed led to low yields and less profitable shrimp farming activities. Illegal fishing (thieves) at people's shrimp farms, climate change effects (flooding), and diseases (white spot) have reduced the interest in shrimp farming. The report also mentions that the majority of shrimp farmers still relied on wild seed collectors and only a few shrimp farmers sourced seed from hatcheries. Interestingly, the consultant team had the opportunity to also perform a field study in Indonesia, and therefore compare the results. The team analyzed Indonesia's intensive and extensive shrimp farming and concluded that intensive farming could not be applied yet in Myanmar. The extensive shrimp farming system in Indonesia also had advantages which were not available in Myanmar such as hatcheries, which were located relatively close to the farms providing quality seed in sufficient quantity. Seed for shrimp farming in Myanmar was mainly sourced from the wild. Although there are nurseries in Myanmar importing seed from Thailand, the quality is not guaranteed and nurseries sourcing from the wild may not provide quality shrimp. Harvest yields of extensive shrimp farms in Indonesia were also found to be twice to three times higher compared to Myanmar. Moreover, the Indonesian shrimp farmers have better certainty as they have a contract agreement with the trading companies that guaranteed prices and volume of shrimp. The trading

companies also work closely with the hatcheries informing of the amount of seed needed for each production cycle of the shrimp farms contracted by the trading company. There also exists a system whereby the trading company informs the shrimp farms of upcoming buying schedule dates. The farmers have the option to decide to sell or not to sell at that scheduled date. Such a network system between trading companies and farmers does not exist in Myanmar, putting farmers at a disadvantage as they have to take the price set by the traders.

Lacking access to financing, farmers who took advance informal loans from traders cannot receive the full amount of the sales income for their harvest. The study found that farmers who converted their rice farm to shrimp farms but retained the land use as rice farm can apply for a loan from the Myanmar Agriculture Development Bank, meant for rice farming but used for shrimp farming instead. However, the available loan amount is limited to 200,000 MMK per acre with a maximum limit of up to 10 acres. The tenure of such a loan is also limited to only one production cycle period. No information was mentioned regarding how many of the farmers were able to secure a loan of this kind. Under the CFI, shrimp farming in mangrove reserves were allowed in the Pyapon district. However, only 10 percent of the CF can be allocated for this purpose. To get higher income, shrimp farms in this area also practiced crab fattening. There is no information of how many shrimp farmers in the area actually practice the combined farming of shrimp with crab fattening activities.

As the document received was still in its draft form, more information may be available in the final document.

Review Findings

The above literature review provides comprehensive information that complements the knowledge platform required for building a case for the selection of value chains for sustainable mangrove restoration. GGGI's early baseline assessments have identified that communities recognize the value of conserving mangrove forests surrounding their communities, both for protection against extreme weather events and as a source of sustenance. The relevance of mangroves has also been connected with their importance as a habitat for crab and shrimp populations, commodities for which their value chains can be compatible with mangrove restoration.

From the literature review, it is noted that aquaculture can be used to stimulate rural development especially in regions like the Ayeyarwady Delta, with the potential for scaling to other coastal regions like Rakhine, Yangon, Bago, Mon, and Tanintharyi. In regard to fishery commodity, mud crab activities have shown to be a suitable environmentally friendly livelihood opportunity, especially for small-scale farmers. However, the future of this activity is questionable if the fishers continue to collect crabs of all sizes, depleting wild stock. There is evidence of an overfishing condition of mud crabs. Recommendations emphasize the need to minimize juvenile mud crab fishery and increasing community awareness of the issues of juvenile catch. Moreover, small juvenile crabs fetch low prices compared to larger size adult crabs. Hence, there is the need to consider crab hatcheries and nurseries to produce juvenile crab stock for crab farming activities.

The process of drying shrimp and fish using conventional open-air drying methodologies and the use of mangrove fuelwood to fire traditional dryers can, and needs to, be improved using special dryer facilities. Renewable energy-based dryer facilities are more efficient, and do not use mangrove wood as fuelwood. Also, products which have been dried in more hygienic conditions using special dryers result in better quality produce, thus able to fetch higher prices.

To date, information for developing sustainable crab culture and implement efficient drying facilities for dried products in the Myanmar country context were not available. Consequently, this report addresses these knowledge gaps by discussing each of those value chains and building financial evidence and business models to assess the viability for potential investments. Discussions of the selected value chains are presented in Section 5 of this report.

04. Methodology

This report has its basis in the Scoping Assessment of Bio-based Products for a Coastal Bioeconomy in the Lower Ayeyarwady Delta by Thi Mar Win (2018). The information in the report helped in identifying value chains that can support and improve the livelihoods of smallholder farmers, fishers and foragers, in bio-based sustainable production systems, complementing mangrove conservation efforts in the Ayeyarwady Region. Additionally, this report complements GGGI's work on the Economic Appraisal of Ayeyarwady Mangrove Forest developed in collaboration with The University of Queensland, which includes an analysis of the impacts of mangrove restoration and better management practices in the production of aquaculture commodities: mud crab and shrimp.

The methodology of this report is framed as follows:

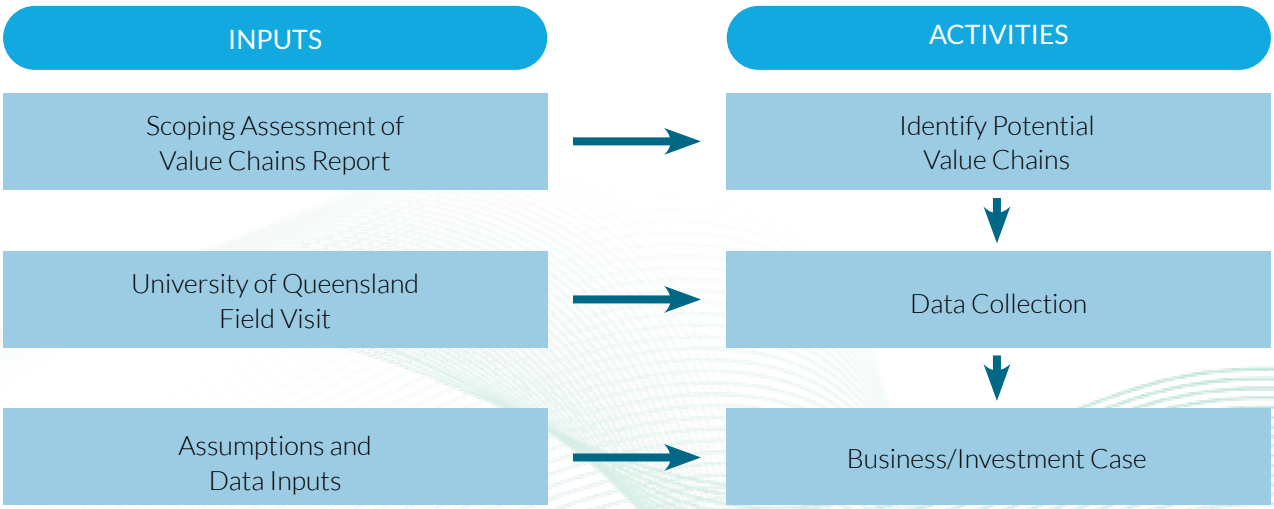
- Mapping of the functional value chain activities, identifying the main stakeholders/agents of the selected value chains.
- Identifying and highlighting strengths, weaknesses, opportunities and threats of each of the selected value chain activities.
- Assessing various financial models which support recommendations for improvements in the selected value chains.

Based on reviews and assessment, the selected value chains for analysis are:

- Hard-shell mud crab
- Dried food products

The framework followed for this analysis is highlighted in the diagram bellow, showing inputs and related activities.

Figure 2: Inputs and Activities Framework



Functional Value Chain Analysis

A Functional Value Chain Analytical method mapped and identified the actors, their activities and the flow of the selected commodities. The functional analysis involved: a) identification of agents, b) identification of their roles, and c) identification of the physical flows along the value chains.

SWOT Analysis

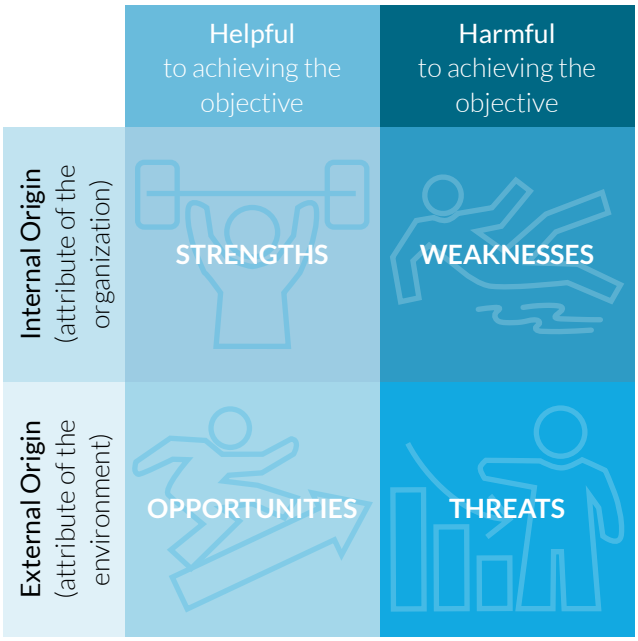
A SWOT analysis identified specific internal aspects (strengths and weaknesses) and external situational factors (opportunities and threats).

Elements of the SWOT analysis are:

- Strengths - contribute to the continued success of the stakeholders implementing the selected value chains.
- Weaknesses - prevent or hamper the success and growth of the selected value chains from achieving their full potential.
- Opportunities - offers implementing plans and strategies which allow the selected value chain activities to gain competitive advantage.
- Threats - jeopardize the profitability and reliability of the selected value chain activities.

This analysis is a useful step to further develop financial analyses and recommendations for sustainable business models.

Figure 3: SWOT Matrix



Financial Analysis

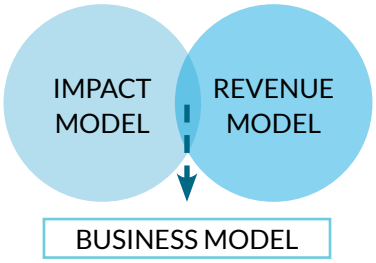
A cost-benefit analysis was used to identify the benefits and costs of selected economic activities in the value chains. In the case of the hard-shell mud crab value chain, the cost-benefit analysis was used for comparing two types of crab fattening practices (natural and intensive). In the case of the dried products, a cost-benefit analysis was used to analyze the implementation of a solar-dome dryer for processing dried products. The outcome of these analyses aims to determine the financial attractiveness of the economic practices under study.

The analysis for implementing a solar-dome dryer was complemented by a discounted payback period analysis in order to determine the number of years that it will take to break even from undertaking the initial investment for installing the facility based on specific assumptions. A two-way sensitivity analysis looks to determine the relationship between the efficient use of the facility and the changes in price (given better quality) with their impact on the discounted payback period.

