



Fisheries and aquaculture of Timor-Leste in 2019: Current knowledge and opportunities



Funded by



Norwegian Embassy

In partnership with



MINISTÉRIO DA
AGRICULTURA
E PISCAS



Gabinete do
Director Geral das Pescas



RESEARCH
PROGRAM ON
Fish

Led by WorldFish

Fisheries and aquaculture of Timor-Leste in 2019: Current knowledge and opportunities

Authors

Juliana López Angarita¹, Kimberley Hunnam², Mario Pereira³, David Jonathan Mills⁴, Jharendu Pant⁴, Teoh Shwu Jiau⁴, Hampus Eriksson⁴, Lourenco Amaral⁵ and Alexander Tilley⁴

Authors' Affiliations

¹ Talking Oceans Foundation, Bogota, Colombia

² Research Institute for the Environment and Livelihoods, Charles Darwin University, Australia & Research School of Biology, The Australian National University, Australia

³ WorldFish, Dili, Timor-Leste

⁴ WorldFish, Penang, Malaysia

⁵ General Fisheries Directorate, Ministry of Agriculture and Fisheries, Government of Timor-Leste, Dili, Timor-Leste

Citation

This publication should be cited as: López-Angarita J, Hunnam KJ, Pereira M, Mills DJ, Pant J, Teoh SJ, Eriksson H, Amaral L and Tilley A. 2019. Fisheries and aquaculture of Timor-Leste in 2019: Current knowledge and opportunities. Penang, Malaysia: WorldFish. Program Report: 2019-15.

Acknowledgments

This work was undertaken as part of the [CGIAR Research Program on Fish Agri-Food Systems \(FISH\)](#) led by [WorldFish](#). The program is supported by contributors to the [CGIAR Trust Fund](#). Funding support for this work was provided by the Norwegian Embassy in Jakarta in the framework of the Fisheries Sector Support Program in Timor-Leste. Initial drafting of this report was conducted by JLA through a consultancy with the World Bank. This publication has not gone through the standard WorldFish science review procedure. The authors gratefully acknowledge the participation and insight of all Timorese fishers and farmers who have generously contributed their knowledge and time to better understand the challenges and opportunities for leveraging the potential of fish and fisheries to alleviate poverty and malnutrition in Timor-Leste.

Contact

WorldFish Communications and Marketing Department, Jalan Batu Maung, Batu Maung, 11960 Bayan Lepas, Penang, Malaysia.
Email: worldfishcenter@cgiar.org

Creative Commons License



Content in this publication is licensed under a Creative Commons Attribution-NonCommercial-NoDerivatives 4.0 International (CC BY-NC-ND 4.0), which permits non-commercial re-use, distribution, and reproduction in any medium, provided the original work is properly cited, and is not altered, transformed, or built upon in any way.

© 2019 WorldFish.

Photo credits

Front cover, page 42, Dave Mills/WorldFish; pages 7, 12, 21, 22, 24, 36, 42, Alexander Tilley/WorldFish; page 18, Pelagic Data Systems; page 20, Agustinha Duarte/WorldFish; page 38, Jharendu Pant WorldFish

Disclaimer

The opinions expressed here belong to the authors, and do not necessarily reflect those of the FISH, WorldFish or CGIAR. The designations employed and the presentation of material in this information product do not imply the expression of any opinion whatsoever on the part of WorldFish concerning the legal or development status of any country, territory, city or area or of its authorities, or concerning the delimitation of its frontiers or boundaries. The mention of specific companies or products of manufacturers, whether or not these have been patented, does not imply that these have been endorsed or recommended by WorldFish in preference to others of a similar nature that are not mentioned. WorldFish encourages the use, reproduction and dissemination of material in this information product. Except where otherwise indicated, material may be copied, downloaded and printed for private study, research and teaching purposes, or for use in noncommercial products or services, provided that appropriate acknowledgment of WorldFish as the source and copyright holder is given and that WorldFish's endorsement of users' views, products or services is not implied in any way. WorldFish information products are available on the WorldFish website (www.worldfishcenter.org).

Table of contents

List of abbreviations	iii
1. Introduction	1
1.1 Context	1
1.2 Timor-Leste Strategic Development Plan	2
1.3 National fish consumption and nutrition policies	2
1.4 National economy: Gross Domestic Product and national spending	4
2. Capture fisheries	5
2.1 Overview	5
2.2 Historical trends of fishing in Timor-Leste	6
2.3 Estimates of fisheries production	6
2.4 Small-scale fisheries	7
2.5 Offshore fisheries	23
2.6 Value chains and nutrition	24
2.7 Governance	27
2.8 Development priorities	31
3. Aquaculture	37
3.1 Background	37
3.2 Governance	39
3.3 Area under aquaculture	40
3.4 Livelihoods and income	41
3.5 Productivity and sustainability	43
3.6 Advances in fish consumption and aquaculture	43
3.7 Development priorities	45
Notes	47
References	50
List of figures	53
List of tables	54
List of plates	55

List of abbreviations

COMPAC-TL	Combatting Malnutrition and Poverty through Aquaculture in Timor-Leste
CPUE	catch per unit effort
EEZ	exclusive economic zone
FAD	fish aggregating device
FAO	Food and Agriculture Organization of the United Nations
DGP	General Directorate of Fisheries (Direasaun Geral das Pescas)
GIFT	genetically improved farmed tilapia
GPS	Global Positioning System
GIS	Geographic Information Systems
HIES	Household Income and Expenditure Survey
JICA	Japan International Cooperation Agency
MAF	Ministry of Agriculture and Fisheries
NADS	National Aquaculture Development Strategy
NDFA	National Directorate of Fisheries and Aquaculture (now DGP)
PADTL	Partnership for Aquaculture Development in Timor-Leste
PeskaAS	The Fisheries Automated Analytics System developed by WorldFish
PICTs	Pacific island countries and territories
POS	points of sale to acronym list
RAEOA	Special Administrative Region of Oecusse-Ambeno
RFLP	Regional Fisheries Livelihood Programme for South and Southeast Asia
SDP	Timor-Leste Strategic Development Plan 2011–2030
SSF	small-scale fisheries
VMS	vessel monitoring system
WDI	World Development Indicators

