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EAST TIMOR: AQUACULTURE FEASIBILITY STUDY

LEO
Leveraging Economic Opportunities

LEO REPORT # 30

June 2016

This publication was produced for review by the United States Agency for International Development. It was prepared by Adam Sendall, Luis Gusmão Pinto and Jinky Comon, for ACDI/VOCA with funding from USAID/E3's Leveraging Economic Opportunities (LEO) project.

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DISCLAIMER

The author's views expressed in this publication do not necessarily reflect the views of the United States Agency for International Development or the United States Government.

ACRONYMS & ABBREVIATIONS

ACIAR	Australian Centre for International Agricultural Research
ADB	Asian Development Bank
AECID	Agencia Española de Cooperación Internacional para el Desarrollo
cif	Cost, Insurance & Freight
COMPACT	Combatting Malnutrition and Poverty through Aquaculture in Timor-Leste (project)
CP	Crude Protein
ºC	Degrees Celsius
FAD	Fish Aggregation Device
FAO	Food and Agriculture Organization (of the United Nations)
FCR	Feed Conversion Ratio
fob	Free on Board
GDS	General Directorate of Statistics
GIFT	Genetically Improved Farmed Tilapia
GoTL	Government of Timor-Leste
Ha	Hectare
IAA	Integrated Agriculture-Aquaculture
IDR	Indonesian Rupiah
ITC	International Trade Centre
IQF	Individually Quick Frozen
IUU	Illegal Unreported and Unregulated (fishing)
Kg	Kilogram me
Km	Kilometer
KOICA	Korea International Cooperation Agency
MAF	Ministry of Agriculture and Fisheries
MCFC	Mud Crab and Fish Cultivation (project)
MCIE	Ministry Commerce, Industry and Environment
MED	Ministry of Economy and Development
MoF	Ministry of Finance
MT	Metric Tonne
NADS	National Aquaculture Development Strategy
NDFA	National Directorate of Fisheries and Aquaculture
NIWA	National Institute of Water and Atmospheric Research
RFLP	Regional Fisheries Livelihoods Programme
SDP	Strategic Development Plan
SRC	Semi-Refined Carrageenan
SWOT	Strengths, Weaknesses, Opportunities and Threats
t	Ton
USAID	United States Agency for International Development
USD	United States Dollar
USDA	United States Department of Agriculture
ZEESM	Zona Especiais de Economia Social de Mercado
$	United States Dollar

GLOSSARY

Floating long-line
A seaweed farming technique whereby lengths of rope up to 100m in length and anchored to the sea bed are kept on the surface of the sea with floats. Seaweed seedlings are then tied along the rope at 20-25cm intervals.

Green water feeding
Semi-intensive, low cost feeding technique whereby fertilizer is applied to ponds to encourage algal growth. Fish then feed upon the algae.

Integrated Aquaculture-Agriculture
Semi-intensive, low cost feeding technique whereby waste from one farm enterprise become inputs for another. For example, poultry pens are erected over fish ponds with the manure falling into the pond to create green water feeding.

Landed Fish
Fish that have been caught and unloaded on-shore for consumption or sale.

Mariculture
Mariculture is a specialized branch of aquaculture involving the cultivation of marine organisms for food and other products in the open ocean, an enclosed section of the ocean, or in tanks, ponds or raceways which are filled with seawater.

Reef gleaning
Searching for edible seafood, such as shellfish and crabs, on shallow reef flats during low tide.

Wet market
A market selling fresh fish, meat and produce; distinguished from dry markets which sell durable goods such as cloth and electronics.

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FOREWORD

The United States Agency International Development (USAID) Country Development Cooperation Strategy 2013-18 for Timor-Leste includes 'Inclusive economic growth accelerated in the agriculture sector' as an intermediate result and two sub-intermediate results: i) improved ability of citizens of Timor-Leste to engage in the private sector and ii) increased productivity of selected agriculture value chains. In consideration of those objectives, the USAID Mission in Timor-Leste requested an assessment of the economic opportunities presented by aquaculture.

The assessment includes analysis of: a) the current status of the aquaculture sector (production and productivity); b) potential markets linkages for Timorese aquaculture products; and, c) the potential for domestic feed production. Strengths, Weaknesses, Opportunities and Threats (SWOT) analysis is used for each aquaculture type (mariculture and marine fisheries, freshwater aquaculture and brackish water aquaculture) to identify fish products most suitable for further development in Timor-Leste.

EXECUTIVE SUMMARY

The purpose of the feasibility study was to analyze the current status of the aquaculture sector (production and productivity); assess markets linkages for Timorese aquaculture products; and, examine the potential for domestic feed production. Strengths, Weaknesses, Opportunities and Threats analysis was used for each aquaculture type (mariculture and marine fisheries, freshwater aquaculture and brackish water aquaculture) to identify fish products most suitable for further development in Timor-Leste. Suitability criteria emphasized community-based aquaculture products that can contribute most to food security and nutrition amongst rural communities.

Total fish consumption in Timor-Leste is estimated at 7,120 tonnes/annum. Average per capita consumption is 6.1kg/year, considerably lower than the Asian average of 17kg/capita/year (NDFA, 2011). In-shore capture fisheries account for 84% of fish consumed and imports of frozen fish a further 15% (ITC, 2015). Aquaculture, mainly freshwater tilapia production, accounts for the remaining 1% of consumption.

Mariculture and Marine Fisheries

In-shore capture fishing provides over 6,065 tonnes of fish consumed in Timor-Leste. Most of the fishing takes place within two kilometers of shore and is carried out by over 5,000 artisanal fishers using small traditional boats, gill nets and long line. Only 21% of boats are motorized. Investment costs are comparatively small for artisanal fishing, which provides a daily income and quick return on investment. The majority of fishers earn between USD 100-300/month.

Although no official 'stock assessment' has been carried out for inshore or offshore marine fisheries, interviews with fishers suggest catches are declining and fish surveys indicate over fishing. Considering Timor-Leste is dependent on capture fisheries for 84% of fish consumption, this poses a considerable and widespread risk to food security in the long-term.

Off-shore capture fishing is carried out in the Exclusive Economic Zone waters south of Timor-Leste by foreign commercial fishing vessels. Fishing licenses are issued to foreign boats and the fish exported, with royalties paid to the Government. Illegal, Unreported and Unregulated fishing is estimated at 18,000 tonnes a year but is impossible to control due to limited capacity of the Maritime Police. Off-shore fisheries offer little direct benefit for rural communities in Timor-Leste.

Seaweed farming mainly takes place on Atauro Island twenty nautical miles north of Dili and is ideal for coastal, community-based income generation. However, the international price for dried seaweed has fallen due to over-supply in Indonesia and the Philippines. Traders from Indonesia have stopped buying from Timor-Leste and local production is too small to directly supply end markets.

Prawn, grouper and sea-cucumber farming have recently been initiated by private sector investors. However, these products are more reliant on export markets and involve high risk, investment costs and management requirements; so are better suited for commercial fish farmers.

Freshwater and Brackish Water Aquaculture

Over recent years the Ministry of Agriculture and Fisheries has rehabilitated four fish hatcheries for the breeding of tilapia (Nile and GIFT), carp and catfish fingerlings. One new mud crab hatchery was also established with the support of the United States Department of Agriculture. Based on the number of fingerlings distributed by hatcheries, it is estimated the production of farmed fish (tilapia, carp and catfish) totaled 15.3 tonnes in 2015, less than 1% of total fish consumption.

Currently, only the Gleno hatchery remains operational, producing Genetically Improved Farmed Tilapia (GIFT). GIFT tilapia are ideal for commercial production as they are quicker growing with batches producing a uniform size at harvest. However, GIFT tilapia are single-sex and new fingerlings need to be purchased each production cycle, whereas Nile tilapia can breed and produce their own replacement fingerlings. Considering the small farmer basis of tilapia production in Timor-Leste and the logistics of procuring fingerlings from Gleno, GIFT fingerlings may not be appropriate at this point in time.

Carp and catfish production has declined due to the lack of available fingerlings. The MAF hatcheries in Bobonaro, Manufahi and Viqueque do not have enough budget to produce and distribute fingerlings. In the case of carp, the budget is only enough to feed and maintain the broodstock only.[1]

Milkfish production is continuing on a small scale with the collection of wild fingerlings, which limits the scale of production. Nonetheless, local sales and imports indicate there is a significant consumer demand.

Mud crab production also continues on a small scale with the collection of wild juveniles for raising in milkfish ponds. However, the demand for mud crab in Dili remains small at only 300kg/week.

Tilapia (GIFT and Nile) is the most popular fish for aquaculture due to ease of production and short three-to-four month production cycle. The fish is also popular with consumers, who are willing to pay USD 5/kg. However, financial analysis of tilapia and milkfish farming shows small gross margins under current levels of productivity. To become viable fish survival rates must be increased, production period reduced and feed costs lowered. For small-scale fish farmers, the promotion of green water feeding and Integrated Aquaculture-Agriculture for on-farm nutrient recycling could contribute towards this.

Fish Feeds

Fish feeds are the major cost in aquaculture. Based upon the number of fingerlings distributed by hatcheries in 2015, the annual demand for fish feed is estimated at 55 tonnes. Although it is possible to produce feeds cheaper in Timor-Leste than to import complete concentrate feeds from Indonesia, it would be reliant on importing the ingredients and milling/mixing them in Timor-Leste on a commercial basis. However, the small potential demand for fish feeds is unlikely to attract private sector investment in feed milling in the short-term.

Suitability and Other Considerations

A summary of the suitability of fish products included in the study is shown in the Table below. Suitability criteria include: food security and nutrition; income generation; short time-frame; impact; and replicability. Analysis shows inshore marine capture fisheries and tilapia and milkfish farming have the most potential for future development.

[1] Based on information received during the consultant team visits to Manufahi and Viqueque hatcheries.