Business Model Design

Business model design considered a balanced approach that generates and sustains both impact and revenue. An Impact Model is intended to ensure that the business model has a beneficial impact in the world (beyond the financial outcome), in this case it has mainly considered social and environmental impacts in line with the Government of Myanmar's policy priorities. A Revenue Model is a way of ensuring financial feasibility of an economic activity through the generation of sustainable income.

Figure 4: Business Model



Data Collection

Data collection was conducted through field visits, consultation meetings and scoping workshops. The data collection focused on three townships, namely Pathein, Bogale, and Pyapon, in the Ayeyarwady Delta. Primary data was collected by private consultation and further complemented by secondary data sourced from local authorities in the area: the Forestry Department, the Department of Agriculture, the Department of Fishery, and the Department of Livestock and Veterinary. Other secondary data sources included published data from the Food and Agriculture Organization, Flora and Fauna, Metta Development Foundation, Welhungerhilfe (WHH), La Deutsche Gesellschaft für Internationale Zusammenarbeit (GIZ), the World Fish Center, University of Queensland, and private entities.

For the hard-shell mud crab data collection, 37 samples were compiled by the University of Queensland (23 samples for intensive crab fattening and 14 samples for natural crab fattening). The selection of pond owners for interviewing followed a standard sample selection considering the townships of interest. A random integer generator tool was utilized for randomly selecting farmers from a list of pond owners that practiced crab fattening as main activity.

For the dried food products analysis, data collection was conducted through field visits and validated through consultation meetings and scoping workshops with public and private entities. This approach followed the interest of analyzing the implementation of a SDD and the current absence of this facility in the area of interest.

Scope and Limitations

The scope of the report is limited to the opportunities identified in association with the selected value chains. Numerous limitations were encountered in the preparation of this report due to:

- Information scarcity, inaccuracies, incomplete data, and outdated information. Statistical information on shrimps and mud crab is very limited in Myanmar.
- Geographical barriers limiting data collection from different actors in the Delta.
- Unwillingness to disclose information related to economic activities.

05. Analysis & Discussion

Hard-shell Mud Crab

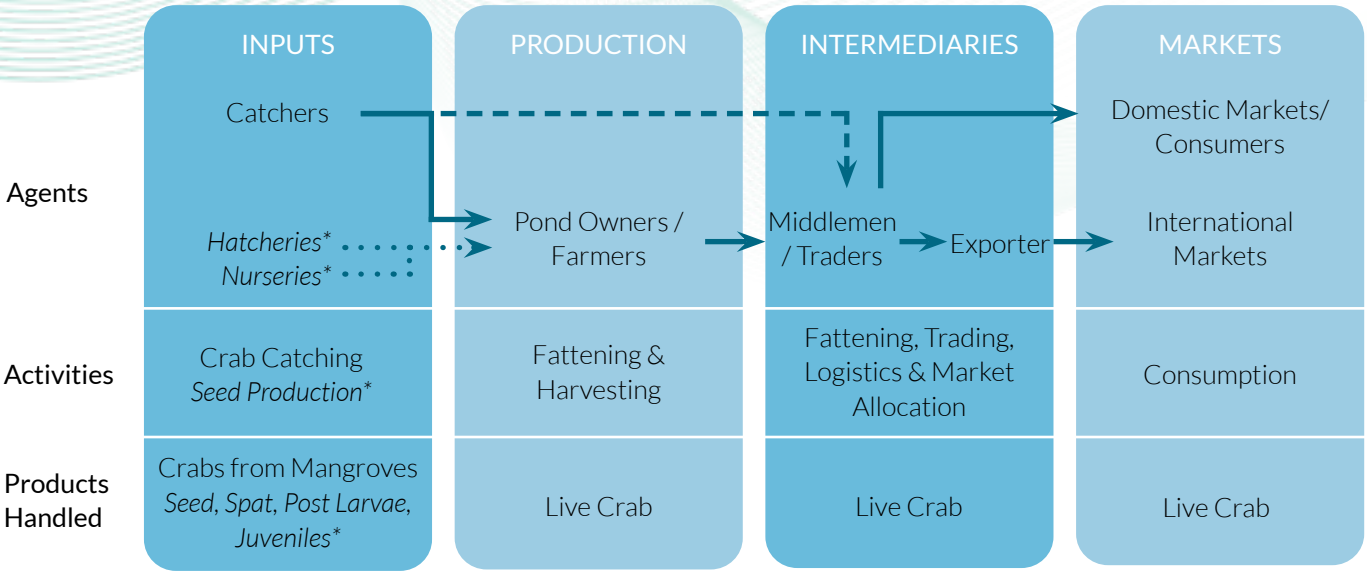
Mud crabs (*Scylla spp.*) are found in the mangrove areas of the Ayeyarwady Delta. The mangrove forests provide crabs with protection from predators and the conditions for their existence. The importance of mangroves is supported by findings that show that small-sized marine animals (including small crabs) can avoid predation by large predatory fish by seeking refuge in mangrove forests. The structural complexity of submerged vegetation, turbidity, and shallow water provides refuge for mud crabs, therefore there is a relationship between mangroves and mud crab stocks (Yadanar, K., 2014). (See Annex 1 – Generalized life cycle of the mud crab).

Value-added mud crab culture has provided positive economic benefits to farmers and contributed to the nation's wealth, as they add value to existing resources and provide foreign exchange. However, the sustainable development of mud crabs has depended, and will depend, on the sustainable supply of inputs, primarily of feed and seed (FAO, 2003). Current practices of catching wild crabs in mangroves have put at risk the future and sustainability of mud crab value chains. According to the research conducted by Htun Thein, et al., about the Population Dynamics and Stock Assessment of Mud Crab in 2015, mud crabs are over-exploited in the Ayeyarwady Delta area. Therefore, there is a need to improve current practices, implementing measures that decrease the pressure in natural stocks, especially overexploitation and mangrove deforestation.

Impact models implemented in Viet Nam, which have integrated aquaculture farming systems with mangroves, have shown the important role of mangroves in providing the habitat and feeding grounds, facilitating the successful capture and culture of mud crabs. Results have clearly shown an increase in juvenile mud crabs caught in stock ponds, therefore supporting a plentiful supply for mud crab farming. The main beneficiaries were the community members who could afford to invest in aquaculture practices, but also fishers that collected seed feed materials to sell to farmers. Local people recognized the positive correlation between the area of mangrove forests and the quantity of wild mud crab available, thereby making it easier to convince them of the importance of conserving mangroves due to their support services for mud crab farming. (FAO, 2011).

Functional Value Chain Analysis

Figure 5: Hard-Shell Mud Crab Functional Value Chain



Input Source

More than half of the villages' households (in some communities even up to 70 percent in the lower Delta) are landless households. Most of them rely heavily on catching mud crabs and shrimps from the mangrove forests (Macintosh, 2016). In the case of mud crab fishing, catchers utilize a variety of inputs for capturing all kinds of crabs' size. Inputs for this activity commonly includes fishing equipment, feeds, seeds, fee to leaseholder family, hired labors and boat costs. Three different kinds of fishing equipment were reported by local people: Paing, Gwe and Daindaung. All the equipment required was considered cheap and of easy application; however, their effectiveness for catching crab is still far less than modern nets. Crab fishers reported to get loans for crab feeds and equipment costs, but they did not need to pay interest, conversely, they had informal deals or verbal agreements with middlemen to allocate their catch in markets at a price set by the middlemen (normally lower than the market price). Also, crab fishers never hired labor for crab fishing and employed only family members for capturing activities (Yadanar, K., 2014).

Crab catches vary, with its highest during the three neap tide days in the month. The rest of the month, catchers vary their crab fishing spots according to the tide. Small size crabs are sold to farmers for further fattening while larger size crabs are directly sold to traders or middlemen. (Macintosh, 2016). The Department of Fisheries advises communities not to catch crabs during the spawning season in the months of April and May. However, during the rest of the year there is no limitation to the amount they can catch. With almost no control over catching young crabs/female crabs/or female crabs with eggs, compounded with the destruction of the crabs' natural habitat, current practices have led to a decline in the number of catches as reported by Htun Thein, et al., and the local population.

The World Bank Fishery Sector Report for Myanmar, published in 2019, concluded that the long-term sustainability and growth of crab farming will depend on the development of crab hatcheries. At hatcheries, crab eggs are hatched, and crab breeds are fed through the early life stages in nurseries until they reach a sufficient size and weight to be sold to farmers. Ideally, hatcheries are integrated with nurseries, and can range from specialized, small, unsophisticated units, to large, sophisticated and environmentally controlled installations (Fox et al, 2017). In Myanmar, there have been two attempts to develop a mud crab hatchery. Both with the same

objective, replenishing wild stocks by releasing crablets into the wild. The first hatchery was developed by the Yangon Technological University and ran between 2002-2003. Unfortunately, the team was not successful in their attempts and did not manage to pass the zoea fourth stage without experiencing high mortality rates. The second one, developed in CahungThar and run by the Department of Fisheries between 2009 and 2010, was not successful due to high mortality rates. One of the reasons was that the feeding technique used was developed for *Scylla serrata* and may have not been suitable for *Scylla olivacea* (Yadanar, K, 2014).

Recently it was reported[1] that in the second quarter of this year (2019), the Myanmar Sustainable Aquaculture Program (MYSAP)[1] and a private foreign joint venture breeding firm, had initiated a pilot program for crab breeding in the Labutta District, Ayeyarwady Region. The breeding farm expects to produce around 100,000 crabs in its first harvest within two months. At the time of preparing this report, the cost of crab seeds was not yet known, therefore, the selling price of the crabs to farmers was not determined. The importance of hatcheries as a mechanism for improving crab culture practices is highlighted in the FAO Manual for Mud Crab Culture. The report suggests that sourcing the crabs from the wild can be associated with relative low efficiency in culture practices reflected in a low densities of crab stocks (crabs/m^2). For example, when farming was solely based on collection of mud crabs from the wild, stocking rates found in Viet Nam were as low as 0.1-0.2 crabs/m^2. Now, with the availability of hatchery produced crablets, stocking is recorded at 1.0-1.5 crabs/m^2. (FAO, 2011).

Production - Fattening

Mud crab fattening essentially involves stocking crabs and holding them until their shells have hardened, reaching the preferred size and weight to be sold alive to local traders or agents. In the Ayeyarwady Delta, Yadanar, K. (2014), identified through his study two types of mud crab culture, fattening (intensive aquaculture) and grow-out (natural or extensive aquaculture) practices. His findings mentioned that grow-out culture was very scarce to find in the study area of Bogalay Township. GGGI's assessments have also identified two types of mud crab culture, intensive crab fattening (ICF) and extensive or natural crab fattening (NCF). Also, it was observed monoculture, polyculture, silvofishery and rice-fishery farming practices.

In the area of interest, practices of intensive and natural crab fattening were particularly differentiated by the time of the cycle of fattening and the use of feed for fattening the crab. Given the cannibal nature of mud crabs, polyculture practices were observed together with other marine animals in earthen brackish water dikes to maximize the space. Crabs were cultured with one or two animals such as fish (seabass) and shrimp. In the case of ICF practices, crabs were also fed with trash fish acquired at low price.