1. Introduction

1.1 Context

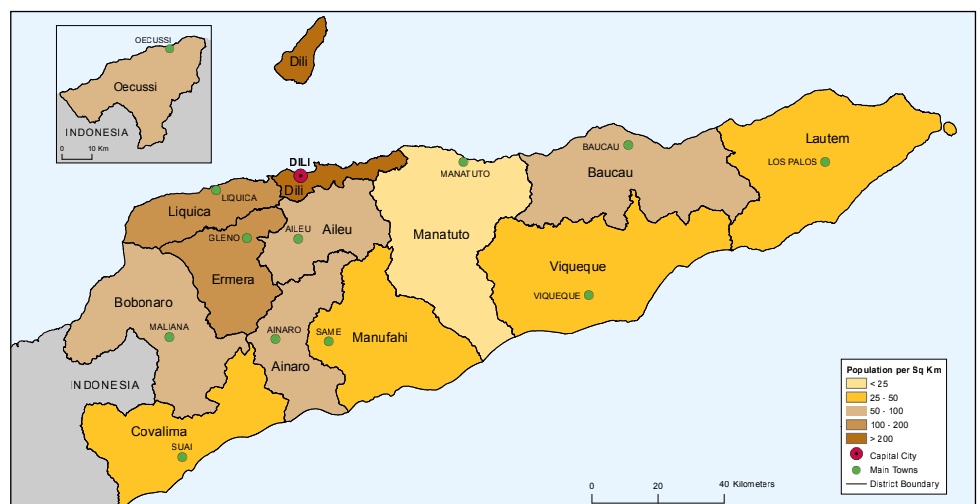
Fish is a crucial resource in island economies and food systems. Produced by capture fisheries and aquaculture systems, it is an invaluable and often irreplaceable source of essential nutrients and micronutrients vital for a healthy life, and particularly for healthy childhood development. The fish-food sector creates jobs, diversifies livelihoods and can drive local economies and provide significant revenues from international investment.

Yet, fisheries face an increasingly diverse set of challenges from drivers such as environmental change, coastal development, competition for resources from increasing numbers of fishers, and market globalization. While 60% of the world's fish stocks have been fished to their capacity (exploited at maximum sustainable levels) and 33% considered overfished, from 1986 to 2016 capture fisheries production showed remarkable resilience, increasing from 69 to 91 million metric tons (FAO 2018). By 2016, aquaculture production had reached 80.6 million metric tons, accounting for 47% of the total global fish supply (FAO 2018). An estimated 60 million people are engaged in fisheries and aquaculture for their livelihoods, and 85% of them are in Asia (FAO 2016)—a clear indicator of the importance of this sector for the region.

Over 90% of people employed in fisheries worldwide are involved in small-scale fisheries (SSF) (World Bank 2012), often in a part-time or seasonal capacity. For these fishers and their families, fish is not only a source of household income but also food. Poor rural communities depend heavily on natural resources, but a lack of access to alternative sources of income and nutrition often leaves them highly vulnerable to resource degradation. This highlights the importance of underpinning management practices with sustainability. Sustainably managed fisheries and aquaculture have the potential to contribute substantially to the eradication of absolute poverty and foster shared growth, while ensuring fish stocks remain resilient for future generations.

The Democratic Republic of Timor-Leste is a small, half-island nation of 15,410 km² with a population of about 1.2 million. Located at the eastern end of the Indonesian archipelago, it has a coastline of 730 km and an exclusive economic zone (EEZ) of about 72,000 km² (FAO 2009). Timor-Leste is one of the world's newest nations. After a 25-year occupation by Indonesia, it became a sovereign state in 2002, but it faces significant post-conflict challenges. The nation ranks 10th in the Global Hunger Index and has among the highest prevalence of stunting in the world, with levels exceeding 50% (Grebmer et al. 2017).

In addition to chronic caloric malnutrition (Williams and Goncalves 2018), much of the population in Timor-Leste suffers from hidden hunger because of a deficiency of crucial micronutrients found in a diverse diet (da Costa et al. 2012). Fish contains high quality animal protein and high quantities of bioavailable vitamins A and D, calcium, iron and polyunsaturated fatty acids, such as omega-3, which are all essential in every stage of life, especially in the first 1000 days (Andersen et al. 2013). Adding fish into the diet, even in small quantities, significantly increases crucial vitamins and fats in poor and vulnerable populations (Bogard et al. 2017). Mitigating malnutrition is the first step to improve population health and well-being, which in turn provides the human capacity for the growth and progress of a nation. Fish is underused



Source: Timor-Leste National Statistics Directorate 2008.

Figure 1. Map of Timor-Leste municipalities and associated demographics.

in Timor-Leste, and the fisheries and aquaculture sectors are underdeveloped. Despite being an island nation, Timor-Leste's fish consumption is particularly low compared to neighboring countries, at an estimated average of 6.1 kg per capita (17 kg in coastal areas; 5.2 kg in inland areas) (AMSAT 2011a), and low compared to the global average of 20.2 kg per capita (FAO 2018).

1.2 Timor-Leste Strategic Development Plan

Timor-Leste's Strategic Development Plan (SDP) 2011–2030 is aligned with the United Nations Millennium Development Goals and provides an integrated package of strategic policies to implement over different periods (1–5 years, 5–10 years and 10–20 years) toward the country's prosperity. The SDP consists of three key areas and objectives: (1) build social capital for a healthy and educated society, (2) become a connected, sustainable and growing nation by developing core and productive infrastructure and (3) enhance economic development to achieve a modern and prosperous nation. In building human capital, the SDP acknowledges that the country faces enormous challenges, because the nutritional status of children and adults in Timor-Leste remains significantly below acceptable world standards, with high prevalence of undernourishment and stunting.

SDP 2011–2030: A thriving agricultural sector is needed to reduce poverty, provide food security and promote economic growth in rural areas and our nation as a whole.

In improving nutrition goals and food security, the SDP recognizes that agricultural development is essential and that the fisheries and aquaculture sectors also have a role to play. Specific goals stated in the SDP to increase the contribution of these sectors to the country's nutrition are displayed throughout this document.

These short- and medium-term strategies are accompanied by other planned actions to enhance the performance of the fisheries and aquaculture sectors, including the following:

1. "the creation of demonstration centers on the use of fisheries electronic control systems and the cutting, processing, transport and storage of seafood products"
2. "research into prawn, abalone, crab and oyster farming"
3. "establishing market links and transport systems"
4. "facilitating the empowerment of fishers and the fish farming community"
5. "providing quality control and supervision of fisheries resources"
6. "developing fishing ports and infrastructure such as piers and landing sites"
7. "developing a fish export market."

Since 2011, overall progress toward implementing these strategies, particularly in the agricultural sector, has been limited. But the aim of this report is to explore and highlight the positive outcomes that have been achieved in fisheries of the WorldFish/DGP partnership in Timor-Leste.