Table: Summary of Suitability

Product	Food security & nutrition	Income generation for small farmers	Short-time frame	Wide-spread impact / community-based	Replicability (further adoption)
Inshore marine capture: tuna, sardine, mackerel, trevally, grouper, snapper	√√	√√	√√	√	√
Offshore marine capture: tuna, scads, squid	O	O	O	O	O
Mariculture: seaweed	√	O	√	√	√
Mariculture: grouper, sea-cucumber & prawn	O	√	O	O	O
Carp	O	√	O	O	O
Catfish	O	√	√	O	O
Milkfish	√√	√	√	√	√
Mud crab	O	√	O	O	O
Tilapia	√√	√	√√	√	√

Legend: O = not suitable, √ = suitable, √√ = very suitable

As in-shore capture fisheries provides the majority of fish for consumption in Timor-Leste and incomes for over 5,000 artisanal fishers, sustainability is a major concern. A 'National Stock Assessment' must be undertaken to develop a sustainable fisheries management plan. Options to improve the sustainability of in-shore capture fisheries may include introducing Fish Aggregation Devices to attract larger pelagic fish closer to shore; introducing larger motorized boats so fishers can fish further off-shore; and facilitating the establishment of community-based co-management practices such as no-take zones at spawning aggregation sites, buffer zones and special regulation zones with a mix of gear restrictions, temporal/seasonal closures at crucial life-cycle stages and species specific take limits. Tilapia and milkfish farming could also be a strategic part of the plan, supplementing the supply of sea fish, whilst wild stocks replenish.

Due to poor transport infrastructure and lack of cold storage facilities, including ice-making, highly perishable produce such as fresh fish are not traded over long distances or for extended periods of time. Whilst putting pressure on the fishing grounds around Dili, this also presents challenges for inland aquaculture fisheries.

Inland aquaculture production is bulk harvested at the end of a production cycle, potentially releasing large amounts of fish on to the market at one time. Demand from small rural communities would soon be satisfied, after which, most of the fish will need to be sold on the Dili market. This will necessitate establishing inland trader networks and cold chains which do not currently exist. If production increases further, there will also be a need for the preservation of surplus fish, requiring filleting facilities and freezer storage.

Apart from access to fingerlings and cost of feed, other barriers to entry for aquaculture include the number of suitable locations with year round access to water which have large enough level areas and deep enough soils to dig ponds.

Imported fish products account for 15% of fish consumption in Timor-Leste. There is an unmet demand for tilapia and milkfish in Dili, as at least twenty tonnes of frozen tilapia and milkfish are imported from Vietnam

every month. The tilapia and milkfish retail in Dili supermarkets for USD 2.90/kg and USD 1.90/kg respectively, considerable cheaper than tilapia and milkfish produced domestically. In short, tilapia and milkfish production would not be viable for commercial purposes but could improve household food security and nutrition, if carried out on a small low-cost basis using semi-intensive production techniques described above.

1.0 BACKGROUND

At independence, much of the fisheries infrastructure such as freshwater hatcheries, fishing centers/landing sites, fish ponds and boats were destroyed or fell into disrepair. Since independence, Timor-Leste has been rebuilding its aquaculture sector, with the main focus upon rehabilitating the four Ministry of Agriculture and Fisheries (MAF) hatcheries and establishing community-based ponds for raising tilapia, carp and catfish.

Constraints faced by the sector are much the same as for the agriculture sector as a whole: poor infrastructure; lack of access to inputs and credit; fragmented supply chains and market linkages; limited processing, storage facilities and agribusiness; and scarce private sector investment. This scenario causes people to consume the food they produce themselves and remain in a subsistence trap.

According to anthropometric indicators, 38% of children under five years old are under weight, 50% of children are stunted and 11% are wasted.[2] These statistics indicate long-term deficiencies in nutrition and even starvation for severe cases. Fish consumption in Timor-Leste is 6.1kg/capita/year, substantially lower than the regional Asian average of 17kg/capita/year. Average meat consumption is 13.3kg/capita/year, also lower than the regional Asian average of 20kg/capita/year.[3]

In short, development of the fisheries sector is important for food security, particularly nutrition, and also brings income to rural areas. This assessment seeks to identify which fisheries types have the most potential to improve food security and nutrition.

1.1 GOVERNMENT POLICIES AND STRATEGIES

The Strategic Development Plan 2011-30 (SDP) articulates the Government's over-arching economic development agenda and emphasizes the importance of a thriving agricultural sector for food and nutritional security, poverty reduction; and economic growth for the nation as a whole.

The SDP's medium term actions (2016 to 2020) for fisheries focus upon ocean-based fishing for export markets and commercial inland aquaculture. The SDP recognizes the creation of a commercial fishing industry will require better boats, dedicated landing sites, refrigerated supply chains and fish processing facilities. The strategy also advocates for the creation of a Marine Research and Development Centre; research into prawn, abalone, crab and oyster farming; and the development of Fisheries Centers along the south coast.

To achieve objectives stated in the SDP, the National Directorate for Fisheries and Aquaculture (NDFA), within the Ministry of Agriculture and Fisheries (MAF), prepared a National Aquaculture Development Strategy 2012-30 (NADS). The vision of NADS is for aquaculture to contribute towards improved food and nutrition security, diversification of livelihoods of inland and coastal communities, and economic growth in Timor-Leste. Both inland and coastal aquaculture are supported in the strategy. Freshwater aquaculture is identified as a means of improving food and nutrition security in inland communities; while brackish water aquaculture and mariculture provides small business and income raising opportunities for coastal communities. It is intended to increase per capita fish consumption from 6.1kg to 15.0kg by 2020 with the expectation that aquaculture will contribute up to 40% of domestic fish supplies by 2030.

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[2] GDS (2015) *Timor Leste Demographic and Health Survey,* MoF
[3] NDFA (2011) *Fish and Animal Protein Consumption and Availability in Timor Leste,* MAF

The strategy promotes Integrated Agriculture-Aquaculture (IAA) techniques; the rehabilitation of fish hatcheries and brackish water ponds; the promotion of seaweed farming; studies on sea cucumber and crab farming; and developing fish feeds through local formulations and green water pond fertilization technology.

Progress to date has included rehabilitating the four MAF hatcheries and establishing community-based ponds for raising tilapia, carp and catfish. There has also been recent private sector investment in commercial prawn, grouper and sea-cucumber farming.

1.2 DONOR SUPPORT

Previously the United States Department of Agriculture (USDA) funded the Mud Crab and Fish Cultivation (MCFC) Project for five years between 2010 and 2015 with a total budget of USD 5.6 million. The project aimed to: i) to increase sustainable production of mud crabs, milkfish and other aquaculture products, ii) to form mud crab and other aquaculture product producer groups and strengthen market linkages, and iii) to develop and transfer an aquaculture hatchery to the MAF. However, after project completion, the hatchery proved unsustainable and has since closed down.

Currently the main donors in the fisheries sector are New Zealand Aid and Norway. New Zealand is funding the Partnership for Aquaculture Development in Timor-Leste project (USD 4 million), with lead implementation by WorldFish. Norway is funding the Combatting Malnutrition and Poverty through Aquaculture in Timor-Leste (COMPACT) project (USD 2.1 million), implemented by Mercy Corps and Hivos (NGOs). These two projects cover eight of the thirteen districts in Timor Leste. However the COMPACT project, which covered six of the districts will finish in August 2016, significantly reducing donor support to the fisheries sector. A summary of on-going fisheries projects is provided in Annex A.

2.0 PRODUCTION AND CONSUMPTION SUB-SYSTEMS

2.1 PRODUCTION

The fisheries sector in Timor-Leste is characterized by artisanal fishing of in-shore coastal areas, which provides 84% of the fish consumed in Timor-Leste. Imports account for a further 15% with the remaining 1% supplied by inland aquaculture.

2.1.1 MARICULTURE & MARINE FISHERIES

Timor-Leste has a coastline of around 783km and 75,000km² of Exclusive Economic Zone waters with rich marine resources and the potential to develop offshore fisheries.

Capture Fisheries

Off-shore fishing was previously was previously dominated by commercial Indonesian fishing vessels. After independence, Timor-Leste entered a number of bilateral agreements that gave foreign fishing fleets limited access to the country's deep-sea fishing areas off the south coast of Timor-Leste, particularly the Sahul Banks area, which are considered the most productive fishing grounds. In return for issuing fishing licenses, the Government receives royalties on fish caught.

Currently, only three offshore fishing licenses have been granted to three Chinese registered boats. Each license is for an annual quota of 150 MT of tuna, scads and squid. To monitor catches and assess royalties, the catch is unloaded and weighed at Com Port in Lautem district. After weighing, the catch is reloaded and transferred to 'mother' boats offshore for export.[4]

The small amount of quota is due to the absence of a 'stock assessment' for both in-shore or off-shore fisheries, therefore sustainable yields are unknown. Beyond the weighing at Com, the Inspectorate of Fisheries is unable to monitor compliance with quotas by the licensees. There is a high level of Illegal Unreported and Unregulated (IUU) fishing in the Sahul Banks area, with suspected vessels originating from Vietnam, Thailand, China and Indonesia. Although the NDFA estimates IUU fishing amounts to 18,000 MT/year in Timorese waters, the Maritime Police has only one operational boat to cover all the Exclusive Economic Zone marine area.

Whilst opportunities may lie in establishing a Timorese offshore fleet, there is little direct benefit to rural communities from off-shore fishing.

In-shore coastal fishing is mainly limited to small-scale artisanal fishers within 2km of shore and the north coast of Timor-Leste is designated specifically for artisanal fishing. Typical fish species caught and supplied to local markets include: tuna, sardine, mackerel, trevally, grouper and snapper. Reef gleaning at low tide is also common for coastal communities to collect snails, octopus and crabs.

[4] Information provided by the Inspectorate of Fisheries, MAF

MAF estimates there are 5,265 artisanal fishers and approximately 1,300 boats have been registered with the Fisheries Inspectorate. Most boats are small wooden outriggers owned by the fishers themselves and only 21% are motorized. The most common fishing gear used is gill nets and long-line.

Most fishers fish every day, for less than six hours a trip. Although fishing is carried out year round on the north coast, heavy rain and storms in the wet season (November to February) reduces the amount of trips made and the volume of landed fish decreases during these months. On the south coast, artisanal fishing only takes place between August and November, due to rough seas during the rest of the year. Average monthly incomes from fishing activities vary between USD 100 to USD 300.[5]

Table 1 shows the estimated coastal fish catch in 2008 (FAO). Consumption analysis under Section 3.2, suggests this is a considerable under estimation and estimates in Table 9 conclude the current volume of landed fish from in-shore capture fisheries is actually 6,065 MT.