Both practices, intensive and natural crab fattening, were reported to be practiced with mangrove trees within the ponds[2]. Farmers practiced the crab fattening in earthen dikes and inners canals with inlet and outlet water sluices gates. Both fattening practices can be developed with or without mangrove trees. However, it is strongly recommended to develop crab fattening practices together with mangrove cultivation in order to obtain a higher integration between mangrove's ecosystem services and aquaculture practices[3].

[1] MYSAP is an aquaculture development project (2017-2021) implemented by MOALI and the German international development agency, GIZ.

[2] Based on University of Queensland's assessment and data collection report.

[3] Refer to the recommended mud crab aquaculture practices presented in the Economic Appraisal of Ayeyarwady Mangrove Forest report.

Figure 6: Intensive Crab Fattening (Left) and Natural Crab Fattening (Right)

Regarding intensive crab fattening, three types of practices were identified in the area of interest. Two of them practiced by farmers and one practiced by middlemen. Intensive crab fattening practiced by farmers were categorized by a fattening cycle of approximately two months, with six cycles per year. Farmers reported acquiring crabs from fishers with an approximate weight of 50 grams per crab. The first type of practice handled by farmers was characterized by the use of feed for crab fattening, a higher average survival rate (0.82), and a higher average crab weight upon harvest (113 grams). (See Table 5). The second type of practice handled by farmers was characterized by the non-use of feed for crab fattening, a lower average survival rate (0.65), and a lower average crab weight upon harvest (100 grams). (See Table 6). The third type of ICF practice was identified to be handled by middlemen. This practice was characterized by a shorter cycle of fattening (approximately 3 weeks), acquiring crabs for fattening with an approximate weight of 110 grams, a high survival rate of 0.9, and an average crab weight upon harvest of 150 grams. (See Table 7). Middlemen crab fattening was practiced in pens made of bamboo, keeping crabs acquired from farmers to fetch higher prices.

With respect to natural crab fattening, two types of practices were identified in the area of interest, both handled only by farmers. The first type of natural crab fattening was characterized by the acquisition of crab seeds for fattening, one cycle per year with an average duration of 10 months, an average survival rate of 0.68, and an average crab weight upon harvest of 125 grams. The second type of NCF was characterized by the non-acquisition, nor catching of crab seeds (natural supply of crabs), one cycle per year with an average duration of 4 months (only during rainy season), and an average crab weight upon harvest of 100 grams.

For both practices, once the crab's shells have hardened, and before they molt again, the crabs are harvested. Farmers mentioned that they rarely hired paid work. They count with the involvement of family members that do not receive money in terms of wage. Also, 30% of ICF farmers reported having been involved in mangrove restoration practices, whereas 35% of NCF farmers reported their involvement in this kind of practices.

Finally, after rejecting non-marketable crabs, fatteners trade the crabs through middlemen who can be either sub collector or collectors. They are in charge to place the product for export and domestic consumption in restaurants and hotels.

Table 3: Crab Fattening Practices Observed in the Area of Interest

		INTENSIVE CRAB FATTENING (ICF)			INTENSIVE CRAB FATTENING (ICF)	
	Unit	Farmers' 1st Type	Farmers' 2nd Type	Middlemen	Farmers' 1st Type	Farmers' 2nd Type
Fattening Cycle Duration	Months	2	2	0.75	10	4
Number of Cycles per Year	# Cycles	6	6	12	1	1
Use of Crab Feed	YES OR NO	YES	NO	YES	NO	NO

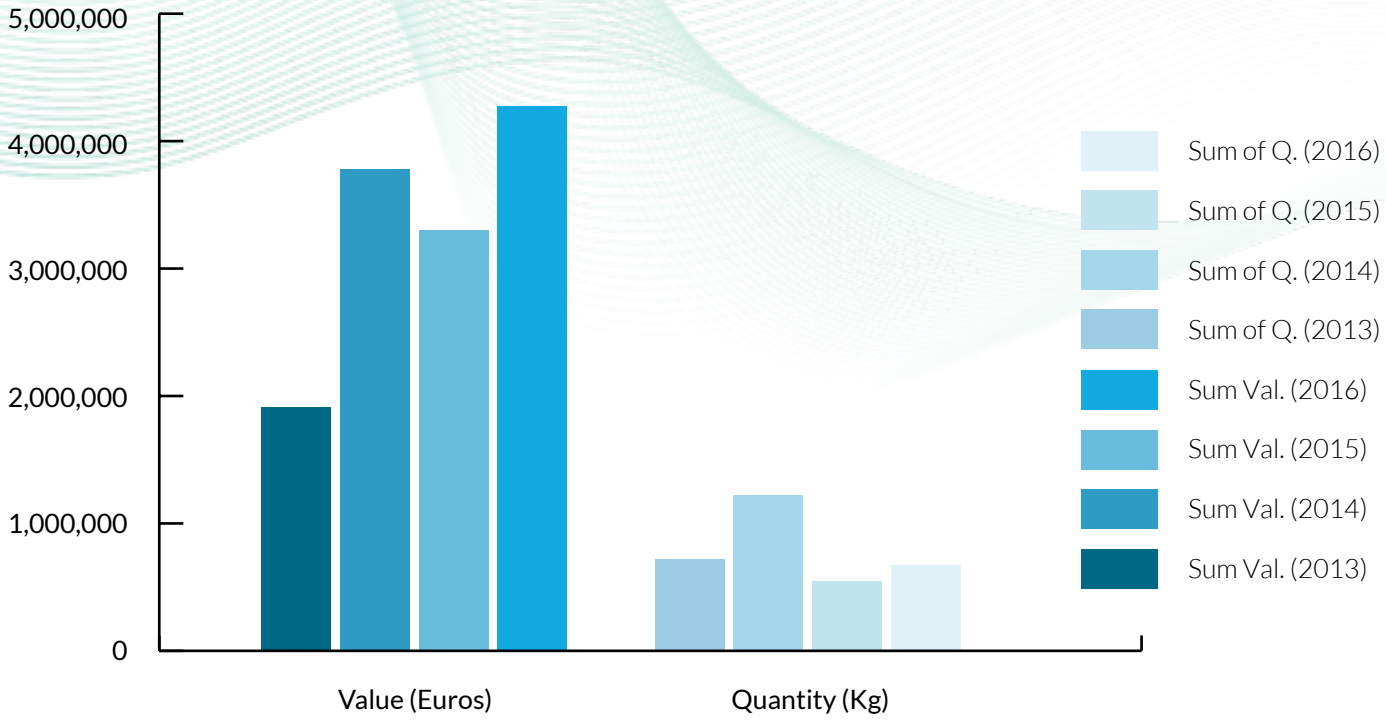
Intermediaries and Final Market

Fatteners sell crabs to traders who transport them to Yangon and further to China. In Bogalay Township, mud crab marketing channels were considered to be simple, starting from wild crab catchers and passing through a certain number of intermediaries such as farmers, middlemen (sub collector and collector) and the exporter to foreign countries. Almost all mud crabs were exported and sold to large domestic hotels and restaurants. Exporters were reported to reside in the capital, most of them private agents that ran their trading with joint ownership (Yadanar, K., 2014). A systematic trading network has been established to transport crabs in order to reach the final markets and restaurants still alive. It was observed that transportation needed for mud crab was simple in the Ayeyarwady Delta.

Several issues about licenses needed for mud crab commercialization were discussed during consultations. Middlemen and fatteners are required to pay a fee based on the amount of mud crab sold. This fee is supposed to be paid to the Department of Fishery at the township level. However, available information and informality did not allow to clearly identify how this system properly works. Another tax required to be paid by middlemen is reported by Yadanar K. (2014). This sort of annual tax has to be paid for releasing awful odor to the surroundings by keeping large amount of crabs. This is also applied to any other business that would affect the environment.

Live mud crab exports play an important role to the foreign exchange earnings of Myanmar. China has emerged as an important export destination. According to GGGI's market assessment, exports of live crabs to China have increased as observed in Figure 9. Exports experienced a significant increase from 2013 to 2014, slightly fell in 2015, and rebounded in 2016. Access to cross-border transportation systems and the ease of transportation without cold storage, has promoted this commercial exchange.

Figure 7: China Live Crab Imports from Myanmar (2013-2016)



Source: Author. Information from Trade Map (ITC)

SWOT Analysis

Table 4: SWOT Analysis for Crab Fattening

	HELPFUL FOR THE ACTIVITY	HARMFUL FOR THE ACTIVITY
INTERNAL TO THE ACTIVITY	**STRENGHTS** • Income generating activity for landless households. • Crab farming is less vulnerable to effects of climate change and deterioration of water quality. (Khan & van Weelden, 2017). • Crab farming can be practiced in an ecologically friendly way, complemented with mangrove restoration. • Can be developed using locally available low-cost materials. • Market allocation through trading networks is relatively well developed. • Gender inclusive, with women contributing in crab farming practices.	**WEAKNESSES** • Lack of hatcheries for sustainable seed production. • Unsustainable capture of crabs from natural habitats (young crabs/female crabs/or female crabs with eggs). • Lack of training for product management. Dependency on price set by traders. • Illegal trading of very small crabs for export (less than 100 grams). • Poor aquaculture operations can lead to outbreak of diseases, deformities, injuries, and stress in crabs. • Use of chemicals and antibiotics can have negative effects on the local environment, animals, plants and lead to increased antibiotic resistance.
EXTERNAL TO THE ACTIVITY	**OPPORTUNITIES** • Some abandoned farming areas can be potentially transformed for mud crab culture without damaging mangrove forests. • Activity compatible with Community Forest development. • Rights and community fishery support from the Ayeyarwady Freshwater Fishery Law (2018). • Domestic and international demand has high growth potential (specially for China).	**THREATS** • Decrease in wild fishery stocks due to external factors (mangrove degradation, outbreak of disease, and climate events). • Production yield negatively affected by brackish water and fertilizer pollution from agricultural areas. • Aquaculture practices constrained by the Farmland Law (2012) and the VFV Land Law (2012). • Formal credit is not available to most small-scale farmers. Most of them are involved in informal financial schemes.

Financial Analysis – Intensive Crab Fattening vs. Natural Crab Fattening

Based on the objective of this report, a cost-benefit analysis was developed for ICF and NCF practices in order to determine the economic attractiveness of these activities and support them as alternative economic activities to reduce the pressure and dependence on mangrove wood commercialization. Considering the different types of ICF and NCF practices observed in the field, the following analysis also aims to recommend potential improvements in practices as a mechanism to enhance farmer's livelihoods while protecting and conserving mangrove forests.

The cost-benefit analysis for ICF and NCF considered labor costs based on the time and effort required to fully handle the activity. In order to reach a comparable base, a unit of 1 year was used for analyzing the different types of practices observed within ICF and NCF.