1.3 National fish consumption and nutrition policies

Chronic food insecurity in Timor-Leste affects 64% of the population during the dry season (May to October) (CARE 2011), and over 50% of children under 5 years old are stunted from malnutrition. As an island country with relatively healthy ocean resources, increasing access to and consumption of fish could tackle this crippling problem by providing a greater source of animal protein along with bioavailable micronutrients essential for human nutrition. A 2011 survey estimated that annual per capita fish consumption in Timor-Leste was 6.1 kg, and the combined annual per capital consumption of fish and meat averaged 19.4 kg in 2011 (Table 1) (AMSAT International 2011a).¹ Global fish consumption increased from 9 kg per capita in 1961 to 20.2 kg in 2015, and developing regions followed this trend, rising from 6 kg in 1961 to 19.3 kg in 2015 (FAO 2018). Southeast Asia had the highest increase (13.1 in 1960 to 33.6 kg in 2013) (FAO 2016). In recent years, the Timorese government has highlighted the importance of fish in its population's diet. The food-based dietary guidelines published by the Department of Nutrition of the Ministry of Health in 2015 state that "fish is a MUST for children to ensure healthy growth and brain development." In the National Aquaculture Development Strategy (NADS), the government made clear its aim to increase national per capita fish consumption from the current level of 6.1 kg to 15 kg by 2020 (NDFA 2013).

	Total (N=820)	Coastal (N=117)	Non-coastal (N=552)	Urban (N=151)
Fish consumption	6.1	17.6	4	6
Meat consumption	13.3	12.1	11.6	19.1

Note: N represents the number of respondents.

Source: AMSAT International 2011a.

Table 1. Annual per capita fish and meat (including poultry) consumption (kg).

Estimates of fish consumption in Timor-Leste are low compared to regional averages (Table 2), but the only available survey in the country only sampled a small number of households (Table 1) across just five of the 13 municipalities. Spatial patterns of consumption in Timor-Leste mirror those of small island countries in nearby Melanesia (Bell et al. 2009), with inland and urban dwellers consuming less fish than coastal dwellers (Table 1). Results of a once-off survey (AMSAT International 2011a) showed the types of seafood most frequently eaten were sardines (58%), tuna (36%), mackerel (23%), snappers (23%) and prawns (22%). These results should be viewed with caution, however, as percentages do not reflect broader knowledge of the sector and are completely at odds with recent data for high-quality fish landings. These results are likely to be at least in part an artefact of survey methodology.

Country/territory*	National	Urban	Rural	Coastal ± SE
Fiji	20.7	15	25.3	113 ± 6.18
Papua New Guinea	13	28.1	10.2	53.3 ± 2.29
Solomon Islands	33	45.5	31.2	118.3 ± 3.98
Vanuatu	20.3	19.3	20.6	29.9 ± 3.10
Timor-Leste	6.1	6	5.2	17.6

*Adapted from HIES in Bell et al. 2009. Timor-Leste figures from AMSAT International 2011a.

Table 2. Annual per capita fish consumption (kg) for Pacific island countries.

In consumption surveys, the main reasons given for not eating fish were high prices and the lack of fish in the market (mainly for non-coastal areas). Fish consumption was significantly tied to education level (AMSAT International 2011a). According to the government fisheries database, the share of fish catch kept by fishers for consumption was 32% across the sites sampled in the Fisheries Automated Analytics System (PesKAAS)² database. This shows the contribution that SSF in Timor-Leste make toward critical food security and household nutrition.

In most Pacific island countries and territories (PICTs), fish contributes 70%–90% of the animal protein in the diet. In Timor-Leste, however, the percentage is only 31%, with chicken as the preferred meat source (54%) (AMSAT International 2011a). When analyzed by areas (urban, coastal and non-coastal), in coastal areas fish consumption was highest (45%), followed by chicken (32.4%), eggs (11.7%) and pork (6.3%). Chicken was the preferred source of animal protein consumed in both urban (68.7%) and non-coastal (54.9%) areas. Interestingly, across the five municipalities in the study, many of the respondents only ate their own livestock during traditional ceremonies.

Meat is crucial in the ritual exchange system of Timor-Leste, and its significance goes beyond its consumption or exchange value. But fish is not part of this system, and it is considered an expensive alternative food item among households not engaged in the fisheries sector (Población 2013). It has been suggested that Timorese culture has had a strong influence on the particularly low levels of fish consumption and underdevelopment of the fisheries sector. Unlike other small island countries, traditional Timorese narratives and discourse (excluding Atauro Island), represent the sea as the space of the wild and the unknown, whereas the country's lineage is identified with the mountainous areas (McWilliam 2003). Timorese people have maintained pastoral livelihoods, and many were introduced to fishing by people from nearby islands during the Indonesian occupation as a consequence of forced migration (McWilliam 2003; Población 2013).

1.4 National economy: Gross Domestic Product and national spending

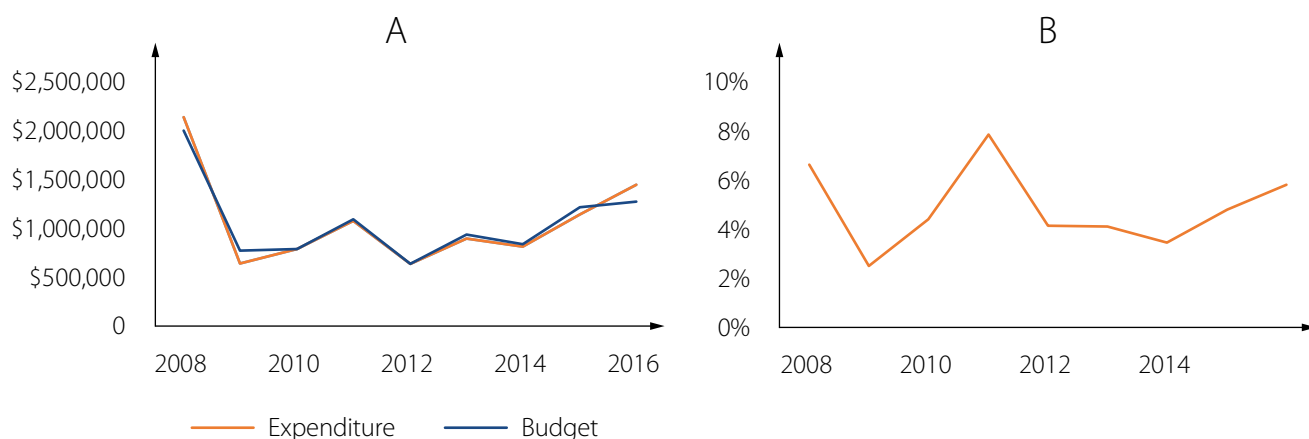
In small island countries, estimating the contribution of fishing to the national economy is particularly difficult because of the informal and scattered nature of the sector. Fishing crew onboard boats are often paid in kind or receive a share of the catch rather than wages, and there are thousands of fishers operating in many locations, with or without boats, using a wide variety of techniques to catch multiple species. The Timor-Leste government's gross domestic product (GDP) calculations are based on rough estimates using production figures from the Food and Agriculture Organization (FAO), so values need to be interpreted with caution.