Table 1: Volume of Landed Fish

District	Production (t)
Aileu	-
Ainaro	14.4
Baucau	93.6
Bobonaro	357.3
Covalima	203.4
Dili	1,170.9
Ermera	-
Lautem	130.5
Liquiça	497.7
Manatutu	176.4
Manufahi	202.5
Oecusse	247.5
Viqueque	112.5
Total	**3,206.7**

No fish are landed in Aileu and Ermera districts as they have no coastline. Dili accounts for 37% of all fish landed, which includes fish from Atauro Island.[6] Interviews carried out with fishers suggest fish catches are declining and fish surveys indicate over fishing. Considering Timor-Leste is dependent on local capture fisheries for 84% of fish consumption, the sustainability of wild fish stocks poses a considerable threat to food security.

Fishers typically receive USD 3/kg for sardine and mackerel. For larger fish such as tuna and snapper, fishers receive USD 6/kg. Artisanal fishing offers fishers a daily income with a relatively small amount of investment (boat, engine and fishing gear) and operating costs (fuel and spare parts).

[5] AMSAT (2011) *Regional Fisheries Livelihoods Programme, Baseline Survey,* AECID/FAO

[6] Anecdotal evidence suggests a large proportion of fish coming from Atauro are supplied by fishers from the neighbouring Indonesian islands of Alor and Wetar.

'Typical artisanal fishing boat'

Mariculture

Seaweed (*Eucheuma cottonii*) farming mainly takes place on Atauro Island, where it is carried out by 1,282 farmers, producing a total of 100 MT/year. Production is mostly carried out using the 'floating long-line' method. Average production is 100kg seaweed per line, every 45 day cycle. Harvesting requires detaching the line from the anchor and transporting it to shore for drying.[7]

Indonesia and the Philippines are the world's largest producers of seaweed and sell dried seaweed and '*carrageenan'* to processors in Japan and USA where it is used as a raw material for the production of food, pharmaceuticals and cosmetics. As production volumes in Timor-Leste remain small, it is sold to Indonesian traders and enters the Indonesian supply chain.

Although seaweed can be easily grown by coastal communities, it is estimated only 20% of suitable cultivation areas on Atauro are being utilized. Productivity has been affected by 'ice-ice' disease; however, the most recent negative impact has been the drastic fall in market prices. Previously, seaweed farmers were paid USD 0.70/kg in Timor-Leste, which made a considerable contribution to household income. In 2015, seaweed prices in Indonesian West Timor fell to IDR 1,000/kg (USD 0.07/kg). Although prices have now recovered somewhat in Indonesia, the market is over supplied and buyers are no longer interested in buying seaweed from Timor-Leste.

[7] Bassford (2011) *Timor Leste Seaweed Value Chain,* WorldFish Centre

'Seaweed farmer in Atauro'

Grouper farming (*Epinephelus* sub-family) in fish cages is being piloted by an entrepreneur behind Cristo Rei in Dili. The farm has 80 cages with capacity to hold 200 fingerlings in each cage. Fingerlings are imported from Indonesia at a cost of USD 1.50 each; feeds are also imported. Buyers in Dili are willing to pay USD 15/kg for fresh fish and buyers from Singapore have expressed an interest in importing live fish. Minimum orders from Singapore are 5 MT every three months, which is currently beyond the capacity of the grouper farmer. Risks, investment costs and management requirements are high. As such, grouper farming is better suited for larger commercial fish farmers.

Sea-cucumber ranching (*Holothuria scabra*) is being piloted by the Best Seafood company (China and Fiji partnership) in Metinaro. The company has reportedly exported one small shipment of dried sea cucumber to the USA but due to business license irregularities, operations have been suspended.

Sea cucumber ranching requires a hatchery and is reliant on the export market for sales. Risks, investment costs and management requirements are high. As such, sea-cucumber ranching is better suited for larger commercial farmers.

Marine Tourism

Marine tourism creates export earnings and there are spill-over benefits for the wider economy (support services, lodging, food). Since independence, scuba diving has become increasingly popular in Timor-Leste. There are currently three dive shops in Dili and one study in 2012 estimated scuba diver expenditure at USD 1.6 million, with one dive shop providing 11,000 dives.[8]

Timor-Leste is also ideally located to witness the annual whale migration from the Pacific to Indian Oceans around November every year. Whale sightings include Blue, Humpback, Pilot, Sperm, Sei, False killer, Melon-headed and Curviers-beak. Dolphin sightings include Rough-toothed, Risso's, Spotted, Spinner and Fraser's.

[8] Pinto et al. (2014) *Economic contributions and trends of SCUBA diving in Timor-Leste,* Conservation International.

Marine tourism is dependent on an abundant marine life and habitat, which further highlights the important issues of marine protection and conservation.

2.1.2 FRESHWATER AQUACULTURE

It is estimated Timor-Leste has the potential to develop at least 4,821ha of aquaculture ponds, producing 14,463 tons of fish per annum.[9] Freshwater aquaculture in Timor-Leste has included raising tilapia, carp and cat fish. The number of fish ponds by district is summarized in Table 2 and includes brackish water ponds (8ha).

Table 2: Number of Fish Ponds by District

District	No. Ponds
Aileu	45
Ainaro	390
Baucau	297
Bobonaro	133
Covalima	45
Dili	168
Ermera	216
Lautem	234
Liquiça	14
Manatutu	45
Manufahi	106
Oecusse	16
Viqueque	296
Total	**2,005**

Source: NDFA, 2015

There are a total of 2,005 fish ponds with roughly the same number of fish farmers and the total area of fish ponds in Timor-Leste is estimated at 75ha (NDFA). Aileu and Ermera are the only two districts without a coastline, so would benefit most from inland aquaculture, even though only 13% of ponds are located there. The majority of ponds (61%) are located in Ainaro, Baucau, Viqueque and Lautem districts.

The annual production of farmed fish was previously estimated at 46 tons in 2012.[10] However, it is difficult to reconcile this number with other analyses. For example, if the 75ha of ponds are fully utilized the production would be 270 MT. [11] The most reliable estimate is based upon the number of fingerlings distributed by the hatcheries in 2015 (See Table 3). Even with an optimistic survival rate of 85%, annual production would only be 15.3 MT.[12]

Availability of fingerlings and cost of feeds are the main determinants for success in aquaculture. MAF has rehabilitated four hatcheries and one new mud crab hatchery was established in Vemase with USDA support. As of May 2016 only the Gleno hatchery remains fully operational, producing only tilapia fingerlings.

[9] NDFA (2012) *Analysis of the Current Situation and Potential for Aquaculture Development in Timor Leste,* MAF
[10] NDFA (2012) *Analysis of the Current Situation and Potential for Aquaculture Development in Timor Leste,* MAF
[11] 1,800kg x 75ha x 2 cycles = 270,000kg
[12] 120,000 fingerlings x 85% survival rate x 0.15kg/fish = 15,300kg

Table 3: Fingerling Production

Hatchery / Year	2012	2013	2014	2015	Species
Bobonaro (Maliana)	3,790	1,450	22,600	21,200	Nile tilapia, catfish
Ermera (Gleno)	13,500	5,660	18,050	59,000	GIFT Tilapia
Manufahi (Same)	9,140	9,350	12,475	21,440	Nile tilapia, carp
Viqueque (Loi Huno)	13,000	9,500	16,000	16,600	Nile tilapia, carp
Baucau (Vemase)		800	20,000	1,726	Mud crab
Total	**39,430**	**26,760**	**89,125**	**119,966**	

Source: NDFA

The hatcheries are owned and operated by MAF, which suffers from financial and technical constraints in hatchery management. The majority of fingerlings to date have been provided free of charge to fish farmers by MAF/donor projects. Ideally, the hatcheries would be operated by the private sector but demand for fingerlings and subsequent financial viability of operating a hatchery is not conducive to attract private sector interest.

'Gleno GIFT tilapia hatchery'

Pelleted concentrate fish feeds are available from agricultural merchants in Dili. Imported from Indonesia, the feeds are general purpose with a basic 16-20% crude protein content and cost USD 1.50/kg. Apart from access to fingerlings and cost of feed, other barriers to entry for aquaculture include the number of suitable locations with year round access to water which have large enough level areas and deep enough soils to dig ponds.

Nile Tilapia (*Oreochromis niloticus*) dominates freshwater aquaculture production in Timor-Leste, although tilapia can also be reared in brackish water. Tilapia are preferred by fish farmers because of the short three-to-four month production cycle, relative ease of cultivation, availability of fingerlings and local market demand.

The only surviving hatchery at Gleno now produces Genetically Improved Farmed Tilapia (GIFT) tilapia. Although ideal for commercial production, due to a faster and uniform growth rate, GIFT tilapia are single-sex and new fingerlings need to be purchased for each production cycle. Considering the small scale of tilapia production in Timor-Leste and the logistics of procuring fingerlings from Gleno, GIFT fingerlings may not be appropriate at this point in time. Although Nile tilapia may not grow as fast as GIFT tilapia, they are voracious breeders and produce their own replacements. This can be done in farmers' own ponds, rather than a centralized hatchery.

Gross Margins for tilapia production are shown in Table 4. The first gross margin is for production under current performance levels using real costs of fingerlings and use of feeds. The second gross margin is for production under industry standard use of feeds, production period and survival rates i.e. what would normally be recommended to improve performance.