Table 5: Cost-benefit Analysis – First Type of Farmers' Intensive Crab Fattening Practices

*Exchange Rate Kyat to USD	1,528	LOWEST ANNUAL NET INCOME CASE		AVERAGE		HIGHEST ANNUAL NET INCOME CASE	
Item	Unit	Total	Total	Total	Total	Total	Total
Income	**Kyat/USD**	**6,598,125**	**4,317**	**11,926,021**	**7,803**	**15,120,000**	**9,893**
Fattening cycles in a year	# of cycles	6		6		6	
Cycle duration	# months	2		2		2	
Total quantity of fattened crabs traded	# crabs (annual)	9,000		14,900		12,600	
Survival rate	%	0.85		0.82		0.80	
Average crab weight upon harvest	Kg	0.100		0.113		0.150	
Average selling price per Kg	Kyat	8,625		8,993		10,000	

Operational Costs	**Kyat/USD**	**4,656,000**	**3,047**	**8,752,667**	**5,727**	**9,180,000**	**6,007**
Cost of crabs acquired for fattening	%	64.4%		77.5%		78.4%	
Maintenance costs	%	2.3%		2.6%		3.9%	
Feeding costs	%	1.3%		3.2%		2.0%	
Labor costs	%	25.8%		14.7%		13.1%	
Other operational costs	%	6.2%		2.0%		2.6%	
Net Income from ICF	**Kyat/USD**	**1,942,125**	**1,271**	**3,173,354**	**2,076**	**5,940,000**	**3,887**
Net margin	**%**	**29.43%**		**25.75%**		**39.29%**	
Benefit to cost ratio (BCR)	**Ratio**	**1.42**		**1.39**		**1.65**	
Income per crab	Kyat/USD	733	0.48	843	0.55	1,200	0.79
Operational cost per crab	Kyat/USD	517	0.34	606	0.40	729	0.48
Earnings per crab	Kyat/USD	216	0.14	237	0.16	471	0.31

As shown in Table 5, the first type of farmers' intensive crab fattening practices were found to be profitable. The average quantity of fattened crabs traded in a year was 14.900 crabs, with an average selling price of 8,993 MMK per kilogram. For this practice, the greatest share of the operational costs came from the crabs acquired for fattening (77.5%). This was followed by the labor costs (14.7%), the feeding costs (3.2%), and other operational costs (2%) that included transportation, license fees, and any additional input required for this activity. The net margin was found to be on average 25.75%, with an average benefit to cost ratio of 1.39, highlighting its economic attractiveness. Two main characteristics should be noticed from the highest annual income case. First, the average crab weight upon harvest is greater than the average (150 grams versus 113 grams upon harvest), and second, the average selling price per kilogram is 10.000 MMK, which is related to the first characteristic.

Given that the second type of farmers' ICF practices reported operating losses in all cases when considering labor costs, the analysis for this type of ICF practice followed a different approach. The information analyzed was the same, but the interest of the analysis was focused in understanding the operations considering labor costs and omitting labor costs as shown in the table below.

Table 6: Cost-benefit Analysis – Second Type of Farmers' Intensive Crab Fattening Practices

*Exchange Rate Kyat to USD	1,528	AVG. OPERATIONS WITH LABOR COST		AVG. OPERATIONS WITHOUT LABOR COST	
Item	Unit	Total	Total	Total	Total
Income	**Kyat/USD**	**2,381,400**	**1,558**	**2,381,400**	**1,558**
Fattening cycles in a year	# of cycles	6		6	
Cycle duration	# months	2		2	
Total quantity of fattened crabs traded	# crabs (annual)	4,470		4,470	
Survival rate	%	0.65		0.65	
Average crab weight upon harvest	Kg	0.100		0.100	
Average selling price per Kg	Kyat	7,750		7,750	
Operational Costs	**Kyat/USD**	**2,724,000**	**1,782**	**2,130,000**	**1,394**
Cost of crabs acquired for fattening	%	64.4%		82.4%	
Maintenance costs	%	7.2%		9.2%	
Feeding costs	%	0.0%		0.0%	
Labor costs	%	21.8%		0.0%	
Other operational costs	%	6.6%		8.5%	
Net Income from ICF	**Kyat/USD**	**-342,600**	**-224**	**251,400**	**164**
Net margin	**%**	**-19.88%**		**15.01%**	
Benefit to cost ratio (BCR)	**Ratio**	**0.84**		**1.20**	
Income per crab	Kyat/USD	505	0.33	505	0.33
Operational cost per crab	Kyat/USD	605	0.40	434	0.28
Earnings per crab	Kyat/USD	-100	-0.07	71	0.05

One main characteristic of the second type of ICF practice is that farmers do not incur feeding costs. Despite this fact, all farmers practicing this type of ICF reported net losses when considering labor costs. Based on the analysis, this type of ICF practice does not provide further benefits than to pay their labor as opportunity cost. One main characteristic reported by farmers practicing this type of ICF was that the average crab weight upon harvest was only 100 grams. Weight at which they commercialize with middlemen at an average price of 7.750 MMK. Finally, the average crab survival rate is lower than the first type analyzed at 0.65, reflecting a low aquaculture efficiency given the cannibalistic nature among the same crabs.

The third type of ICF observed was handled by the middlemen, who acquired crabs from farmers with an average weight of 117 grams and placed them in the market at 150 grams per crab after a period of approximately one month of fattening. As for the first type of ICF, the greatest share of the operational costs came from the crabs acquired for fattening (89.12%). Compared to the first type of farmers' ICF practices, the average net margin and the average BCR of middlemen ICF practices are lower (12.77% and 1.21 respectively). However, the average annual net income of middlemen ICF practices represent 1.67 times the average annual net income of the first type of farmers' ICF practices. The greatest benefits come from a larger and faster operational scale, which also represents the need for greater cash flow to cover the operational costs, a limitation for farmers considering their poor access to financial resources.

Table 7: Cost-benefit Analysis – Third Type of Intensive Crab Fattening Practices - Middlemen

*Exchange Rate Kyat to USD	1,528	LOWEST ANNUAL NET INCOME CASE		AVERAGE		HIGHEST ANNUAL NET INCOME CASE	
Item	Unit	Total	Total	Total	Total	Total	Total
Income	**Kyat/USD**	**24,300,000**	**15,900**	**39,425,400**	**25,797**	**56,430,000**	**36,923**
Fattening cycles in a year	# of cycles	12		12		12	
Cycle duration	# months	0.75		0.75		0.75	
Total quantity of fattened crabs traded	# crabs (annual)	15,000		24,180		33,000	
Survival rate	%	0.90		0.90		0.95	
Average crab weight upon harvest	Kg	0.150		0.150		0.150	
Average selling price per Kg	Kyat	12,000		12,000		12,000	

Operational Costs	**Kyat/USD**	**22,230,000**	**14,546**	**34,112,000**	**22,320**	**48,396,000**	**31,667**
Cost of crabs acquired for fattening	%	86.37%		89.12%		89.26%	
Maintenance costs	%	0.00%		0.00%		0.00%	
Feeding costs	%	2.16%		1.41%		1.24%	
Labor costs	%	6.07%		5.28%		5.58%	
Other operational costs	%	5.40%		4.20%		3.92%	
Net Income from ICF	**Kyat/USD**	**2,070,000**	**1,354**	**5,313,400**	**3,477**	**8,034,000**	**5,257**
Net margin	**%**	**8.52%**		**12.77%**		**14.24%**	
Benefit to cost ratio (BCR)	**Ratio**	**1.16**		**1.21**		**1.23**	
Income per crab	Kyat/USD	1,620	1.06	1,620	1.06	1,710	1.12
Operational cost per crab	Kyat/USD	1,392	0.91	1,338	0.88	1,385	0.91
Earnings per crab	Kyat/USD	228	0.15	282	0.18	325	0.21

Regarding NCF, two types of natural crab fattening practices handled only by farmers were observed in the field. The first type of farmers' NCF practices were found to be profitable as shown in Table 6. The average quantity of fattened crabs traded in a year was 3.783 crabs, with an average selling price of 8.833 MMK per kilogram. For this practice, the greatest share of the operational costs came also from the crabs acquired for fattening (66.1%). The net margin was found to be on average 32.48%, with an average benefit to cost ratio of 1.49, highlighting its economic attractiveness. However, comparing this practice with the first type of farmers' ICF practices, the average annual net income from farmers' NCF is approximately one third of the average annual net income from farmers' ICF practices.

The main reason is behind the amount of crabs traded over a year. One important characteristic should be noticed from this first type of NCF practice. The average crab survival rate is 0.68, reflecting a low aquaculture efficiency given the cannibalistic nature among the same crabs. Sourcing crab seeds with different sizes and weight for the fattening cycle increases the likelihood of crabs eating each other.

Table 8: Cost-benefit Analysis – First Type of Farmers' Natural Crab Fattening Practices

*Exchange Rate Kyat to USD	1,528	LOWEST ANNUAL NET INCOME CASE		AVERAGE		HIGHEST ANNUAL NET INCOME CASE	
Item	Unit	Total	Total	Total	Total	Total	Total
Income	**Kyat/USD**	**2,160,000**	**1,413**	**2,866,875**	**1,876**	**3,622,500**	**2,370**
Fattening cycles in a year	# of cycles	1		1		1	
Cycle duration	# months	5		10		12	
Total quantity of fattened crabs traded	# crabs (annual)	3,600		3,783		4,600	
Survival rate	%	0.60		0.68		0.70	
Average crab weight upon harvest	Kg	0.125		0.125		0.125	
Average selling price per Kg	Kyat	8,000		8,833		9,000	
Operational Costs	**Kyat/USD**	**1,630,000**	**1,067**	**1,929,778**	**1,263**	**2,298,667**	**1,504**
Cost of crabs acquired for fattening	%	61.3%		66.1%		74.0%	
Maintenance costs	%	12.3%		7.5%		7.3%	
Feeding costs	%	0.0%		0.0%		0.0%	
Labor costs	%	11.0%		20.8%		18.8%	
Other operational costs	%	15.3%		5.6%		0.0%	

Net Income from ICF	**Kyat/USD**	**530,000**	**347**	**937,097**	**613**	**1,323,833**	**866**
Net margin	**%**	**24.54%**		**32.48%**		**36.54%**	
Benefit to cost ratio (BCR)	**Ratio**	**1.33**		**1.49**		**1.58**	
Income per crab	Kyat/USD	600	0.39	756	0.49	788	0.52
Operational cost per crab	Kyat/USD	453	0.30	508	0.33	500	0.33
Earnings per crab	Kyat/USD	147	0.10	248	0.16	288	0.19

Finally, given that the second type of farmers' NCF practices were reported to be practiced only during the rainy season and as a secondary economic activity, the analysis for this type of NCF followed the interest of understanding its operations considering labor costs and omitting labor costs as shown in the table below.