Timor-Leste has a high dependency on petroleum for revenue receipts. On average, 95% of the country's total revenue between 2013 and 2015 came from offshore oil and gas (World Bank 2018). With little other economic activity driving growth in the country, agriculture is one of the most important sectors contributing to the non-oil GDP, despite having decreased from 28.3% in 2008 to 17.1% in 2016 (GDS 2017). The fastest growing sector is livestock, whereas the fisheries sector remained relatively constant between 2008 and 2015 (World Bank, In prep). The sector's overall contribution is marginal, ranging between 2% and 3% of the non-oil GDP, which is less than 1% of total GDP.

With 70% of the population living in rural areas, almost 90% of Timorese engage in agricultural activities (GOTL 2015), making it a key sector for poverty reduction and job creation. However, the proportion of the national budget assigned to the Ministry of Agriculture and Fisheries (MAF) is low relative to the importance of the agriculture sector in country's economy. Even though agriculture's contribution to GDP is within the average for small island nations in the Pacific, its share of the budget is low compared to these countries (World Bank, In prep). The MAF's share of the state budget decreased from 4% in 2008 to 1% in 2016, and the budget for fisheries and aquaculture was cut by more than 50% over the same period. Between 2008 and 2016, an average of 0.1% of the state budget and 5% of the MAF budget was allocated for the fisheries and aquaculture sectors (Figure 2). For 2018, the MAF's budget was cut to just over USD 7 million—its lowest level in the past decade (budgettransparency.gov.tl).

The Agriculture Production and Productivity subprogram of the MAF is tasked with improving food production by helping farmers to access inputs, such as research, improved technologies, extension services and improved access to water. But its budget was cut from an average of USD 23 million in 2008–2009 to USD 11 million in 2015–2016. With most of the subprogram's expenditures related to agriculture (58%), the fisheries sector received an average allocation of just 11.4%.

In 2017, Timor-Leste received USD 27 million from external development partners. The money was invested in 50 different projects across all sectors, and seven of these projects involved aquaculture and fisheries.³ In the past 5–6 years, development partners have invested significantly more than the government in the agriculture and fisheries sector (World Bank, In prep).



Sources: Agriculture Public Expenditure Analysis; budgettransparency.gov.tl.

Figure 2. Expenditure and budget (in USD) of the fisheries and aquaculture sector of Timor-Leste (A), and proportion of the MAF budget allocated to fisheries and aquaculture (B).

2. Capture fisheries

2.1 Overview

The Timorese fisheries sector is made up of subsistence, artisanal, semi-industrial and industrial fishing. Subsistence and artisanal fisheries (including gleaning) represent all the national investment in fisheries, whereas the entirety of the semi-industrial sector is from foreign origin (Table 3).

The small-scale (subsistence and artisanal) fishing fleet is made up of mostly non-motorized boats. These boats use low technological types of gear, such as gill nets and hook and line to capture reef and surface dwelling fish species (such as sardines, mackerel and flying fish) in shallow waters within 2 km of the coast, occasionally venturing offshore (FAO 2013).

Gleaning is the artisanal collection of mollusks, crabs, octopus and fish during low tide. It mainly involves women and children, who use spears, hand lines and cast nets as well as manual collection. Catch is generally destined for family consumption, but excess catch and high value species, such as octopus, are sold (AMSAT International 2011b). Other (non-boat) fishing methods carried out include underwater spear fishing and cast netting.

Over time, Timor-Leste has entered a number of bilateral agreements allowing commercial foreign fishing fleets to access deep-sea fishing areas, but these were cancelled because of noncompliance issues (FAO 2009). In 2016, the government granted commercial fishing licenses to 18 Chinese vessels from two different companies—Hong Long (15 vessels) and Best Seafood (three vessels)—to exploit demersal and pelagic fish species offshore. These vessels fished using gill nets and reported monthly landings to the MAF. The catch from these fleets was exported directly following onboard inspection. In 2018, one vessel belonging to Best Seafood strayed into Indonesian territory on Timor-Leste's south coast and was confiscated and sunk by Indonesian fisheries authorities. Investigations also took place into the fishing activities of the Hong Long vessels following drone footage documenting the capture of prohibited shark species. At the time of the infraction, all species of shark were protected in Timor-Leste, but following this incident the list of prohibited species was reduced to 12 threatened species. Hong Long was fined for illegal fishing but was granted a license to return. At the time of writing, however, they have not returned and there are no active foreign vessels fishing in Timor-Leste waters.

Fleet	Max vessel length (m)	Engine	Equipment	Fishing gear used	Number of licenses	Number of active boats	Production in 2017
Artisanal	10	Manual to < 100CV	None specified	Gill nets, hand lines, beach draggers, small trawls	1,330*	2,237	1,963 t
Semi-industrial	> 8–10 < 20	Mechanical propulsion	Thermally isolated fish holds, refrigeration, rest room, flush deck, specified electronics, (all most comply with offshore safety requirements)	N/A	0	0	N/A
Industrial	> 20	> 1,500CV for trawlers	Same as semi-industrial plus processing capacity	Bottom set gill nets for deployment at ~30–40 m, pelagic gill nets, demersal fish traps	18	18	379.1 t

*Data from Needham et al. 2013. Only for boats with engine. A licensing system for the artisanal fishing fleet is due to be established soon, according to the MAF. Source: General Regulation on Fishing.

Table 3. Definitions used to classify fishing fleets.

2.2 Historical trends of fishing in Timor-Leste

Timorese fishing traditions date back at least 42,000 years, according to archaeological evidence from a limestone cave site known as the Jerimalai shelter, located in the southeast of Tutuala (Lautém municipality) on the eastern tip of East Timor. Remains at this site include a variety of pelagic fish bones and scales and the earliest known example of fish-hook manufacture, providing evidence that inhabitants were fishing in the deep sea (O'Connor et al. 2011). As deep-sea fishing requires complex technology, it is thought that early modern humans in Southeast Asia had advanced maritime skills that allowed them to exploit pelagic resources.

From the early 1500s until 1974 Timor-Leste was a colony of Portugal. After declaring independence in 1975, it was shortly invaded by Indonesia, which occupied the country until 1999. Timor-Leste regained its formal independence in 2002. Catch reconstruction analysis estimates total fisheries catches to be 51,000 t from 1950 to 1974 (2400 t/year) and 72,000 t during the Indonesian period from 1974 until 2002 (2536 t/year) (Barbosa and Booth 2009). Following the destruction of infrastructure that marked the end of the Indonesian occupation, it is thought the commercial catches plummeted while SSF grew in importance, increasing from 2500 to 3500 t/year from 1999 to 2009 (Barbosa et al. 2009).