Table 4: Gross Margins for Tilapia (GIFT and Nile) Production

1. Timor-Leste Actual Productivity (1ha)	USD	2. Industry Standard Productivity (1ha)	USD
Income		Income	
12,000 fish x 0.15kg/fish = 1,800kg @ $5/kg	9,000	25,500 fish x 0.15kg/fish = 3,825kg @ $5/kg	19,125
Variable Costs		Variable Costs	
30,000 fingerlings @ $0.05/fingerling	1,500	30,000 fingerlings @ $0.05/fingerling	1,500
6,480kg rice bran @ $0.50/kg	3,240	13,770kg feed[1] @ $1.50/kg	20,655
Kitchen waste	0		
Farm yard manure	0		
Sub-total	*4,740*	*Sub-total*	*22,155*
Gross Margin	**4,260**	**Gross margin**	**(3,030)**
Technical assumptions		**Technical assumptions**	
Stocking rate: 3 fish/m² = 30,000 fish/ha		Stocking rate: 3 fish/m² = 30,000 fish/ha	
Survival rate: 40%		Survival rate: 85%	
Production period: 6 months		Production period: 4 months	
		Feed Requirement: 3% of body weight/day	

[1] 3,825kg fish x 3% body weight daily feed rate x 120 days

Interviews with fish-farmers revealed that fingerling survival rates are only 40% and it takes up to six months for the fish to reach harvestable size. Low survival rates are caused by physico-chemical conditions such as poor water quality due to stagnation/lack of oxygenation, high water temperature and pollution from feeds. Fish are also lost due to seepage and predation. The underlying cause for the slow growth rate is that farmers are not feeding the recommended concentrate feed requirements but are substituting with rice bran and kitchen waste.

Aquaculture projects initially provided fingerlings and concentrate feeds free of charge to farmers. Since then few farmers have purchased fingerlings from the hatcheries or concentrate feeds themselves. Although productivity is low, the enterprise is profitable with an average 100m² pond producing 120 fish to eat or a gross margin of USD42.60.

The second gross margin example uses an improved survival rate of 85% and a shorter production cycle of four months (due to the use of concentrate feeds), which are both average industry standards for small-scale tilapia production. However, due to the use of concentrate feeds the gross margin becomes negative at minus USD 3,030/ha. Therefore, the only remaining means to improve financial performance is to decrease feed costs and just to break-even, feed costs would need to reduce from USD1.50/kg to USD 1.28/kg. The potential for domestic feed milling in Timor-Leste to reduce costs is further analyzed under Section 3.1.4.

Opportunities to improve tilapia productivity for small fish farmers lie in improving survival rates and developing appropriate production models to reduce feed costs. These include green feeding; supplementary feeding with locally available by-products; Integrated Agriculture Aquaculture systems for on-farm nutrient recycling; and, raising own fingerling replacements.

There is a demand for tilapia in Dili, as Kmanek supermarket imports 10 MT of frozen tilapia/month from Vietnam.[13] Developing tilapia production on a commercial basis would be reliant on access to cheaper feeds and require the development of a commercial feed mill in Timor-Leste. However, the biggest barrier to commercial tilapia production is the cheap imported tilapia which retails at USD 2.90/kg. Whilst tilapia is popular for home consumption and there is a small local demand in rural communities who are willing to pay USD 5/kg, it is unlikely fish farmers will be able to compete on Dili markets against cheap imports.

Nonetheless, it is estimated the urban population in non-coastal areas outside of Dili is 54,698 persons and the average fish consumption of non-coastal communities is 4kg/person/year. This provides a potential demand of 219 tonnes of fish per year.[14]

'Hapa nets at the Gleno hatchery'

Carp (*Cyprinus carpio*) and Catfish *(Clarias batrachus)* were introduced during the Indonesian regime. Although carp is preferred as an eating fish by consumers, it has a longer production cycle of nine-to-twelve months, so is less attractive to fish farmers. Carp and catfish fingerlings need to be sourced from a hatchery as the number of fingerlings produced from natural breeding is too small. Consequently, carp and catfish production has considerably decreased since the MAF hatcheries stopped producing fingerlings. The MAF hatcheries in Bobonaro, Manufahi and Viqueque do not have enough budget to produce and distribute fingerlings. In the case of carp, the budget is only enough to feed and maintain the broodstock only.[15]

2.1.3 BRACKISH WATER AQUACULTURE

Brackish water ponds are located in coastal areas. In Timor-Leste they have been used for the production of milkfish, mud crab and prawns, although tilapia can also be farmed under brackish water conditions.

Milkfish (*Chanos chanos*) production was previously introduced by the USDA MCFC Project. There are 48 milk fish ponds located in Liquiça (Manemori, Tetsari, and Terleu), and Dili (Hera and Metinaro) with a total area of 8ha. The most common pond size is 250m². Milkfish have four-to-six month production cycles, are easy to raise and there is a local market demand.

[13] Baticados (2014) *Market Study of Farmer Milkfish and Tilapia in Timor Leste,* ACDI/VOCA
[14] Consultant estimates
[15] Based on information received during the consultant team visits to Manufahi and Viqueque hatcheries.

Table 5 shows the gross margin for milk fish production.[16] Previously, milkfish fingerlings were sourced in Indonesia but due to the high mortality rate and transportation cost from Kupang to Dili, fish farmers now catch fingerlings from the sea for cultivation in ponds. This significantly limits the scale of production.

Table 5: Gross Margin for Milk Fish Production

1 ha pond / 6 month cycle	USD
Income	
20,000 fish[1] x 0.15kg/fish = 3,000kg @ $6/kg	18,000
Variable Costs	
8,100kg feed[2] @ $1.50/kg	12,150
3,240kg bran @ $0.50/kg	1,620
Kitchen waste	0
Farm yard manure	0
Sub-total	*13,770*
Gross Margin	**4,230**

[1]Survival rate of 40% from original 5 fish/m²

[2] 3,000 kg fish x 1.5% body weight daily feed x 180 days

Interviews with fish-farmers revealed that fingerling survival rates are only 40% and it takes up to six months for the fish to reach harvestable size. Low survival rates are caused by physico-chemical conditions such as poor water quality due to stagnation/lack of oxygenation, high water temperature and pollution from feeds. Fish are also lost due to seepage and predation. Although not feeding the recommended amounts of concentrate feeds, milkfish farmers are buying some concentrate feed and mixing it with locally available bran and kitchen waste. Average gross margins for a 250m² pond under this scenario is USD1,058. Productivity could be improved through increasing the survival rate and reducing concentrate feed costs, described further under Section 3.1.4.

There is a demand for milkfish in Dili as Kmanek supermarket imports 10 MT of frozen milkfish/month from Vietnam.[17] Developing milkfish production on a commercial basis would be reliant on establishing a hatchery and gaining access to cheaper feeds. However, the biggest barrier to commercial milkfish production in Timor-Leste is the cheap imported milkfish which retails at USD 1.90/kg. Whilst milkfish is popular for home consumption and there is a small local demand in rural communities who are willing to pay USD 6/kg, it is unlikely fish farmers will be able to compete on Dili markets against cheap imports.

Mud crab *(Scylla serrata)* was previously introduced by the USDA MCFC project, which established a mud crab hatchery in Vemase. The hatchery has currently ceased operations whilst repair works to the water intake gallery take place. However, the hatchery will only be viable if supplying crablets on a large scale to commercial crab farmers, who in turn would need to supply end markets overseas.

Under the USDA MCFC project, crabs were raised in twenty of the milkfish ponds under a polyculture system. Production has been low and currently there are only five groups who continue to catch juvenile crabs from the mangrove and raise them for sale to seafood restaurants in Dili. Restaurants demand live crabs, weighing at least 800 grams each and the current farm-gate price is USD 10/kg. The demand for crab in Dili remains small at about 300kg/week.[18]

[16] Based on Consultant interviews with fish farmers

[17] Baticados (2014) *Market Study of Farmer Milkfish and Tilapia in Timor Leste,* ACDI/VOCA

[18] Wilkinson (2011) *Mud Crab Value Chain Analysis,* ACDI/VOCA

Prawn farming was introduced under the Indonesian regime; however, the ponds remain abandoned at Tibar. 'Mariscus Timor' has recently started the first commercial prawn farm in Timor-Leste. Located in Metinaro, the site has eight 2,500m² ponds capable of producing 7 MT of '*faname*' prawn in each pond, every four months. Feeds and fry will be imported from Indonesia.

It is expected the main market will be overseas. Frozen prawns are currently imported from Vietnam and retail for USD 15/kg in Dili supermarkets. Prawn production is very cost competitive and dependent on economies of size to reduce costs. Risks such as reliance on imported inputs and export end markets, investment costs and management requirements are high. As such, prawn farming is better suited for larger commercial farmers.

2.1.4 FISH FEEDS

Fish feed is the biggest variable cost in aquaculture and has a direct and significant impact upon profitability.

Supply

There is no domestic feed production/milling in Timor-Leste, however, complete concentrate pelleted fish feed is imported from Surabaya and sold in Dili by agricultural merchants. A 30kg bag of fish feed with 16-20% crude protein content costs USD 40, or USD 1.50/kg.

Demand

Based upon the number of fingerlings distributed by the hatcheries in 2015, the annual demand for fish feed in Timor-Leste is 55 MT.[19] This is an optimistic estimate as the production of fingerlings has since reduced, the 85% survival rate is higher than current averages and it assumes all fish farmers are willing and able to purchase feeds.

Local feed production

Based upon gross margin analysis carried out in Table 4, the major cost of aquaculture is feeds. Local feed preparations have been prepared under two scenarios: local milling/local ingredients and local milling/imported ingredients. The local ingredient formulation, as shown in Table 6, has a production cost of USD 0.30/kg and uses leucaena leaf meal as the main source of protein. Whilst this is appropriate for an individual household, it would be difficult to source the ingredients for large-scale production.

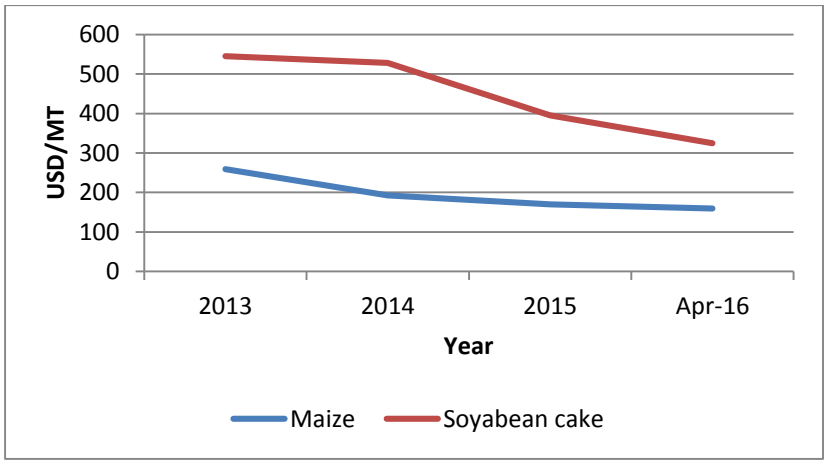
Table 6: Feed Formulation Using Local Ingredients

Local milling, local ingredients	
Ingredients	
Rice bran	40%
Leucaena leaf meal	49%
Fresh cassava	10%
Salt	1%
Cost	**$0.30/kg**
Nutritional value	
Crude Protein	22%
Fiber	11%
Fat	12%

The international prices of maize and soya bean cake have been falling over recent years, as shown in Figure 1.