Table 9: Cost-benefit Analysis – Second Type of Farmers' Natural Crab Fattening Practices

**Exchange Rate Kyat to USD*	*1,528*	AVG. OPERATIONS WITH LABOR COST		AVG. OPERATIONS WITHOUT LABOR COST	
Item	Unit	Total	Total	Total	Total
Income	**Kyat/USD**	**232,000**	**152**	**232,000**	**152**
Fattening cycles in a year	# of cycles	1		1	
Cycle duration	# months	4		4	
Total quantity of fattened crabs traded	# crabs (annual)	384		384	
Survival rate	%	0.00		0.00	
Average crab weight upon harvest	Kg	0.100		0.100	
Average selling price per Kg	Kyat	6,000		6,000	

Operational Costs	**Kyat/USD**	**199,143**	**130**	**119,143**	**78**
Cost of crabs acquired for fattening	%	0%		0%	
Maintenance costs	%	29%		48%	
Feeding costs	%	0.0%		0.0%	
Labor costs	%	40%		0.0%	
Other operational costs	%	31%		52%	
Net Income from ICF	**Kyat/USD**	**32,857**	**21**	**112,857**	**74**
Net margin	**%**	**11%**		**47%**	
Benefit to cost ratio (BCR)	**Ratio**	**1.16**		**1.93**	
Income per crab	Kyat/USD	600	0.39	600	0.39
Operational cost per crab	Kyat/USD	519	0.34	310	0.20
Earnings per crab	Kyat/USD	81	0.05	290	0.19

Two main characteristics of the second type of NCF practice is that farmers do not acquire crabs for the fattening process, nor incur in feeding costs. However, this practice is only held during the rainy season (approximately 4 months) in order to source the crabs naturally for the fattening cycle. This practice covers the opportunity cost of labor with a non-significant gain for every crab traded compared to the previous practices analyzed.

Dried Food Products (Solar Dome Dryer[4])

The analysis of this value chain is based on the opportunity of implementing a solar-dome dryer facility for processing fishery and agroforestry harvests. The SDD is a processing plant that can be easily transported, assembled on site with minimal training for its operation, and its maintenance is neither costly nor complicated.

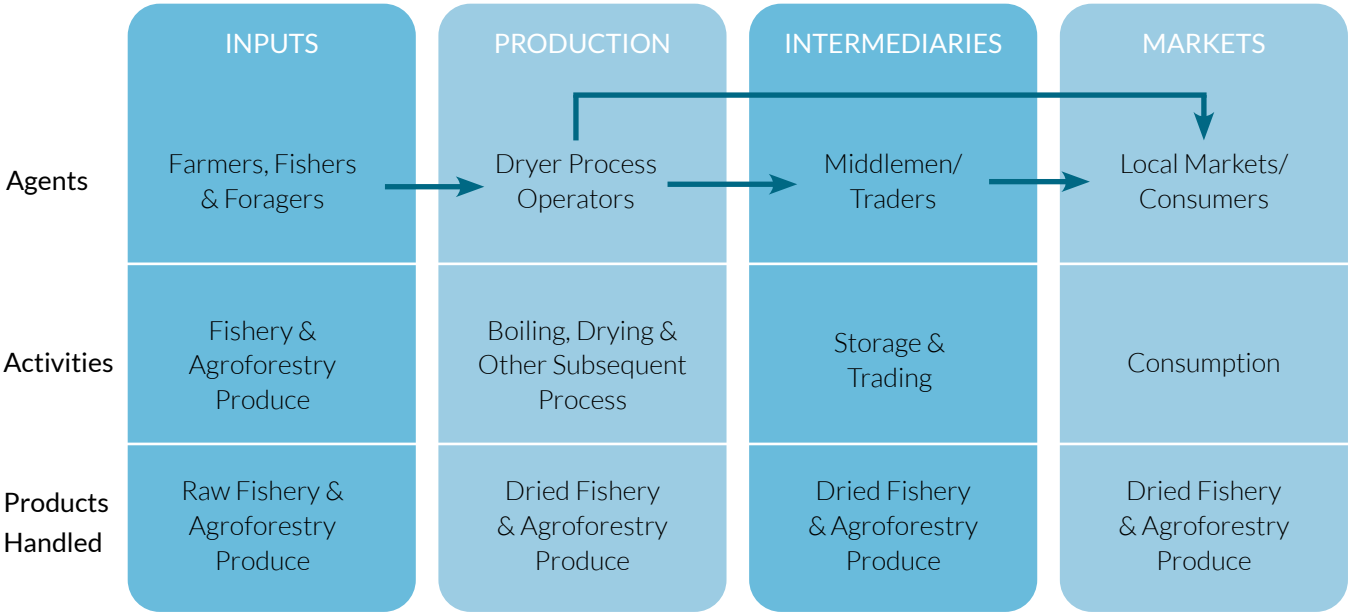
[4] Most of the information contained in this subsection was sourced from the SDD supplier based in Myanmar.

The benefits of using SDD includes reducing the amount of mangrove wood used for drying during the rainy season, reducing the post-harvest product waste, getting greater value for final produce, promotion of green energy use, and can be inclusively developed, which can lead to poverty reduction. While data on the implementation of such dryers is still at a minimum, there is a private company in Myanmar which has already installed more than forty of this type of SDD in the Rakhine area. The SDD supplier company has expressed interest in expanding its operations to the Ayeyarwady Delta region.

Figure 8: Solar Dome Dryer in the Field[4]

Functional Value Chain Analysis

Figure 9: Functional Value Chain Analysis of Dried Products



Input Source

In the Delta, the daily diet includes the consumption of dried products such as shrimp (*Penaeidae spp.* and *Penaeus spp.*), fish (multiple species), and products collected like fruits and vegetables. These perishable products are collected and caught by landless people and farmers, and further processed for self-consumption or local commercialization. Currently, there are problems of food waste due to mishandling perishable products, as well as local reports of a declining trend in the collection of aquatic resources,

[5] Source: https://www.naturalfarmfreshmyanmar.com/

especially shrimp.

Among the products collected and caught for further processing, the shrimp is the main product given the importance of it in the Delta's menu. (ILO, 2016). Considering that shrimp has been identified as one of the most important dried products commercialized in the area, the analysis of this value chain, from input source to market allocation, focuses primarily on this commodity.

Production

Fishery actors preserve their catch by icing, salting, smoking and sun drying. In the Delta, the practice to produce dried shrimps requires them to be cooked (using fuelwood), removed the excess of water, and sun dried usually up to two days. Much of the conventional drying process is still done in the open air, in a disorganized and unhygienic process. Open air drying is often done over the ground using a mat. During the rainy season, the drying process is done using mangrove fuelwood through traditional dryers. It was reported that around 4 to 5 bundles of mangrove fuelwood were used for drying 1 viss (approx. 1.6329 kg) of shrimp. When considering other products that do not required the cooking process, 100% of the fuelwood acquired is utilized for drying the produce. Overall, a significant portion of the products are contaminated by dust and pests like rodents and insects. This negatively affects the commercial economic value by 30 to 50 percent. Dried products then are stored for self-consumption or further commercialized, facing low trading prices as a consequence of low quality.

According to the analysis of Industrial Fuelwood and Charcoal Consumption prepared by the Myanmar Survey Research in the Ayeyarwady Delta (2019), fishery drying businesses (below 20 employees) mostly rely only on fuelwood for the drying process. Only few use a second or third energy source, such as rice husk, charcoal, solar power, kerosene and in one case electricity. Even though the rubber tree (*Hevea braziliensis*) is the main type of wood used by fish drying facilities, around 21% of the wood used for drying is Thit Mhae, a type of mangrove (*Sonneratia alba*). The volume of fuelwood consumption averages 13.281 viss per month for fish drying facilities, with variations related to production and size of the different facilities.

Using a SDD is reported by its manufacturer to help farmers, fishers and foragers processing their harvest with better quality than open air drying. SDD can provide farmers, fishers and foragers with significant postharvest losses reduction and allows their produce to have a longer shelf life. The SDD also allows for proper drying in shorter periods of time as well as during the rainy season. The temperature inside the SDD can increase up to two times higher than the outside temperature, making it possible to significantly shorten the drying process time. For example, fish and shrimp can be dried in just one and a half days instead of two days if using the conventional open-air drying method. In addition, small fans adapted in the SDD enable air circulation and remove moisture from the SDD, preventing the development of mold.

Figure 10: Traditional sun drying process of shrimp, Ayeyarwady Delta.

Intermediation and Market Allocation

As mentioned before, the dried shrimp is one of the most popular items in Myanmar's menu. It is widely used in salads, soups and condiments with an average consumption of 0.4Kg per capita per year. The estimated total consumption of dried shrimp in Myanmar is approximately 21,600 tons per year, with a likely future trend of higher demand due to population growth. (ILO and NORAD, 2016).

SWOT Analysis

Table 10: SWOT Analysis for Solar Dome Dryer

	HELPFUL FOR THE VALUE CHAIN	HARMFUL FOR THE VALUE CHAIN
INTERNAL TO THE VALUE CHAIN	**STRENGHTS** • Inclusive income generating activity for communities. • Allows processing (drying) throughout the year. • Hygienic (no dust, no animals, no foreign materials, etc.) and quality (color, taste, skin) improvement. • Reduction of food waste and post-harvest losses. • Avoids using mangrove wood for the drying process during the rainy season. • Shorter period required for drying and longer shelf life for products processed. • Gender inclusive, with potential major participation of women in the drying process and management of the business.	**WEAKNESSES** • No track record of solar-dome development in the Ayeyarwady Region, yet. • Lack of access to finance for purchasing SDD.
EXTERNAL TO THE VALUE CHAIN	**OPPORTUNITIES** • Intention from government to support community forest and the development of non-timber products and value-added products. • Interest of a company that manages solar domes to start operations in the Delta. • Local market opportunity for dried products, especially for the popular dried shrimp.	**THREATS** • Aquatic resources negatively affected by mangrove deforestation and agriculture contamination. • Infrastructure (solar dome) can be destructed by climate events. • Local market not willing to pay more for higher quality or greater production standards. • Other hygienic issues, that do not depend on the solar dome processing, need to be improved. • Lack of transparency, communication, and data sharing. • Formal credit is not available to most small-scale farmers. Most of them are involved in informal financial schemes.

Solar Dome Dryer Business Case and Financial Analysis

The financial analysis follows two steps. First, a cost-benefit analysis shows the operational difference between drying through current practices and drying with the solar-dome facility. Second, the financial analysis aims to determine the number of years that it will take to break even from undertaking the initial investment for installing the facility. For this, the analysis follows certain characteristics from the leasing scheme that the supplier company provides, such as the investment required for the facility, the discount interest rate, and the leasing time that the company has established as a reference point.

Lack of field data from the area of interest and considering that, at the moment there are no reported cases of an implementation of a solar-dome dryer, prompted the creation of an example case analysis following two assumptions. First, the following financial analysis has only considered the processing of only one commodity: shrimp. Second, considering the capacity of the smallest SDD facility offered by a company in Myanmar , the financial analysis has been developed with a fix processing amount of 200 kg of shrimp. The table below presents the data taken into consideration for the financial analysis of current drying practices. The data was provided by field observation and by the company supplying the facility. The information was later validated through public and private consultation, proceeding to analyze it with conservative figures.