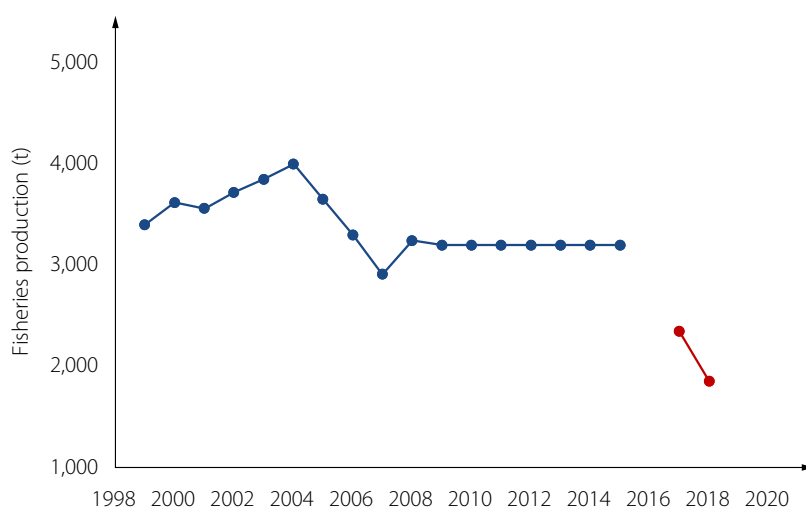
The slow development of the fisheries sector has been attributed to limited equipment and

limited knowledge of fishing (Wever 2008), as well as the severe damage to the fishing sector that occurred after the 1999 conflict and “scorched earth” withdrawal by Indonesia (Barbosa and Booth 2009). As a result, there is ample opportunity for the fisheries sector to boost Timor-Leste’s growth and food security, akin to the situation in neighboring PICTs.

2.3 Estimates of fisheries production

SDP 2011–2030: In the short term (2011–2015), strategies and actions to improve the management of coastal and inland fisheries and create a vibrant commercial fisheries sector will focus on increasing the catch from traditional fishing activities and exploiting fishing grounds in the Exclusive Economic Zone.

Reliable data and information on the fishery resources of Timor-Leste are scant, significantly limiting potential scenarios for developing the sector. Historically, all reported catches are estimations by the fisheries department and FAO. Potential annual fisheries productivity, including unexploited offshore sectors, has been projected to reach 116,000 t (FAO 2009). But annual estimated catches reported by FAO from 1998 to 2015, excluding illegal, unreported and unregulated fishing, were well below this estimate, and recent production estimates from PeskaAS are lower still (Figure 3).



Source: World Bank WDI 2016.

Figure 3. Timor-Leste’s capture fisheries production between 1998 and 2016, as reported to FAO. Data for 2017 and 2018 (solid red circles) represents the estimate generated by data from the PeskaAS database.

Since late 2016, more accurate data has been available from the PeskAAS SSF monitoring program, developed through the Fisheries Sector Support Program, funded by the Norwegian Embassy in Jakarta. The national catch of the artisanal fleet in 2017 was estimated at 1,963 t and 1,865 t in 2018 (see section 2.4.2 for production estimates of SSF). In 2017, the General Directorate of Fisheries (DGP) reported exports of 379.1 t of frozen fish caught by the foreign commercial fleet with licenses to fish in Timorese waters. Subsequently, the total estimated production of the capture fisheries sector (excluding gleaning) for 2017 was 2,342.1 t. These figures are slightly lower but not far removed from estimates reported to FAO.

2.4 Small-scale fisheries

2.4.1 Capture fisheries

This section provides a characterization of the SSF sector, including fishers' livelihoods, gender dimensions, fishing gear and important target species.

Boat types, fleet size and gear

According to the Regional Fisheries Livelihood Programme for South and Southeast Asia (RFLP),⁴ fishers generally fish every day, alone or in groups of two to three, for 6–12 hours. Some fishers report groups of up to five or six per boat, while larger boats on Atauro Island can accommodate up to 20.⁵ Most artisanal fishers use small, paddle canoes made of wood. Many are fitted with small skids or longitudinal outriggers (Plate 1). The canoes range in length from 2 to 6 m, and larger motorized boats from 4 to 7 m, with a few larger boats reported in some places (e.g. Atauro Island). According to DGP data, there were 1,590 wooden canoes and 647 motorboats registered in the country as of 2018 (DGP unpublished data).

Regionally, with 3.5 million vessels, Asia has the largest fishing fleet in the world, representing 75% of global fishing power (FAO 2018). For Timor-Leste, FAO reports that boat numbers increased

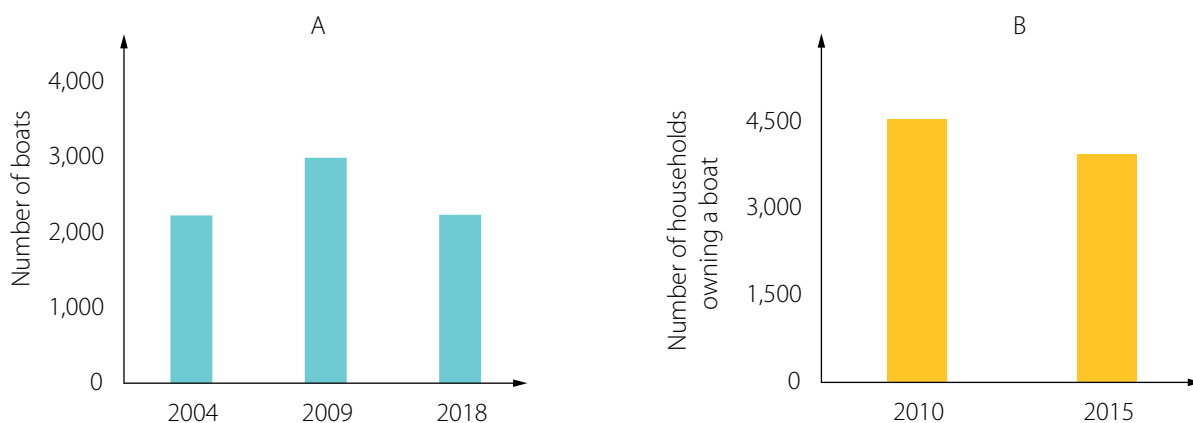


Plate 1. Wood outrigger canoes in Viqueque municipality. These are the most commonly used fishing vessels in Timor-Leste's artisanal fishing fleet.

from 2230 in 2004 to 3000 in 2009 (Figure 4A) (FAO 2009), while data obtained directly from the DGP lists the number of boats at 2237. The number of private households self-reporting to own a boat decreased from 4551 in the 2010 census to 3943 in the 2015 census (Figure 4B). These figures represent 2.5% and 2% of all households in the country respectively. The majority of fishers own their vessels (Figure 5), with 77% of these self-funded and 11% receiving assistance from the government as well as nongovernmental organizations (NGOs). One of the places with the highest boat ownership is the island of Atauro (Mills et al. 2013). The number of motorized vessels in Timor-Leste's fleet is low (29%) compared to regional reports for Asia, where motorized vessels represent 70% of the fishing fleet (FAO 2018).