[19] 120,000 fish x 0.15kg weight x 85% survival rate x 3% body weight daily feed rate x 4 months = 55,080kg

Figure 1: Imported Soya Bean Cake and Maize Costs



Source: World Bank Pink Sheet
Notes: Maize price fob US Gulf Ports, soya bean cake price cif Rotterdam

Soya bean cake and maize are much cheaper to import, than buy locally even if sufficient volumes were available. Local soya bean costs USD 1,000/MT, whilst imported soya bean cake costs only USD 325/MT. Similarly local maize costs USD 250/MT, whilst imported maize costs USD 159/MT. The cost of producing a basic protein supplement (18% CP) using imported maize and soya bean cake is presented in Table 7 and costs only USD 0.18/kg.

Table 7: Protein Supplement using Imported Maize and Soya Bean Cake

Ingredient	Amount	Cost (USD)
Soybean cake (44% CP)	25% @ USD325/MT	81
Maize (9% CP)	75% @ USD159/MT	99
Total (USD/MT)		**180**

Table 8 shows the cost of preparing a complete concentrate feed in Timor-Leste using imported ingredients is USD 0.54/kg, which is considerably cheaper than the imported feed and could be produced at a commercial level.

Table 8: Feed Formulation Using Imported Ingredients

Local milling, imported ingredients	
Ingredients	
Rice bran	20%
Fish meal	10%
Soya bean cake	10%
Wheat bran	22%
Cattle/poultry stomach meal	10%
Blood meal	5%
Palm kernel cake	5%
Cassava meal	14%
Vitamin & mineral mix	3%
Salt	1%
Cost	**$0.54/kg**
Nutritional value	
Crude Protein	26.7%
Fibre	6.6%

In conclusion, it is possible to produce feeds cheaper in Timor-Leste than to import the complete concentrate feeds from Indonesia. However, it would be reliant on importing the ingredients and mixing them in Timor-Leste, which needs to have a commercial basis. Based on a demand for fish feeds of only 55 MT/annum, it is unlikely private sector investors would be interested in establishing a feed mill in Timor-Leste at this point in time.

A commercial level of fish farming is required to attract commercial feed millers and future opportunities may lie in supplying the new Mariscus Timor prawn farm. The wider livestock feeds industry also needs to be considered. The Grasia egg farm in Ermera requires concentrate layer feeds and the availability of cheaper pig and poultry rations could stimulate a game-changing growth in intensive pig and poultry production in Timor-Leste.

2.2 POPULATION AND CONSUMPTION

Timor-Leste has a total population of 1,167,242 persons, 328,281 (28%) of whom are considered urban and therefore, net food consumers. Dili is the largest urban center with 222,323 residents.[20] Mean household income is estimated at USD 378/month, with urban households (USD 674/month) earning more than twice that of rural households (USD 292/month).[21]

Average fish consumption in Timor-Leste is 6.1kg/capita/year, giving a national annual consumption of 7,120 MT.[22] Unsurprisingly, coastal communities eat more fish (17.6kg/capita/year) than meat (12.1kg/capita/year) and non-coastal communities eat more meat (11.6kg/capita/year) than fish (4kg/capita/year). Chicken is the most common type of meat eaten. The underlying rationale for eating fish or meat is whether you are a fisher or a farmer and produce your own fish or meat.

Table 9 shows the demand and supply of fish products in Timor-Leste. The amount of farmed fish is calculated on the number of fingerlings distributed by the hatcheries in 2015 (See Table 3) and amounts to less than 1% of national fish consumption. As imports account for 15%, the remaining 6,065 MT (85%) is assumed to originate from in-shore capture fisheries.

Table 9: Supply and Demand of Fish Products in Timor-Leste

Demand	MT
1,167,242 persons x 6.1kg	7,120
Supply	**MT**
Imports[1]	1,040
Farmed fish[2]	15
Capture fish[3]	6,065

[1] ITC
[2] Based on number of fingerlings distributed
[3] Demand minus imports and farmed fish

Table 10 shows the importation of fish products in 2014 amounted to a value of USD 1.85 million, nearly triple that in 2010. Imports of aquaculture products such as prawn, tilapia and milkfish are sourced from Vietnam. Whilst imports of marine products such as octopus, squid and sardine are sourced from Portugal.

[20] GDS (2015) *Population and Housing Census 2015 (Preliminary results),* MoF
[21] GDS (2011) *Timor Leste Household Income and Expenditure Survey,* MoF
[22] NDFA (2011) *Fish and Animal Protein Consumption and Availability in Timor Leste,* MAF

Table 10: Fish, Crustacean, Mollusk and other Aquatic Invertebrates Imports by Value

Year	2010	2011	2012	2013	2014
Value (USD '000)	662	153	402	1,135	1,853

Source: MoF, External Trade Statistics, 2014

In quantity terms, ITC estimates Timor-Leste imported 986 tons of whole frozen fish, 34 tons of molluscs, 18 tons of fish fillets and 2 tons of crustaceans in 2015. Imported fish products are mainly for the Dili market and sold through supermarkets. Imports could be substituted by local products if there were adequate volumes available that could be supplied through consistent supply chains at a competitive price.

There are no records of fish exports from Timor-Leste. However, there is significant regional demand for fish products, particularly fresh whole fish. If Timor-Leste was ever to consider exporting fish products, Singapore would be an ideal market as there is high demand and it is close-by with air and sea links already established. Table 11 shows seafood imports for Singapore in 2015.

Table 11: Singapore Seafood Imports 2015

Product	Imports (t)	Origin
Fresh whole fish	43,388	Indonesia, Malaysia
Frozen whole fish	27,243	China
Fish fillets (frozen or fresh)	26,417	Vietnam
Crustaceans (lobster, crab, prawn)	25,273	Malaysia, Indonesia
Molluscs (oysters, scallops, mussels, abalone, octopus, squid, clams)	15,802	Malaysia, China, Indonesia

Source: ITC

Most of the seafood imports into Singapore are consumed domestically. Singapore could easily absorb the small volumes of seafood products produced by Timor-Leste; however, the constraint is producing enough volume to attract Singapore buyers.

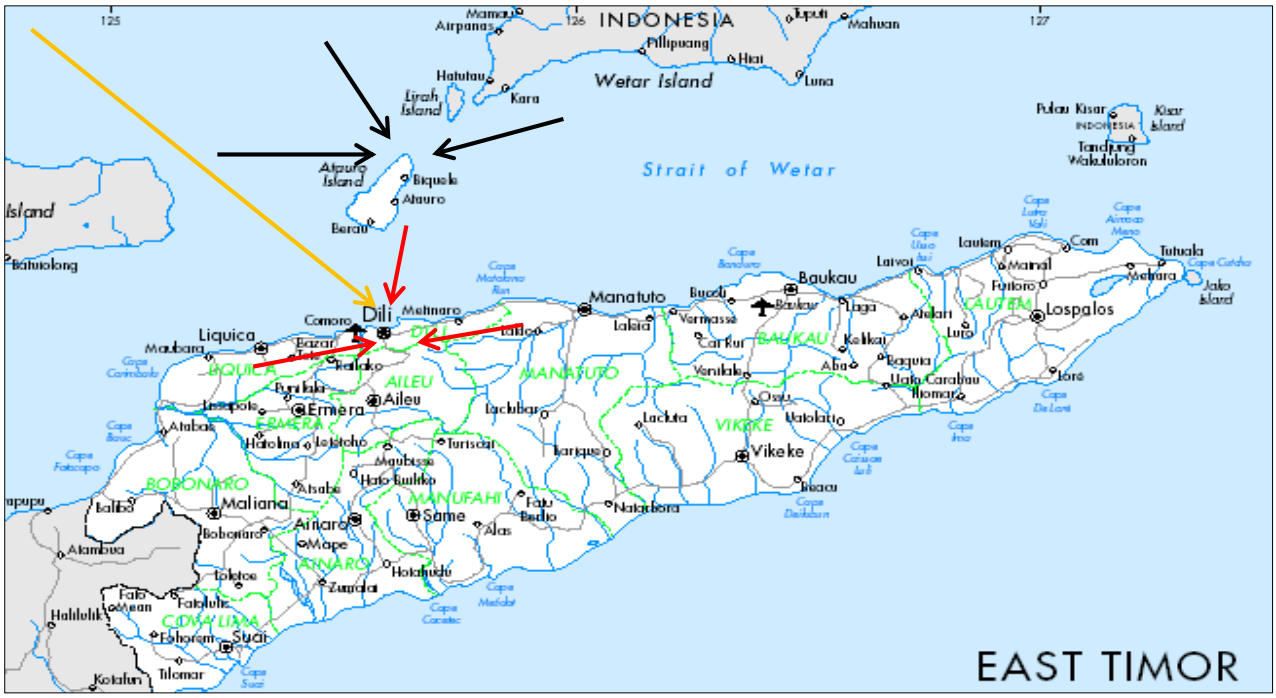
3.0 THE MARKETING SUB-SYSTEM

3.1 SPATIAL MARKETING FLOWS

Capture Fish

Small-scale artisanal sea-fishers tend to land their catch close to their respective homes and villages, where they are consumed. As fish is highly perishable and the cold chain is limited to ice in Dili, very little fish is transported around Timor-Leste. Figure 2 shows a map of spatial marketing flows for fish.