Table 11: Information employed for analyzing current drying processes (product: Shrimp)

	UNIT	JAN	FEB	MAR	APR	MAY	JUN	DAYS IN YEAR
Days per month	Days	31	28	31	30	31	30	365
Region - Average precipitation	Days	0	0	0	3	13	23	121
Average days available for sun-dry per month	Days	31	28	31	27	18	7	244
Average days NOT available for sun-dry per month	Days	0	0	0	3	13	23	121

[6] Natural Farm Fresh Myanmar Co., Ltd.

	UNIT	JUL	AUG	SEP	OCT	NOV	DEC	DAYS IN YEAR
Days per month	Days	31	31	30	31	30	31	365
Region - Average precipitation	Days	25	25	18	10	4	0	121
Average days available for sun-dry per month	Days	6	6	12	21	26	31	244
Average days NOT available for sun-dry per month	Days	25	25	18	10	4	0	121

Number of days required for sun-dry	Days	2
Number of days required to dry with fuelwood	Days	2
Number of sun-dry processes per year	Units	122
Number of fuelwood dry processes per year	Units	61
Total processes per year	***Units***	***183***
Amount of shrimp acquired for processing	Kilogram	200
Price of shrimp acquired for processing	Kyat/kg	2,745
Fuelwood for boiling process	bundle/kg	1.22
Fuelwood for drying process when rainy days	bundle/kg	2.44
Price of fuelwood	per bundle / Kyat	500
Out-turn ratio (of shrimp processed)	%	11.25%
Price of dried shrimp	Kyat/kg	36,600
Labor Cost per day per man	Labor/day/man	5,000
Number of people required for processing 200kg	Man	10
Kyat to USD exchange rate	USD/Kyat	1,528.30

The cost-benefit analysis for current drying processes shows a positive net income with a net margin of 3%. The greatest share of operational costs comes from the cooking process which includes the acquisition of the shrimps and the cost of fuelwood required for cooking. Considering the rainy season, the operational costs are distributed between the resources required for cooking, drying, and labor. In this case, the drying operational cost only includes the fuelwood required for the drying process. Of all the fuelwood utilized for one year of processing (cooking and drying), around 40% is exclusively utilized for drying the shrimp during the rainy season.

Table 12: Cost-benefit Analysis for Current Drying Operational Practices (product: Shrimp)

ANNUAL OPERATIONAL INFORMATION		
Income	**100%**	Fuelwood Utilized
Total drying processes in a year	183	
Operational costs	**97%**	
From sun-drying	60%	
Cooking	93%	40.20%
Labor	7%	
From fuelwood drying	40%	
Cooking	70%	19.93%
Drying	25%	39.87%
Labor	5%	
Net Income	**3%**	

The information for analyzing the economic attractiveness of implementing a SDD was mostly provided by the company supplying the facility. (See Table 13 and Table 14). According to the company, the SDD works like a greenhouse. It decreases the time required for drying up to 40%. It reduces the losses caused by the spoilage/wastage up to 50%. Its main advantages are the quality improvement which drives greater prices and its operability during the rainy season, replacing the use of fuelwood for the drying process.

For analyzing the implementation of the solar-dome dryer facility, the information presented in the following two tables were considered. Two variables, number of days required to dry with the SDD and the improvement in price, were conservatively modeled when analyzing the impact of implementing the solar dome dryer facility.

Table 13: Information employed for analyzing drying processes through the SDD (product: Shrimp)

DRYING PROCESS WITH SOLAR DOME		
Efficiency - use of the installation	%	100%
Number of days required to dry with SDD	Days	1.4
Number of SDD processes per year	Units	261
Amount of shrimp acquired for processing	Kilogram	200
Price of shrimp acquired for processing	Kyat/kg	2,745
Fuelwood for boiling process	bundle/kg	1.22
Price of fuelwood	per bundle / Kyat	500
Out-turn ratio	%	11.25%
Price of dried shrimp	Kyat/kg	36,600
Current price of dried shrimp	***Kyat/kg***	***36,600***
Improvement in price (using SDD)	***Kyat/kg***	***0%***
Cost of maintenance of operational activities (per 200kg processed)	Kyat	10,000
Labor cost per day per man	Labor/day/man	5,000
Number of people required for processing 200kg	Man	10
Kyat to USD exchange rate	USD/Kyat	1,528.30
Inflation rate	%	10%
Discount rate (Discount rate used by the company when providing leasing)	%	13%

Table 14: Investment Required for Implementing a Solar Dome Dryer Facility (Capacity 200kg)

	UNIT	COST PER UNIT (MMK)	NUMBER OF UNITS	TOTAL COST	DURATION
Solar dryer parabolic dome - small size (design, supply, install)	Set	9,000,000	1	9,000,000	10 years
Foundation work for small size	Lot	1,500,000	1	1,500,000	10 years
Transportation, lodging, and outstation allowance for installer	Set	2,500,000	1	2,500,000	Once per installation
Total Investment Required (MMK)				13,000,000	

The implementation of the SDD facility shows a positive and improved net income with a net margin of 11%, eight percentage points greater than the current drying operational practices. As observed in the table below, the greatest share of operational costs comes from the cooking process which in this case also includes the acquisition of the shrimps and the cost of fuelwood required for cooking. Maintenance costs involves regular cleaning of the polycarbonate sheets and other components of the installation.

Compared to current practices, the implementation of the SDD eliminates the need to acquire fuelwood for drying; however, the implementation of the facility also increases the number of days available for processing. The increase in the number of days available for processing (from 183 to 261) implies a greater use of fuelwood for the cooking process. In this case, the decrease of the total use of fuelwood utilized during the year by implementing the SDD only represents around 15 percent compared to the total annual fuelwood utilized by current practices. If the SDD facility is used for the same number of processes available for processing following current practices (183), then the reduction on fuelwood will represent around 40%. Nevertheless, using the facility for only 183 processes during the year instead of 261, represents a decrease in efficiency of 30%.

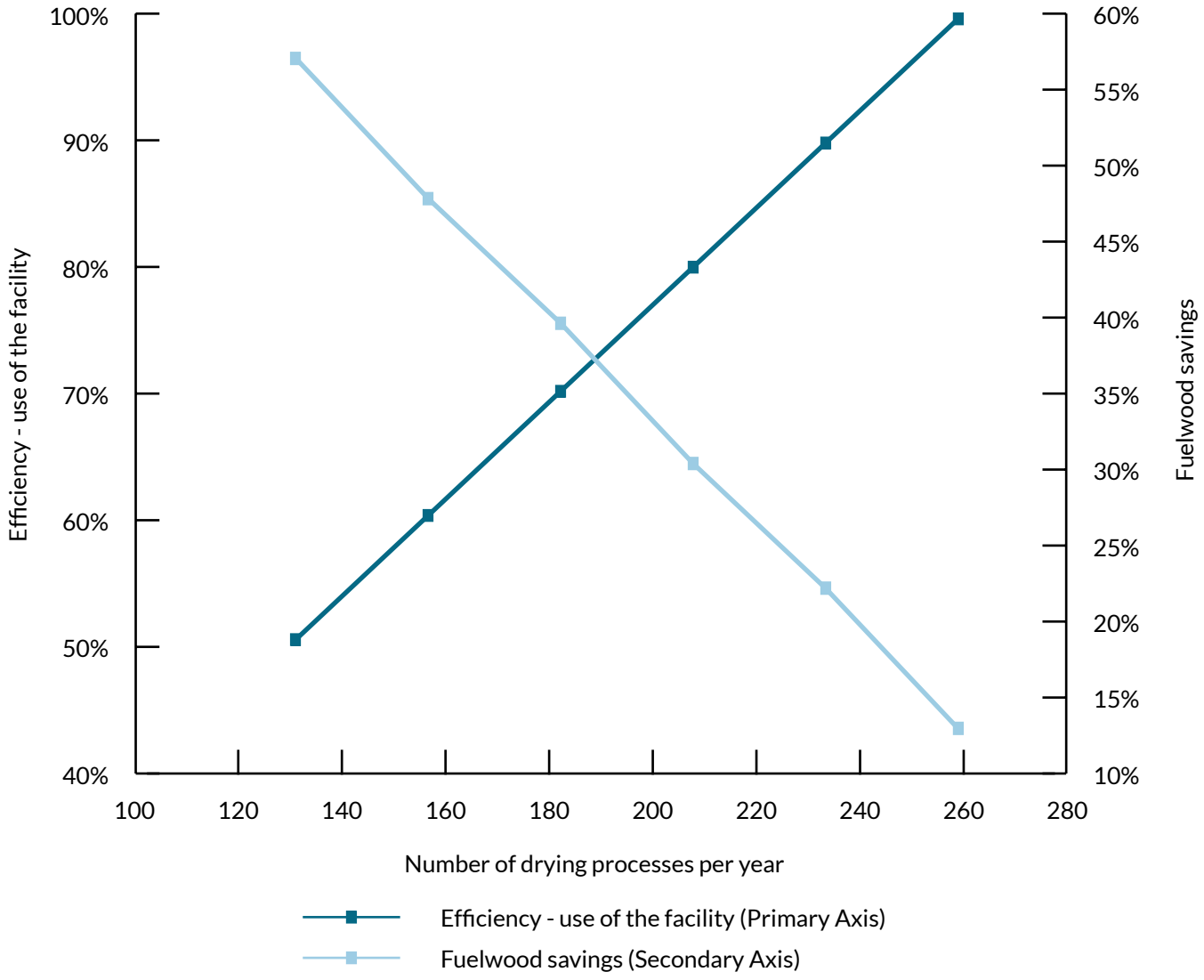
Table 15: Cost-benefit Analysis for Drying Operational Practices through the SDD (product: Shrimp)

ANNUAL OPERATIONAL INFORMATION		
Income	**100%**	Fuelwood Utilized
Total drying processes in a year (100% efficiency-use of installation)	261	
Operational costs	**89%**	
Cooking	92%	100%

Maintenance costs	1%	
Labor	7%	
Net Income	**11%**	
BCR (NPV Benefits / NPV Costs)	**1.257**	