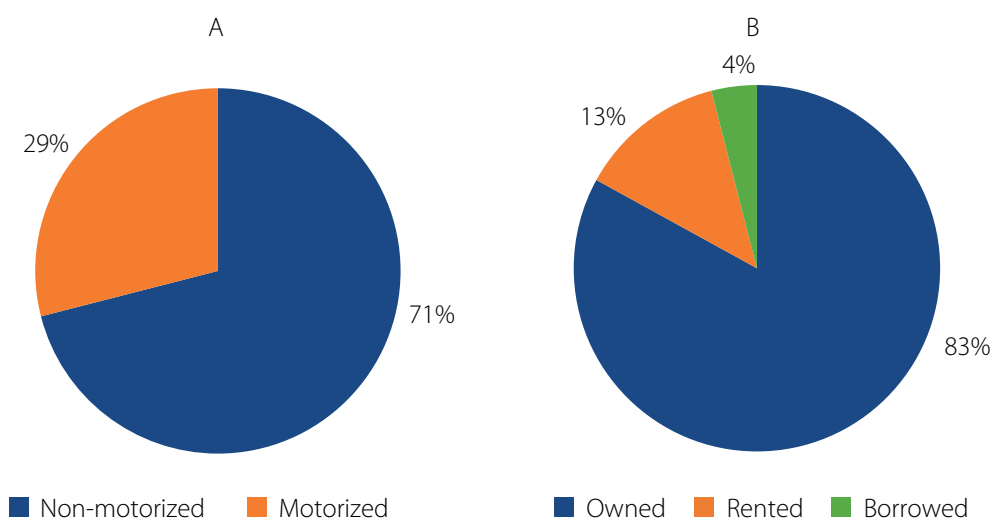
However, this regional figure is likely to greatly underrepresent non-motorized boats in the small-scale sector which, unlike motor vessels, are often not subject to registration.

Non-motorized boats are used for fishing near shore in a variety of habitats with baited and non-baited hand lines (reported hook sizes mainly range from #4 to 18) as well as drifting gill nets (reported mesh sizes range from 1 to 5 inches).⁷ Motorized outrigger canoes are usually powered by 5.5 hp long tail engines or 15 hp outboard engines. They are mainly used for fishing small and medium pelagic fish using hand lines, bottom-set long lines or gill nets (drift nets), and the capacity of the canoes restricts catching large pelagic fish (Nao Tsujimura and Alonso 2012).



Sources: FAO 2009; DIGPRP 2018; GOTL 2010, 2015.

Figure 4. Number of boats (A) in 2004, 2009 and 2018, and number of households (B) reported to own a boat for 2010 and 2015.



Source: DIGPRP 2018.

Figure 5. Percentage of motorized and non-motorized boats in the Timorese artisanal fishing fleet (A). Proportion of fishers whose boat is owned, rented or borrowed (B).

Fiberglass fishing boats (7 m long with 15–20 hp outboard engines) make up 4% of the artisanal motorized fleet. These boats were donated to fisher groups from 2003 to 2011 through various government and nongovernment programs aimed at restoring the fishing capacity of the sector (Nao Tsujimura and Alonso 2012). But the donation of boats and fishing equipment has been unsuccessful for several reasons: (i) it has increased dependency of fishers on external aid, (ii) there are often no safe moorings for these vessels in strong weather and currents, (iii) fiberglass repairs are costly and unavailable in Timor-Leste, so it is common that boats are inoperative after less than 1 year of use, and (iv) fishing capacity was not increased as boats were not appropriate for using more or better gear or for exploring more distant fishing areas than traditional outrigger canoes⁸ (Nao Tsujimura and Alonso 2012).

Line fishing and net fishing from boats are the most widespread fishing activities in Timor-Leste, occurring adjacent to all 11 coastal municipalities (Figure 6). Fishing from boats around fish aggregation devices (FAD) (*rumpon*) (Box 1) occurs in some communities in Baucau, Lautem, Bobonaro and Viqueque as well as on Atauro Island, and typically involves fishers working together in groups of 10–12.⁹

A diversity of traditional fishing activities is carried out in Timor-Leste without the use of boats. Gleaning is done in all coastal municipalities, though not in all fishing communities, since it is dependent on the presence of intertidal habitat and tends to be

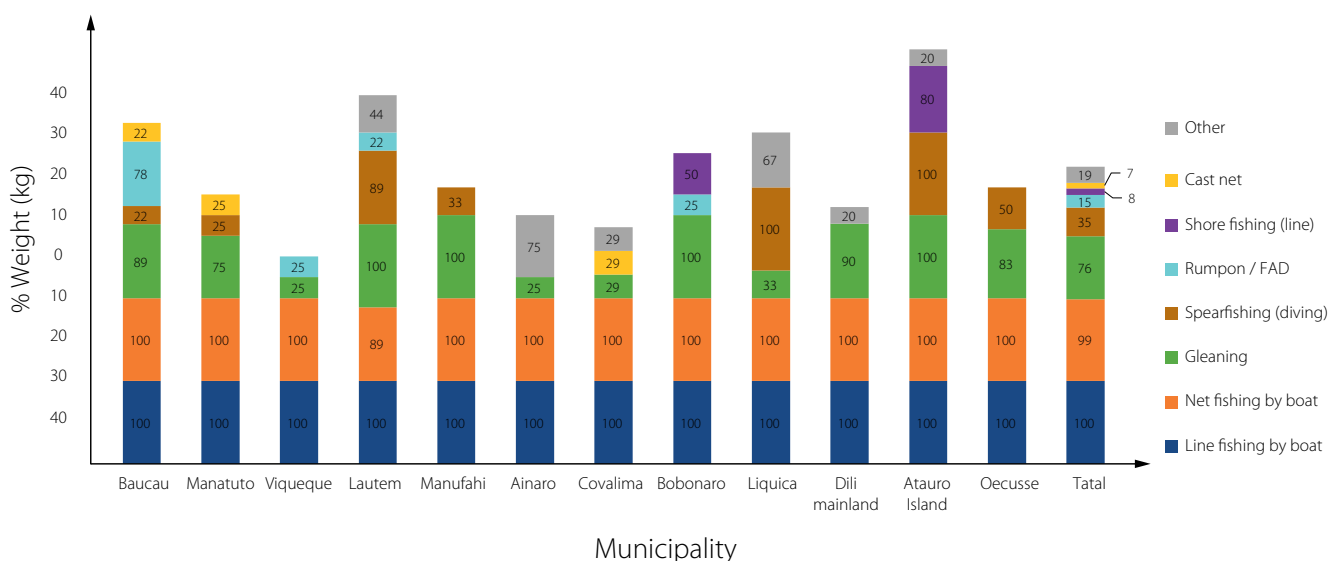
moderated by the prevalence of crocodiles. For the same reason, diving and spearfishing (on reefs) occur less frequently on the south coast than the north.¹⁰

2.4.2 Production estimates

Important fish species for fishers

To estimate the most important fish species for fishers, the country was divided into five regions where pre-consultation meetings for the National Fisheries Strategy (NFS) took place in 2018 (Figure 7). Small-scale fishers in Timor-Leste catch a diverse range of fish. Most fishers report that they do not target a particular species but use a variety of gear throughout the year to catch multiple species.¹¹ While some species are caught throughout the country, there is also considerable variability between and within regions, as to be expected given the variety of nearshore marine habitat.