Figure 2: Spatial Marketing Flows



Legend:

- Fish from Atauro, Liquiça and Metinaro
- Fish from Indonesia to Atauro
- Imported frozen fish via container ship from Singapore

Fish caught and landed between Liquiça, to the west of Dili, and Metinaro, to the east of Dili, are transported the short distance to Dili by land. However the majority of sea fish sold in Dili is brought from Atauro Island, situated 20 nautical miles north of Dili. Anecdotal evidence suggests that at least 50% of this fish is actually caught by Indonesian boats from the neighboring islands of Alor and Wetar, and sold on to Atauro fishers, who transport it with their own caught fish for sale in Dili.

Imported fish is brought in frozen by container ship from Singapore to supply supermarkets in Dili.

Farmed fish

Due to the low quantities produced, most fish from aquaculture ponds are sold and consumed locally. Ponds located near urban centers such as Dili and Baucau sell some fish to traders from markets there.

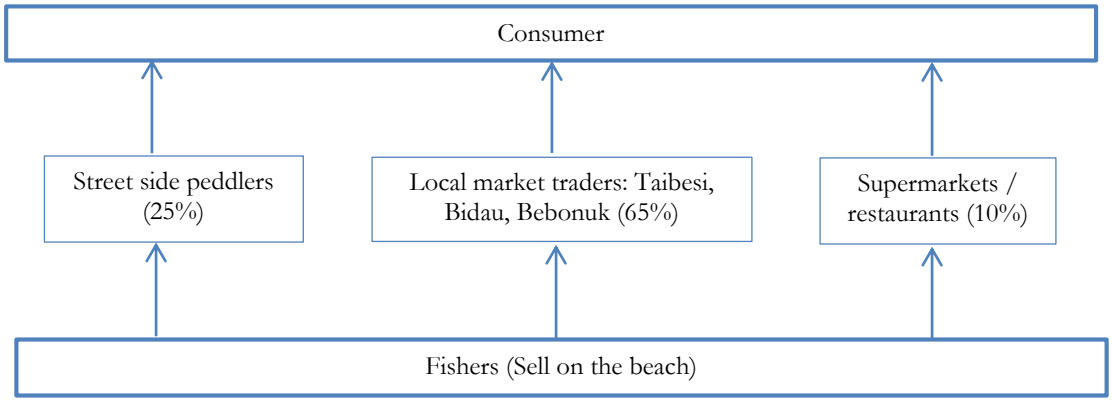
3.2 INSTITUTIONAL COMMODITY FLOWS

Institutional commodity flows are relatively short for both capture and farmed fish, largely due to perishability of the product.

Capture fish

Fishers sell their daily catch on the beach directly after returning from the sea. In Dili, most fish (65%) are sold to traders from the wet market at Taibesi, or the temporary beachside fish markets in Bebonuk and Bidau. Smaller amounts (25%) are sold to itinerant street-side peddlers and the remaining 10% is sold to supermarkets and restaurants. The institutional commodity flow for sea fish sold in Dili is summarized in Figure 3.

Figure 3: Institutional Commodity Flow for Sea Fish Sold in Dili

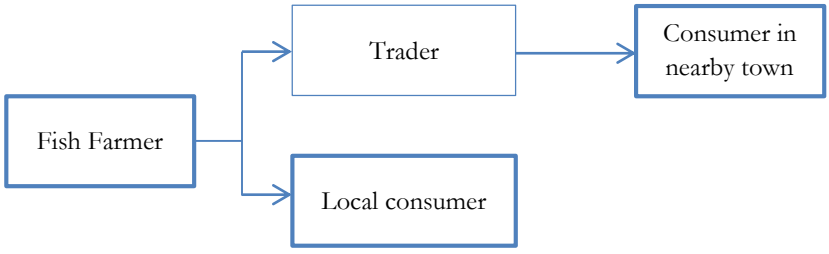


In non-urban coastal areas more fish is sold direct to consumers (64%) and in non-coastal areas more fish is sold through local district markets (79%).[23]

Farmed fish

The institutional commodity flow for tilapia and milkfish is even simpler than for capture fish, as shown in Figure 4. When the fish are harvested, the local community and traders are informed to come and buy at the ponds. Most of the fish are sold directly to consumers, although some traders may buy fish to sell in nearby towns.

Figure 4: Institutional Commodity Flow for Tilapia / Milk Fish



With the current low volumes of production, selling pond fish is not a problem. However, if production were to increase, marketing will become increasingly important as pond fish are harvested in bulk at the end of a

[23] NDFA (2011) *Fish and Animal Protein Consumption and Availability in Timor Leste,* MAF

production cycle and need to be sold/consumed quickly due to the lack of cold storage. This could be further exacerbated if several ponds were harvested at the same time. Descriptions of the different stakeholders in the institutional commodity flow are provided below.

Fishers/fish farmers: MAF estimates there are 5,265 fishers in Timor. The average artisanal fisher, fishes for less than six hours per day and catches approximately 110kg/month. The fisher household will consume 10kg of fish/month and sell 100kg of fish/month to traders on the beach when they return to shore. Fishing provides a daily income which can amount to USD300/month. Most fishers also have other income streams from activities such as farming.

There are approximately 2,000 fish farmers in Timor-Leste. For most, aquaculture is a new activity in addition to regular crop and livestock farming. Most fish are consumed by the farm household, with any surpluses sold direct to the local community.

Fish traders: There are approximately 100 fish traders in Dili, plus a few in each district market. Fish traders buy directly from fishers and retail to consumers. Traders only deal in fish and seafood products and sell approximately 800kg of fish a month each. Although there is no formal fish trader association, there is some self-regulation with regards who can trade fish in the established markets.

Itinerant street peddlers: Itinerant street peddlers are either fishers wishing to sell direct to consumers or opportunistic individuals seeking cash in the short-term. Due to the temporary nature of their business, they are unable to trade in the established markets. Nonetheless, they are responsible for 25% of fish sales in Dili.

Supermarkets: The four main supermarkets in Dili (Kmanek, Leader, Lita and Landmark) mostly import and sell frozen fish and seafood products, which are cheaper than local products. Kmanek reportedly imports 10 MT of tilapia and 10 MT of milkfish a month.[24] Until production quantities increase and prices decrease, it is unlikely supermarkets will become interested in engaging with local supply chains. Nonetheless, a central landing site with processing/chilling/freezing facilities in Dili would facilitate this.

Restaurants: Restaurants buy direct from fishers to ensure freshness and quality. There are only two restaurants in Dili specializing in seafood and it is estimated weekly sales through either of these restaurants is comparatively small at 200kg. The majority of cooked, ready-to-eat fish is sold through the multitude of small roadside eateries.

Consumers: The Fish Consumption Survey concluded that although higher meat consumption was related to higher incomes, there was no correlation between fish consumption and income. Nonetheless, as a lower middle income country, with the majority of income spent on food, the average consumer is price conscious. Most fish is bought in amounts between one and two kilograms and 40% of consumers buy fish at least once a week.[25]

[24] Baticados (2014) *Market Study of Farmer Milkfish and Tilapia in Timor Leste,* ACDI/VOCA
[25] NDFA (2011) *Fish and Animal Protein Consumption and Availability in Timor Leste,* MAF

3.3 MARKET FUNCTIONS

3.3.1 EXCHANGE

The main fish market in Dili is at Taibesi. The Government provided an area with tiled tables, running water and cold storage. However, the facility has fallen into disrepair and traders sell from ice boxes. Temporary markets have also been established by the beachside in Bidau and Bebonuk. Fish are kept in ice boxes and some are displayed on wooden benches, exposed to passing traffic fumes, dust and flies. Fish markets in the districts are a similar standard to these temporary markets.

Supermarkets sell only frozen fish, although there are plans for quality fresh fish to be sold in a small delicatessen for the high-end consumer market.

As most of the fish in Dili is sourced from Atauro, Dili would benefit from a central landing site where fish auctions could take place to support a more efficient distribution network. The site could also provide an ice plant, cold storage and processing facilities.

'Fish market in Bebonuk'

3.3.2 PROCESSING

Primary processing is undertaken in Timor-Leste for fish and seaweed.

Fish

Fish are generally sold fresh, which attracts the highest price. Processing, mostly drying, is carried out to preserve fish that cannot be sold and would otherwise go to waste. If the loss of weight during the drying process is accounted for, processed fish sells for a third of the cost of fresh fish. Fish drying is carried out by scaling, deheading/finning, gutting and splitting the fish along its length into two connected halves (one fillet with the vertebrae and one without). The fish is then sun-dried on a bamboo rack covered by fly screen.

'Traditional fish drying'

'Tilapia fillets for freezing'

Other processing such as filleting has yet to develop in Timor-Leste, as most consumers still prefer to buy whole fresh fish. Nonetheless, there may be interest in filleted fish in the future from restaurants and high-end delicatessens. Also, if fish are to be frozen for storage, filleting, or just gutting and scaling is recommended to maintain quality.

Seaweed

Timor-Leste exports dried seaweed, which is cleaned and sorted before drying on platforms over 2-3 days to a moisture content between 35-40%. The dried seaweed is packed in plastic sacks to await collection.

Seaweed can also be exported as 'refined' or 'traditionally extracted carrageenan' and 'semi-refined carrageenan' (SRC), also known as 'Philippines Natural Grade Carrageenan'. In Indonesia, a major producer of seaweed, value-addition is being promoted by processing the seaweed into SRC before export. SRC processing requires an Alkali Treated Chip processing plant and mini plants requiring only 100 MT of dry seaweed/month are being piloted there. [26]

3.3.3 STORAGE

There is no commercial ice plant in Timor-Leste and most ice is made in domestic freezers. FAO estimates up to 10% of the fish catch is wasted due to inappropriate post-harvest management. Although ice is used by up to 70% of fishers in Dili and Atauro, outside of Dili district, only 8% of fishers use ice.[27]

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[26] Bassford (2011) *Timor Leste Seaweed Value Chain,* WorldFish Centre

[27] AMSAT (2011) *Regional Fisheries Livelihoods Programme, Baseline Survey,* AECID/FAO

When ice is available, blocks are placed with fish in 70 liter styrofoam insulated ice boxes. If the temperature is kept at 0ºC and melt water drained, fish can be kept in ice boxes for up to ten days. If fish is to be stored any longer, it must be frozen or processed.