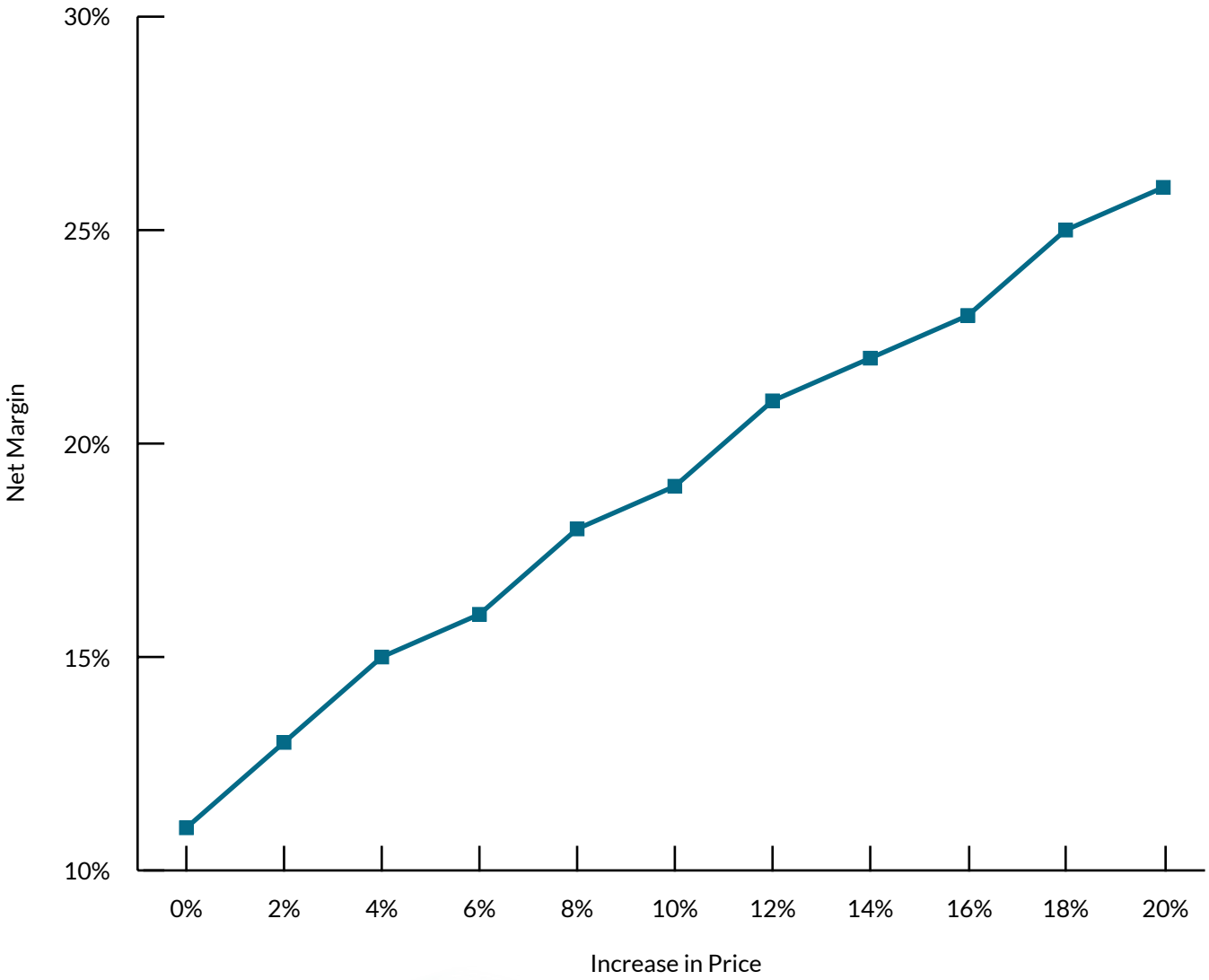
The following graph allows understanding better the relationship between the efficiency in using the SDD expressed in the number of drying processes during the year, and the consumption of fuelwood required for cooking purposes. The graph shows the total annual savings of fuelwood utilization compared to current practices when implementing the SDD.

Figure 11: Annual fuelwood savings from implementing the SDD compared to current practices, based on the number of drying processes in a year.



When implementing the SDD, it was observed that changes in the efficiency in utilizing the facility did not affect the net margin (11%). On the other hand, increases in the price given better quality of processed products showed to positively impact the net margin. The following graph shows how the net margin is affected by price increases up to 20%, the greatest price increase that can come from quality improvement according to the facility supplier.

Figure 12: Net Margin Changes given Price Increase for Quality Improvement



The discounted payback period (DPP) was analyzed considering the opportunity to collectively implement a SDD by groups of fishers, farmers, and forager communities and/or associations. In this case, the analysis included a potential group of 10 people, a discount rate of 13% that is used by the Myanmar company which provides the facility through leasing, and an investment of 13,000,000 MMK, which is the amount required to place a functioning SDD in the area of interest. Considering that the DPP period is sensitive to changes in the efficiency in use of the installation and price changes based on improved quality, a two-way sensitivity analysis was conducted to analyze the conditions to cover the required investment. The results interpretation considers the leasing scheme requirements provided by the SDD supplier company in Myanmar as a reference point.

Figure 13: Two-way Sensitivity Analysis for the Discounted Payback Period

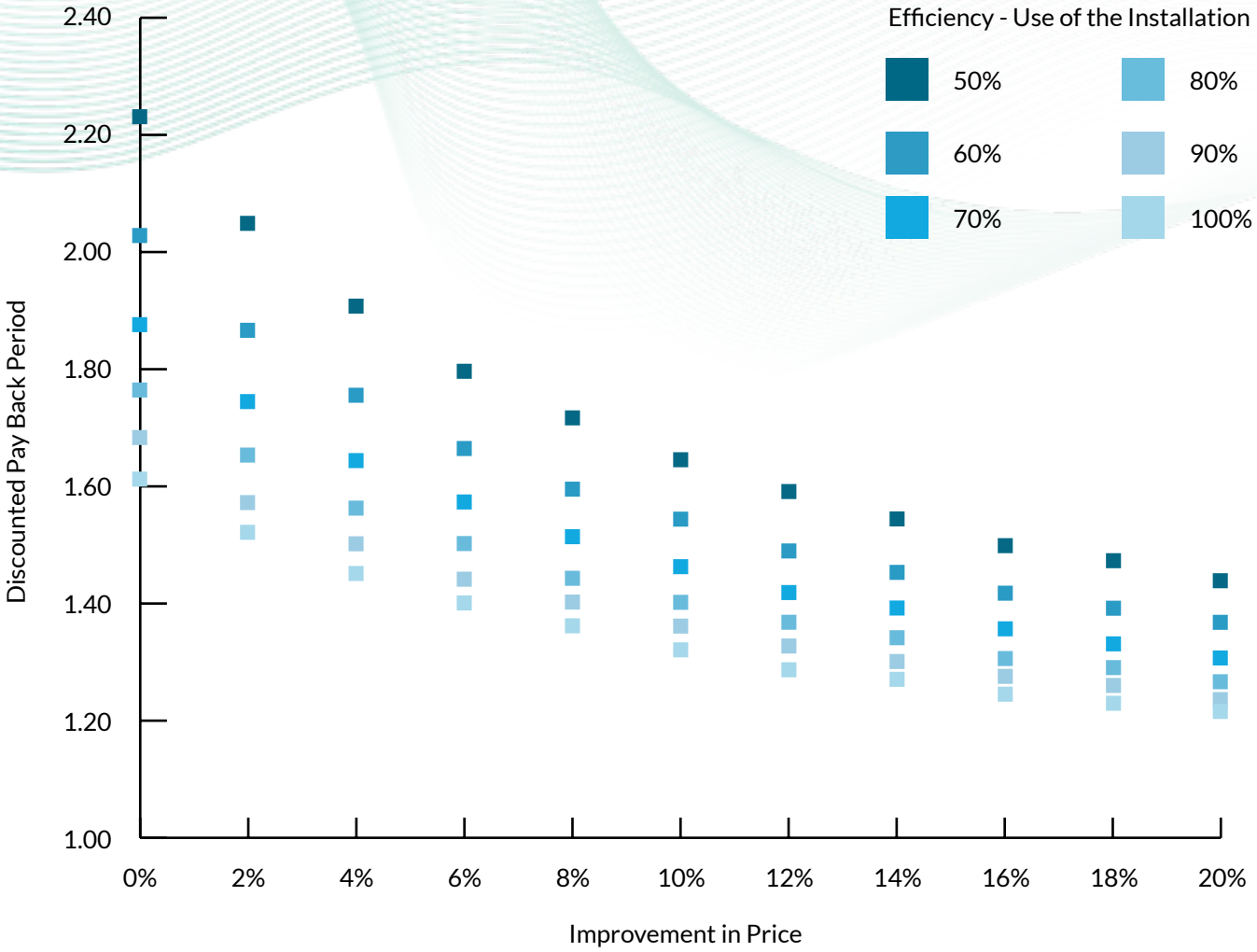


Table 16: Two-Way Sensitivity Analysis for the Discounted Payback Period

DISCOUNTED PAYBACK PERIOD		EFFICIENCY - USE OF THE INSTALLATION					
		50%	60%	70%	80%	90%	100%
IMPROVEMENT IN PRICE	0%	2.22	2.02	1.87	1.76	1.68	1.61
	2%	2.04	1.86	1.74	1.65	1.57	1.52
	4%	1.90	1.75	1.64	1.56	1.50	1.45
	6%	1.79	1.66	1.57	1.50	1.44	1.40
	8%	1.71	1.59	1.51	1.44	1.40	1.36
	10%	1.64	1.54	1.46	1.40	1.36	1.32
	12%	1.59	1.49	1.42	1.37	1.33	1.29
	14%	1.54	1.45	1.39	1.34	1.30	1.27
	16%	1.50	1.42	1.36	1.31	1.28	1.25
	18%	1.47	1.39	1.33	1.29	1.26	1.23
	20%	1.44	1.37	1.31	1.27	1.24	1.22

In order to meet the two-years leasing scheme, the facility should operate at least at 70% efficiency (processing days per year) if there is no increase in the price for improved quality. On the other hand, if the facility operates at 60% or 50% efficiency, then the price increase should be at least 2% and 4% respectively to meet the two-years leasing scheme requirements. Overall, the less efficiency in the use of the facility (number of drying processes per year), the greater the impact on the DPP given price changes for quality improvement. Conversely, the greater the efficiency in the use of the facility, the lower the impact on the DPP given price changes for quality improvement.

06. Conclusion & Recommendations

Conclusions

Mangrove forests are an important component in Ayeyarwady Delta's economic activities and daily needs; therefore, it is necessary to foster livelihoods for the population that reduce pressure on mangrove forests and at the same time improve their economic welfare. Mangrove restoration process requires a decrease in the level of disturbance from economic activities based on wood. This does not mean that efforts for restoration should focus on heavily extracting other commodities. On the contrary, and considering the Ayeyarwady landscape, the development of responsible business models and the improvement in value chains represent a sustainable opportunity to fulfill the economic income from mangrove wood-based activities.

Institutional Landscape Framework

Not all land is suitable for rice and crop production in the Ayeyarwady Delta. Current land use regulations limit the use of land for other economically attractive practices in the region like aquaculture. The conversion of paddy land or other agriculture land to aquaculture is tediously constrained by bureaucratic procedures. Policies have not adapted to the current conditions and needs of the population, neither responding to product demand nor market opportunities. The historical legacy from previous governments, that placed heavy emphasis on protecting crop cultivation to ensure national food security, still prevails in the region. This limits the adaptation and execution of activities to develop viable aquaculture livelihood practices, that can also improve public revenue collection.