Ranked lists were compiled from around the country of the top five fish that fishers consider most important for sale. About 25 fish species or groups of species were identified, from at least 14 families.¹² Sardines (*Sardinella* spp. and others) and a short-bodied mackerel (*Rastrelliger* spp. and possibly some *Decapterus* spp. because of differences in local name use) were ranked highly across most mainland regions, indicating the widespread importance of these species for trade across the country. Other species ranked highly for trade included bullet tuna (*Auxis* spp.), garfish (*Hemiramphus* sp.), trevally (*Carangoides* spp.), grouper/rock cod (*Epinephelus* sp.), Spanish mackerel (*Scomberomorus* sp.), flying fish (*Cypselurus*



Notes: N=74, ranging from 3–12 per municipality. The height of the bar indicates the diversity of fishing gear across multiple fishing centers within a municipality.

Figure 6. Fishing methods in Timor-Leste, as reported by fishers at participating fisher centers.

spp.) and snapper (*Lutjanus* sp.) (Table 4). The most universally important families for trade were Scombridae (in all regions), followed by Clupeidae (all regions except Atauro) and Lutjanidae.

Compiled lists of the top five fish that fishers consider most important for home consumption identified a broader range: 32 fish species or groups of species from at least 19 families. Important species for consumption varied strongly by region. Snapper (*Lutjanus* sp.), short-bodied mackerel (*Rastrelliger* sp.) and trevally (*Carangoides* sp.) were important in Manufahi, Ainaro and Covalima (Region II) (Figure 6), whereas sardines (*Sardellina* spp. and others) and flying fish (*Cypselurus* sp.) were

important in Bobonaro, Liquica and Dili (Region III). Fusiliers (*Caesio* and *Pterocaesio* spp.) and surgeonfish (*Acanthurus* spp.) were consistently important for consumption to fishers in Atauro Island. Interestingly, these fish were not identified as most important for trade. Important species for consumption in Baucau, Manatuto, Lautem and Viqueque (Region I) as well as RAEOA (Special Administrative Region of Oecusse-Ambeno) included a wider range of species (Table 5).

Small-scale fishery landings

WorldFish and the DGP launched PesKAAS in 2016. This program involved training and hiring

TOP FISH SOLD based on species/type				Average score (from fisher ranking) ◊					
Tetum name	English common name	Species name	Family	Region I	Region II	Region III	Atauro	RAEOA	Timor-Leste
Sardina	Sardine	Sardinella spp. and others	Clupeidae	52	60	60	0	60	52
Bainar Mutin/Kombong*	Short Bodied Mackerel*	Rastrelliger sp.*	Scombridae*	36	73	27	60	93	50
Tongkol/Kasareta	Bullet tuna	Auxis sp.	Scombridae	56	13	13	0	20	27
Samber	Garfish	Hemiramphus sp.	Zerchopteridae	32	40	20	0	7	26
Koku	Trevally	Carangoides sp.	Carangidae	32	7	20	47	33	24
Garopa/Kerapu	Grouper / Rock Cod	Epinephelus sp.	Serranidae	32	0	33	53	0	23
Sera/Tengiri	Spanish mackerel	Scomberomorus sp.	Scombridae	20	33	20	7	0	21
Ikan Manu	Flying fish	Cypselurus sp.	Exocoetidae	12	0	60	0	13	20
Ikan Mean/Kamera	Snapper	Lutjanus sp.	Lutjanidae	20	13	13	47	27	19
Ikan Daun	Long tom	Tylosurus sp.	Belonidae	16	0	0	13	0	6

TOP FISH FAMILIES SOLD based on family groupings		Average score (from fisher ranking) ◊						
Region I: Baucau, Manatuto, Lautem, Viqueque Region II: Manufahi, Ainaro, Covalima Region III: Dili (mainland), Liquica, Bobonaro Atauro: Atauro Island RAEOA: Special Administrative Region of Oecusse Ambeno		Family	Region I	Region II	Region III	Atauro	RAEOA	Timor-Leste
		Scombridae*	112	120	60	67	113	97
Clupeidae	52	60	60	0	60	52		
Lutjanidae	60	13	40	47	33	40		
Zerchopteridae	32	40	20	0	7	26		
Carangidae	32	7	20	47	33	24		
Serranidae	32	0	33	53	0	23		
Exocoetidae	12	0	60	0	13	20		
Laxar (unknown)	0	27	0	0	0	7		
Belonidae	16	0	0	13	0	6		
Caesionidae	16	0	0	0	0	5		
Trichiuridae	0	20	0	0	0	5		

* Bainar Mutin/Kombong (*Scombridae*) may also include some scads (e.g. *Decapterus* spp. (*Carangidae*)) because of local differences in naming.

◊ Higher scores indicates higher ranking.

Note: Timor-Leste score is the overall average weighted by the number of municipalities in the region.

Table 4. Top 10 fish species and families identified by fishers as most important for sale across Timor-Leste.



Note: Region I: Baucau, Manatuto, Lautem, Viqueque. Region II: Manufahi, Ainaro, Covalima. Region III: Dili (mainland), Liquica, Bobonaro. Atauro: Atauro Island. RAEOA: Special Administrative Region of Oecusse-Ambeno.

Figure 7. Classification of Timor-Leste’s regions used during pre-consultation meetings for the National Fisheries Strategy.