Storage of farmed fish will become more important as production increases, due to the bulk harvest from ponds. Ice will need to be made more readily available in rural areas and filleting may need to take place before freezing. Individual Quick Freezing (IQF) with blast freezers to -30ºC allows the storage of fish for up to twelve months and conventional freezing to -18ºC allows storage for four months.

'Fish stored in chipped ice'

3.3.4 TRANSPORT

Although there are a few small refrigerated trucks in Timor-Leste, most fish is packed in 70 liter styrofoam ice boxes, as described above, and transported by pickup trucks. As long as the fish are not over packed and cold temperatures are maintained, transport is not a major constraint for fish marketing.

3.4 INTRA-FIRM ORGANIZATION

Intra-firm organization relates to the efficiency of supply chains. Horizontal integration refers to coordination between producers to supply a product in sufficient quantities and at regular intervals to attract traders. Vertical integration refers to linkages or business arrangements between producers and traders to better access end markets.

Horizontal integration

Aquaculture producer groups and associations have been established by donor projects for the purposes of production and marketing. However, as production levels are still low, they have yet to fully function.

Once production increases and market linkages become more important, groups can benefit from having supply agreements with buyers to assure market access. Buyers require regular and consistent supplies, which single fish ponds are unable to provide, as the fish are harvested in bulk. Therefore, the coordination and scheduling of supply between several groups will be important to improve market linkages in the future.

On Atauro, five cooperatives have been established with a total of 286 members, to market members' sea fish and seaweed. In turn, the five cooperatives are members of the Federation of Atauro Fishing Cooperatives. The Federation buys fish from its member cooperatives and trades as an independent entity. The Federation also provides ice for its members and currently transports one ton of fish per week for sale to traders in Dili. This appears to be an excellent business model, whereby the cooperatives provide horizontal integration to aggregate supply and the Federation provides vertical integration with markets.

Vertical integration

Sea fishers have established informal linkages with traders. However, no formal contracts exist and quantities and prices are agreed on the day of sale. This can create uncertainty for both parties – unsure quantities and quality for traders and unsure prices for fishers.

Inland aquaculture production is bulk harvested at the end of a production cycle, potentially releasing large amounts of fish on to the market at one time. Although not currently an issue, if production does significantly increase, marketing will become a challenge. As demand from local rural communities is limited, most of the fish will need to be sold on urban markets, requiring market linkages with traders there. Such marketing networks do not yet exist in inland rural Timor-Leste.

4.0 CROSS-CUTTING FACTORS

4.1 GENDER[28]

Marine capture fisheries are generally a male activity, although women and children take part in reef gleaning. Aquaculture is viewed to greatly benefit women as production activities can be carried out close to homesteads and with minimal investment.

Although men dominate fish trading; women carry out the majority of handling, preservation, and processing of fish products. The role of women in fisheries is often viewed to be small-scale and home-based. As such, development policies have traditionally targeted women as fish processors, whereas men are engaged as fishers and managers of the resources, excluding women in the 'mainstream' planning of the sector.

Women's involvement and contribution to fisheries and aquaculture have been long established. However, lack of education and leadership capacity, high demands on time for domestic tasks and family care, restrictions of mobility outside their home domains, and norms and values embedded in the culture regarding women's roles and position in society; all pose complex challenges in effectively improving women's equitable participation and benefits in the sector. The comparatively low value attached to women's work reinforces gender inequities in access to production technologies, information and training on new technology, market information, and in taking up leadership and management roles in fisheries and aquaculture.

4.2 YOUTH

Timor-Leste has a very young population with 43% of the demographic aged under 19 years old. Youth unemployment is a major concern in Timor-Leste. Although the official employment rate for 15 to 64 year olds is 90%, this does not relate to salaried employment, as most of the population are smallholder farmers.[29] Salaried employment opportunities, particularly in the private sector, are limited and school leavers are generally uninterested in undertaking the drudgery and low returns offered by the traditional fisheries sector. However, experience in other countries has shown youth are interested in modern intensive aquaculture and aquabusiness that produces incomes comparable to other commercial sectors.

4.3 SUSTAINABILITY & ENVIRONMENTAL IMPACT

Capture Fish

The sustainability of wild fish stocks is a major concern for marine capture fisheries. Timor-Leste is part of the Coral Triangle and is home to abundant and diverse marine species. However, many of the larger fish such as sharks, whale sharks, manta rays, big-eye tuna and Napoleon Wrasse have been identified as vulnerable; and a number of turtle species are endangered.[30]

The sustainability of offshore commercial fisheries is commonly managed by licensing and quotas, based on a comprehensive 'stock assessment'. Zoning is also used to establish fish sanctuaries; protection of critical fish

[28] FAO (2013) *Mainstreaming Gender in Fisheries and Aquaculture,* Rome
[29] GDS (2011) *Population and Housing Census of Timor Leste 2010,* MoF
[30] MED (2011) *The National Biodiversity Strategy and Action Plan for Timor Leste,* GoTL

habitat e.g. spawning aggregation sites; seasonal closure at crucial life-cycle stages; exclusion zones and the banning of catching some species. However, no 'stock assessment' has been carried out in Timor-Leste and the Maritime Police are unable to control IUU fishing, which poses a threat to the long-term sustainability of off-shore fisheries.

Fringing coral reefs form an almost continuous strip along the coastal waters of Timor-Leste. Reefs are important for protecting coastlines and mangrove from wave action, providing shelter for spawning and protection of juvenile fish before they make their way to the open sea. A rapid assessment undertaken in 2013 concluded the coral reefs exhibited relatively low levels of recent injury from crown-of-thorns, bleaching or blast fishing.[31] Other assessments concur that although the coral reefs are in good condition and there are a diverse number of fish species, there is an absence of larger fish and larger fish species. Though this is indicative of over-fishing, stocks could replenish if sustainably managed.[32]

To reduce the stress upon fish numbers in coastal areas, fishers can use larger motorized boats to fish further off-shore or introduce Fish Aggregation Devices (FAD) to attract larger pelagic fish closer to shore. Conservation International (NGO) has introduced community-based co-management practices for sustainable fisheries in the 'Nino Konis Santana National Park' in Lautem which includes a 55,600ha marine component. Sustainable management practices include multi-use zoning to sustain fish stocks, no-take zones, buffer zones and special regulation zones with a mix of gear restrictions, temporal closures and species specific take limits. Such interventions would need to be introduced for the rest of Timor-Leste, if fish stocks are to replenish.

Farmed fish

Mangrove forests protect the coastline from erosion and coral reefs from sedimentation and, along with seagrasses and coral reefs, are the primary breeding grounds for many fish and shellfish species. The country's mangroves occupy approximately 750ha, with the largest stand found in the Metinaro region. Mangrove forests appear relatively intact in Timor-Leste, although they are occasionally harvested for timber and fuelwood.[33]

In other countries such as Indonesia, the establishment of large commercial brackish water prawn and fish ponds has had a devastating effect on mangrove resulting in habitat loss and water pollution due to chemicals, nutrients and organic matter in waste effluent. This has not happened in Timor Leste due to the current small-scale of aquaculture production. Nevertheless, environmental impact can be mitigated through Initial Environmental Impact Assessments and sustainable management plans before issuing business licenses.

The sustainability of fish farming is reliant on access to fingerlings and feed. All but one of the MAF hatcheries has ceased producing fingerlings and the future of the remaining hatchery in Gleno is uncertain due to lack of Government funding. Although feed is available, it has to be imported from Indonesia. Prospects for sustainability would improve through the emergence of private-sector hatcheries and feed mills. However, this will only take place if demand for those inputs increases on a commercial basis.

[31] Erdmann & Mohan (2013) *A Rapid Marine Biological Assessment of Timor Leste,* Coral Triangle Support Partnership
[32] Pinto (2015) *How healthy are our stocks? An analysis of Oé-Cusse fish biomass data,* ZEESM
[33] MED (2011) *The National Biodiversity Strategy and Action Plan for Timor Leste,* GoTL

5.0 CONCLSUIONS

Conclusions are presented as a Strengths, Weaknesses, Opportunities and Threats (SWOT). Products which have similar results have been clustered into a single SWOT framework, to avoid repetition.

5.1 MARICULTURE AND MARINE FISHERIES

INSHORE MARINE CAPTURE	
Strengths • Diverse species: snapper, trevally, sardine, wrasse, grouper. • Artisanal capture fisheries provide daily food and income. • Relatively small investment costs and quick returns. • Basic marketing networks already established in all coastal areas. • Many experienced fishers with own boats.	**Weaknesses** • Wastage, no ice plant. • No processing facilities. • No central landing site (Dili). • Poor food safety. • No national trader marketing network. • Use of traditional fishing methods.
Opportunities • 783km of coastline. • High demand for fresh sea fish. • Improved fishing techniques e.g. FADs.	**Threats** • Over fishing: coastal fish stocks are already depleted – Need for sustainable fisheries management – stock assessment, community-based fisheries plan.

OFFSHORE MARINE CAPTURE	
Strengths • None – no domestic offshore fishing fleet.	**Weaknesses** • No direct benefit for rural communities. • Ineffective Maritime Police. • No stock assessment. • No commercial landing site.
Opportunities • 75,000km² of Exclusive Economic Zone waters. • Sahul banks area rich in fish. • Stock assessment to establish sustainable fishing quotas. • Establish domestic offshore fleet. • High export potential.	**Threats** • High level of Illegal Unreported Unregulated fishing.

MARICULTURE - SEAWEED	
Strengths • Seaweed farming cooperatives already established in Atauro. • Can be widely grown by coastal communities.	**Weaknesses** • Low productivity.

• Established market networks to Indonesia.	• Low volumes of production, seaweed has to enter Indonesian supply chain, rather than direct to end market. • Small domestic demand, dependent on export market.
Opportunities • Further processing into 'Semi-Refined Carrageenan'. • Produce new (food) products for domestic market.	**Threats** • Over production in Indonesia & Philippines. • Low prices, Indonesian traders no longer buy from Timor-Leste.