There are inconsistences in the legal framework that overshadow the development of value chains related to aquaculture. On one side, the Ayeyarwady Freshwater Fishery Law aims to promote economic activities based on available fishery resources (fish catch). On the other side, the necessary activities required to transform fishery inputs into produce that reach greater marketable conditions and margins for farmers (e.g. fattened crabs or farmed shrimps), are limited by the barriers imposed by land use regulations and precarious support for their development.

Sustainable practices for crab management are weakly controlled in the region. The Department of Fisheries advices to not catch crabs during the spawning season in the months of April and May. However, during the rest of the year there is no limitation to the amount that people can catch. There is almost no control over catching young crabs, female crabs and female crabs with eggs. Enforcement in control of sustainable practices for crab and other fishery resources are required to secure the future stock of these natural assets.

Business and Investment Models

Mud crabs represent an opportunity for economic development for different stakeholders in the region. Driven by market demand, intensive and natural mud crab fattening have shown to be a profitable and mangrove friendly activities in the area of interest. For this, certain characteristics were identified to drive their profitability. The identification of these characteristics also opens the doors for opportunities to improve their efficiency and economic attractiveness. First, the closer the average crab weight upon harvest reaches the final market demand (150 grams), the better the farmers can operationally perform. However, this may depend on the commercial agreements that farmers have with the middlemen. Also, the savings from the omission of crab feed should not be interpreted as an operational advantage. Taking the cannibalistic nature of the crabs into consideration, savings in crab feed negatively impact the survival rate of crabs during the fattening cycle. Especially considering that currently crab seeds are sourced from natural sources, with different sizes and weights.

The future and viability of mud crab production, as well as other fishery activities may be at risk if no proper and sustainable management practices are implemented. Regional studies caution the need for proper management of crab collection, not targeting all crab sizes in order to ensure the future of the crab stock in the wild. The long-term sustainability and growth of crab farming will depend on the development of successful crab hatcheries, nurseries, and feeding processing plants. Even more, sourcing from these facilities eases the improvement of profitability and efficiency of crab fattening practices.

Mud crab fattening represents an opportunity for mangrove restoration and an adaptation mechanism for climate change. Studies indicate that crab farming is less vulnerable to the effects of climate change compared to other fish farming, and better adapts to some level of deterioration of water quality. ICF and NCF crab fattening can be ecologically practiced in complement with mangrove restoration and can present inclusiveness of vulnerable populations in the area. Finally, sustainably sourced mud crab presents an opportunity for the private sector to further develop potential value chains (soft-shell crab) and export to neighboring countries and developed markets.

Demand for quality processed products is growing in line with the population growth in Myanmar, especially for dried products. Current processes for obtaining dried products, using conventional open-air drying and traditional dryers using mangrove fuelwood, do not respond to the required standards for quality commercialized dried products. As more of the Myanmar population become urbanities, the growth of supermarkets and minimarkets will grow together with the demand for improved and more hygienic processed dried products. Use of alternative energy sources are recommended to power the drying process during the rainy season in order to prevent unsustainable use of mangroves.

The implementation of solar-dome dryers represents an opportunity to decrease mangrove fuelwood consumption and a mechanism to improve communities' income. In the case of dried shrimps, the case example showed a decrease in mangrove fuelwood consumption up to 15% if the SDD is 100% effectively operated. In the case of products that do not require cooking process, the SDD can decrease mangrove fuelwood consumption in 100 percent. Also, the example showed an improvement in the income margin up to eight percentual points compared to current practices. When considering price increases for product quality improvement, the net margin can potentially increase up to 26%.

Mud crab fattening practices and the implementation of SDDs represent an opportunity to be developed by community forest user groups. For this, CF user groups require to be representative, legitimate, and supported by different entities in order to develop sustainable economic activities. The integration of these practices with CF represents an opportunity for significant returns at community level, while centralizing decision making and improving inclusiveness of marginalized groups.

Access to Capital

Lack of access to formal financing is identified as a major issue for economic actors in the region. Aside from land access and security of land tenure, lack of access to credit and support services and lack of micro-credit institutions in Myanmar's financial sector impose a barrier for economic development. Farmers take informal loans from traders, making them subject to high interest rates or limited to accepting authoritative selling prices set by traders. There is the need to access formal financial institutions. The lack of access to them has made farmers and communities vulnerable to be trapped in high interest debt cycles and disadvantaged prices.

Access to financial resources is required in order to improve farmers' operational activities. To improve the economic attractiveness of crab fattening practices, farmers require greater operational resources to scale up their operations and improve the cycles of fattening. In the case of dried products, financial access is required to implement the SDD. Their current operational activities are limited by the resources that they can access.

Recommendations

The following recommendations are proposed as means to promote sustainable economic activities within the value chains analyzed, which complement the efforts of mangrove restoration and conservation.

The introduction of sustainable activities and improvement of value chains depend on the ease and strength that the institutional framework can provide in order to enable the development of the suggested livelihood activities. Therefore, there is a need to strengthen the institutional landscape, allowing for an inclusive, environmentally responsible and economically attractive environment. The institutional capacity and the bureaucratic processes relevant to land-use need to be improved.

It is recommended to promote aquaculture related activities under clear guidelines and regulations. For this, regulations related to aquaculture livelihood activities need to be harmonized and simplified with the objective of improving targeted actors' wellbeing, while simultaneously allowing mangrove restoration efforts. It is recommended to strengthen and enhance control by relevant institutions and agencies to prevent depletion of natural stock and ensure long-term sustainability of fishery resources.

Capacity building (integrating collective action and responsible resource management) of stakeholders involved in natural resource extraction and production becomes crucial for improving current value chains. Strengthening farmers' skills may also improve information asymmetry, promoting the exchange of information and improving market efficiency. Building up community action will open the opportunity for financial mechanisms and will facilitate the access to resources for improving current practices. Based on the assumption that capacity of stakeholders is built, and financial resources becomes available, the improvement of the value chains related to crab fattening and dried products is recommended.

The institutional framework to develop a clear and enabling environment for sustainable crab fattening is urgently needed to attract farmers and financial institutions. For this value chain, the development of specialized crab hatcheries, nurseries and feed processing facilities are required for achieving long term sustainability. Even more, these facilities are required to improve the efficiency and economic attractiveness of activities based on mud crab fattening. Developing and providing the necessary infrastructure (quality power supply and roads) can also benefit the development of crab hatcheries and crab farming facilities. It is recommended and required to enforce policy/regulation to control unsustainable wild catching of crabs. Finally, the establishment of eco-friendly and inclusive process-guidelines are required to sustain and improve mud crab value chain activities.

Improvement of the value chain of dried products is recommended through the implementation of a SDD facility. This recommendation is based on the efficiency and quality improvement of fishery and

agroforestry products processed through this facility. It is recommended to implement the SDD at farmers or fisher's community level; this, as the operational business model for the SDD can be implemented with inclusive efforts involving women, youth and other vulnerable social actors.

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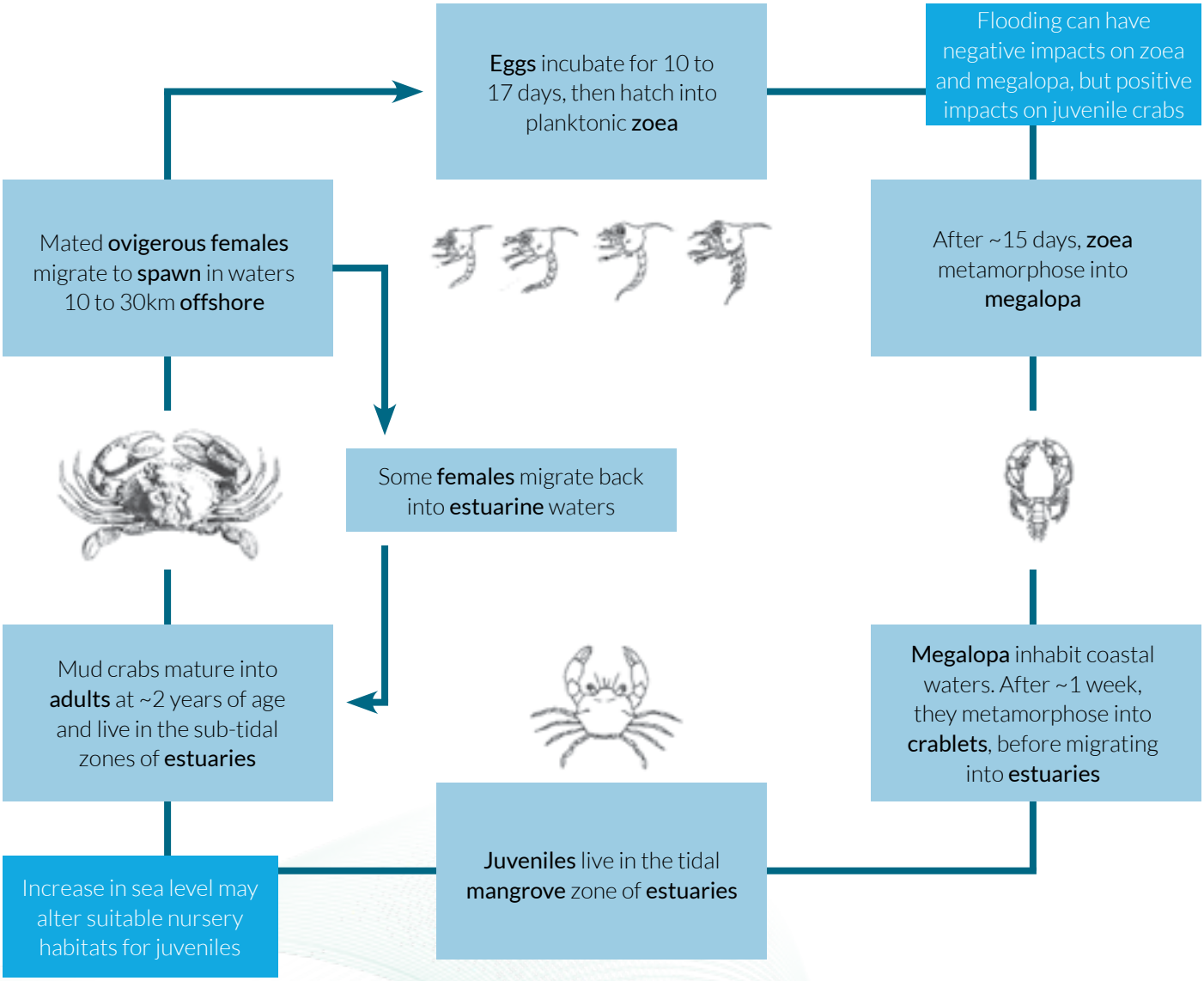
07. Appendix

Generalized Life Cycle of the Mud Crab, Scylla Serrata



Source: Lawson et al. cited in Welch & Johnson, 2013.

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