MARICULTURE – GROUPER, SEA-CUCUMBER & PRAWN	
Strengths • One private grouper farm. • One private sea cucumber rancher. • New private commercial prawn farm.	**Weaknesses** • No storage / ice plant or processing facilities. • Have to import fingerlings and feed from Indonesia (grouper, prawn). • High investment costs and management requirements = high risk. • Small potential volumes of production (not enough to access export markets). • No previous experience and introduction of new technologies required. • Domestic demand limited to Dili.
Opportunities • Demand in Dili for high quality fresh fish (e.g. grouper) and prawn.	**Threats** • Mariculture susceptible to environmental change i.e. water temperature, salinity. • Import of frozen prawn from Vietnam undermines development of commercial shrimp production in Timor-Leste.

5.2 FRESHWATER AND BRACKISH WATER AQUACULTURE

CARP, CATFISH & MUDCRAB	
Strengths • Carp is most preferred eating fish. • Catfish has short cultivation period (3-4 months). • Low feed requirements (carp and catfish). • Catfish can survive in poor physico-chemical environment.	**Weaknesses** • Carp has long cultivation period (9-12 months). • No operating hatcheries to supply carp and catfish fingerlings or crablets. • Poor pond management skills. • Dependent on reliable access to fresh water (carp and catfish). • High cost of mechanical pond digging. • Lack of rural marketing network. • Limited demand for mud crab in Dili.
Opportunities • Some consumer demand in Dili.	**Threats** • Cheap frozen imports.

• Develop carp and catfish farming models appropriate for small farmers e.g. IAA, green technology feeds.	

TILAPIA & MILKFISH	
Strengths • High consumer demand in Dili and rural communities for small amounts already produced. • Easy to farm & short cultivation period (4-6 months). • Gleno hatchery produces GIFT tilapia fingerlings. • Several NGOs implementing aquaculture projects e.g. World Fish, Mercy Corp, Hivos. • Milk fish suitable for brackish water / coastal areas. • Tilapia can be farmed in both brackish water (coastal) and fresh water (inland).	**Weaknesses** • Ability of small farmers to purchase fingerlings and concentrate feeds. • Small-scale production (mainly for home consumption). • Only one hatchery in Gleno/Ermera currently produces tilapia fingerlings. • No hatchery producing milkfish fingerlings, production limited by collection of wild fingerlings. • Poor pond management skills. • Dependent on reliable access to fresh water. • High cost of mechanical pond digging. • Bulk harvesting requires improved rural marketing network, cold chain and possibly filleting and freezing facilities if production significantly increases.
Opportunities • Develop tilapia and milk fish farming models appropriate for small farmers e.g. IAA, green technology feeds, sustainable fingerling replacement (tilapia), collection of wild fry/fingerlings (milkfish). • Milkfish polyculture with other species such as mud crab. • Introduce brackish water tilapia production. • Introduce school fish ponds (school feeding). • Improve post-harvest handling (ice making). • Improve market linkages. • Aquaculture can supplement marine artisanal fisheries.	**Threats** • Cheap imports of frozen tilapia and milkfish from Vietnam undermines development of commercial production in Timor-Leste. • Unsure land ownership for commercial pond construction.

5.3 DOMESTIC FISH FEED PRODUCTION

FISH FEED	
Strengths • Imported feeds available at $1.50/kg (retail). • Local commercial production: imported ingredients, mixed locally = $0.54/kg (cost of inputs). • Local small-scale production with local ingredients = $0.30/kg (cost of inputs).	**Weaknesses** • Capacity of small farmers to purchase feeds. • Not enough locally available inputs. • Limited current demand (55 MT) does not attract private sector investment for commercial feed mill.
Opportunities • Small farmers: low input/low output feed technologies e.g. greening, IAA. • Supplying emerging commercial producers e.g. Mariscus Timor prawn farm, Grasia egg farm with feed formulations based on imported inputs. • Potential to also intensify pig and poultry production.	**Threats** • Import licensing & quarantine restrictions on feeds and inputs. • Cheap frozen fish and poultry imports undermine development of commercial aqua/agriculture industry in Timor-Leste and need for commercial feed mill.

ANNEXES

ANNEX A: ON-GOING FISHERIES PROJECTS

Project: Partnership for Aquaculture Development in Timor-Leste		
Donor: New Zealand Aid	Duration: 2014 - 2019	Budget: USD 4 million
Location: Baucau, Bobonaro, Ermera districts.		
Description: Implemented by World Fish, NIWA and TISBE. Supports MAF implement the National Aquaculture Strategy with the main objective of increasing economic and food security benefits from sustainable fisheries and aquaculture. Main achievement has been rehabilitating the Gleno Hatchery to produce GIFT tilapia fingerlings.		

Project: Combatting Malnutrition and Poverty through Aquaculture in Timor-Leste (COMPACT-TL)		
Donor: Norwegian Ministry of Foreign Affairs	Duration: 2013 - 16	Budget: USD 2.1 million
Location: Ainaro, Baucau, Lautem, Viqueque, Manufahi, Covalima districts.		
Description: Implemented by Mercy Corps and Hivos. The projects overall objective is improved nutrition security and increased incomes for 1,500 households. Main activities include promoting community-based fish ponds.		

Project: Fisheries Support Programme		
Donor: Norway	Duration: 2016 - 18	Budget: USD 1.2 million
Location: Baucau, Viqueque, Bobonaro districts.		
Description: Implemented by World Fish. Pilot project to improve fisheries information and exploring artisanal inshore fisheries potential in three villages.		

Project: Exploring Options for Improving Livelihoods and Resource Management in Timor-Leste's Coastal Communities		
Donor: ACIAR	Duration: 2013 - 16	Budget: USD 601,845
Location: Atauro and Bobonaro districts.		
Description: Piloting seaweed and FADs in coastal communities.		

Project: Fisheries Training Centre in Liquiça		
Donor: KOICA	Duration: 2014-17	Budget: USD 6.5 million
Location: Liquiça		
Description: The training center will provide short-duration aquaculture (tilapia and milkfish) training courses for MAF Extension Workers and community leaders. The Centre will also provide 6 month training courses for Timorese overseas workers going to Korea.		

ANNEX B: DOCUMENTS REVIEWED

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AMSAT (2011) *Fish and Animal Protein Consumption and Availability in Timor-Leste,* RFLP/AECID/FAO

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Wilkinson (2011) *Mud Crab Value Chain Analysis,* ACDI/VOCA

ANNEX C: PERSONS MET

Name	Designation	Place	Contact
Government			
Horacio Amaral dos Santos Guterres	National Director for Aquaculture, NDFA, MAF	Dili	77546399
Dani Fernandes	Chief Hatcheries Department, NDFA	Dili	77665068
Pedro Rodrigues	Chief Fisheries Inspectorate, NDFA	Dili	77664520
Márcio Lay	Director External Trade, MCIA	Dili	78141457
Oscar da Cruz	Gleno Hatchery Technician	Ermera	
Edalino Ximenes	Gleno Hatchery Technician	Ermera	
Marcos Freitas	Chief, Gleno Hatchery	Ermera	77345495
Francisco	Chief, Same Hatchery	Manufahi	
Estevao da Silva	Chief Fisheries, MAF	Baucau	77371042
Regio da Cruz Salu	Regional Secretary for Agriculture & Rural Development	Oecusse	77340018
Fernanda Dina	Chief, Agriculture & Fisheries	Oecusse	
Agusto Guterres	Technical Assistant, Vemase Hatchery	Baucau	77866196
Fransisco da Silva	Officer, Loihuno Hatchery	Viqueque	77322671
Olivio Freitas	Coordinator, Loihuno Hatchery	Viqueque	77271106
Donors / Projects			
Wahyu Nogroho	Acting Country Director, Mercy Corps	Dili	
Shivaun Leonard	USAID Fisheries Expert		
Dr Jhinkyoo Chae	Fisheries Advisor, KOICA	Dili	7846 1487
Mario Pereira	Senior Research Analyst, World Fish	Dili	7785 1358
Silvia de Araujo	Field Technician, World Fish	Gleno	77415003
Nelson Mendonca	Technician, Mercy Corps	Ainaro	77344790
Norberto Gomes	District Manager, Mercy Corps	Ainaro	77245410
Marito Soares	Extension Staff, Mercy Corps	Manufahi	77573836
Domingos Correia	Field Staff, Prospek	Baucau	77822639
Miguel de Sousa	Field Staff, Fraterna	Viqueque	77365664
Producers			
Wilhelmus Mapa	Fish farmer	Ainaro	
Mouzinho da Costa	Fish farmer	Ainaro	
Santina de Jesus	Fish farmer	Ainaro	
Dominghos de Araujo	Fish farmer	Ainaro	
Francisco Magno	Fish farmer	Ainaro	
Joao da Costa	Fingerling supplier/fish farmer	Manufahi	
Maria Soares	Fish farmer	Manufahi	77417691
Jose Soares de Jesus	Fish farmer	Oecusse	
Paulo Correia	Ulmera Mud Crab & Milk Fish Association	Liquiça	
Mario Sousa	Beiraka Mud Crab & Milk Fish Association	Hera	
Manuel Saldanha	Metinaro Mud Crab & Milk Fish Association	Dili	75871896
Julio da Silva	Field Technician, Metimurak Timor Milkfish Farm	Metinaro	76610156
Benedito Alves	Technical Manager, Mariscus Timor prawn farm	Metinaro	77836733
Tomas da Silva	Group Leader, Bercoli Group Leader, Ossu de Cima	Baucau	
Artur Pinto	Coordinator, Grouper Farm	Viqueque	
Guilherme Gomes	3 Fishing Cooperatives	Cristo Rei	77248198
Sea fishers & seaweed producers		Atauro	

Traders, Supermarkets & Restaurants			
Clarence Lim	CEO, Kmanek Trading	Dili	77284388
Elizito Barros	Kmanek Trading	Dili	331 0965
Traders	Bidau fish market	Dili	
Traders	Bebonuk fish market	Dili	
Traders	Taibesi fish market	Dili	
Danny Lee	Owner, Ocean View Restaurant	Dili	
Mariano da Cruz	CEO, Federation of Fishing Cooperatives	Atauro	77026369

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