TOP FISH EATEN based on species/type				Average score (from fisher ranking) ◊					
Tetum name	English common name	Species name	Family	Region I	Region II	Region III	Atauro	Oecusse	Timor-Leste
Bainar Mutin/Kombong*	Short-bodied mackerel*	Rastrelliger sp.*	Scombridae*	28	73	27	27	0	37
Sardina	Sardine	Sardinella spp. and others	Clupeidae	36	0	80	0	33	35
Ikan Mean/Kamera	Snapper	Lutjanus sp.	Lutjanidae	20	87	13	0	33	34
Garopa/Kerapu	Grouper/rock cod	Epinephelus sp.	Serranidae	32	40	33	20	13	32
Ikan Manu	Flying fish	Cypselurus spp.	Exocoetidae	16	0	80	0	0	25
Koku	Trevally	Carangoides sp.	Carangidae	12	60	0	0	20	21
Bainar Fatuk	Fusilier	Caesio and Pterocaesio spp.	Caesionidae	32	0	0	93	27	21
Ikan Daun	Long tom	Tylosurus sp.	Belonidae	48	13	0	0	0	19
Tongkol/Kasareta	Bullet tuna	Auxis sp.	Scombridae	36	0	13	0	27	18
Kamera Merdani	Mangrove jack	Lutjanus argentimaculatus	Lutjanidae	36	0	0	0	0	12

TOP FISH FAMILIES EATEN based on family groupings		Average score (from fisher ranking) ◊					
Region I: Baucau, Manatuto, Lautem, Viqueque Region II: Manufahi, Ainaro, Covalima Region III: Dili (mainland), Liquica, Bobonaro Atauro: Atauro Island RAEOA: Special Administrative Region of Oecusse Ambeno	Family	Region I	Region II	Region III	Atauro	RAEOA	Timor-Leste
	Scombridae*	68	93	40	27	27	60
	Lutjanidae	76	87	20	0	33	55
	Clupeidae	36	0	80	0	33	35
	Serranidae	32	40	33	20	13	32
	Carangidae	12	60	20	0	20	26
	Exocoetidae	16	0	80	0	0	25
	Caesionidae	32	0	0	93	27	21
	Belonidae	48	13	0	0	0	19
	Zerchopteridae	24	0	0	0	0	8

*Bainar Mutin/Kombong (Scombridae) may also include some scads (e.g. Decapterus spp. (Carangidae) because of local differences in naming.

◊Higher scores indicates higher ranking.

Note: Timor-Leste score: overall average weighted by the number of municipalities in the region.

Table 5. Top 10 fish species and families identified by fishers as most important for home consumption.

local fishers (in partnership with Conservation International) to record landings in 19 locations¹³ around the country using tablets to document information on catches, such as fish species, size, weight and number. This information is complemented by geospatial data of the boats recorded through a Global Position System (GPS) tracking device installed in fishers' canoes. Via cellular networks, this information is then integrated and analyzed through a series of data servers. The process culminates by displaying the information gathered in the field on a platform that provides analytics such as estimated fisheries production, fishing effort and fishing areas. The resulting figures are based not only on catch data,

but on close to real-time information on vessel activity across all fleet segments.

Using PeskAAS, the national estimated catch for SSF in 2017 was 1963 t. This figure was produced using the most recent DGP estimates of the number of boats and fishers. It is calculated using the combined monthly catch per unit effort (CPUE) across all 19 landing sites where data was collected, the mean effort per trip (wooden canoes = 3:22 hours per trip; motorboats = 4:04 hours per trip), the average number of trips per month per boat (wooden canoes = 8.2 trips per month; motorboats = 15.3 trips per month) and the total number of boats (wooden canoes = 1590; motorboats = 647;



Fishers with their catch of large long Tom fish. Adara, Atauro Island, Timor-Leste.

fishers = 5185). This national production figure does not currently incorporate gleaning catches because of the difficulties in estimating a figure for overall gleaning activity per month. However, gleaning landings are collected as part of PeskAAS.

Subsistence fishery yield in Timor-Leste is low when compared to that of other small island countries (Figure 8). This is fundamentally the consequence of a poorly developed sector, but simultaneously production may be underrepresented because of limited catch monitoring and out-of-date information on fleet size. Given the complex and diffuse nature of small-scale coastal fisheries in the Pacific and Timor-Leste, reliable estimates of maximum sustainable production are unattainable for most countries. National reported capture fisheries production statistics are known to largely underestimate SSF production (World Bank 2012).

Reef fish biomass (standing stock)

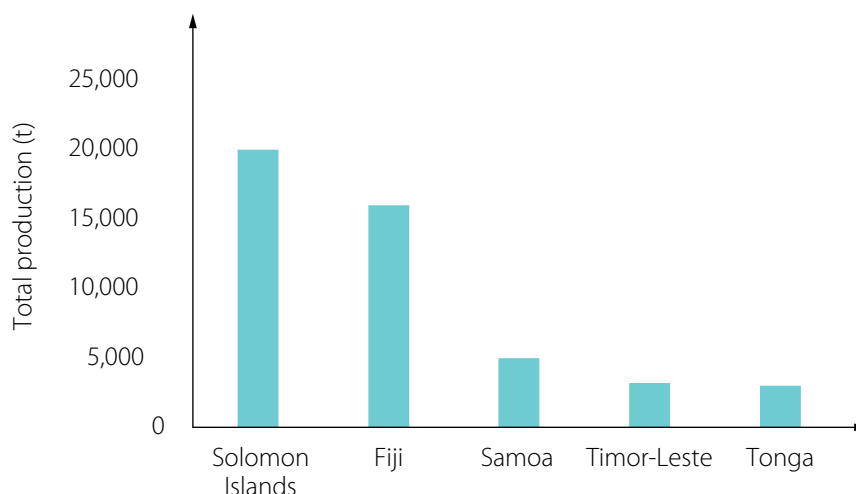
Fish biomass is a measurement of the mass of living fish in a given area. It is often used as an indicator of reef health and on how heavily fished an area is. In December 2016 and June 2018, WorldFish used underwater visual surveys to assess reef fish biomass at five locations in Timor-Leste: Adara, Adarai, Beloi, Uaroana and Vemasse. In each location, experienced divers collected data on the number and length of all diurnally active, non-cryptic reef fish species. Surveys were performed in fore-reefs and reef flats between 5 and 10 m deep and in three sites per locations and four transects per site. Total biomass of fish on each transect was calculated using published

length-weight relationship estimates available on FishBase (fishbase.org).

Results show an annual mean of 1624.4 kg/ha across all sites (Table 6). This figure fits in the range of reef fish biomass estimates from unfished reefs in the Indian Ocean (500–1800 kg/ha) (Graham and McClanahan 2013) and is an order of magnitude higher than biomass seen on heavily fished reefs (MacNeil et al. 2015). The fact that Timor-Leste fits in the range of unfished reefs may reflect a relatively low level of exploitation of the reefs, but also is likely the result of interacting factors such as oceanography and island geomorphology. Maintaining reef fish biomass at the current levels is beneficial for adjacent local communities, as high levels of biomass and sustainable exploitation rates ensure the provision of ecosystem services that these communities rely upon.

Target species (by landed weight and habitat)

The most “important” target species of a fishery can be obtained using the Index of Relative Importance (IRI). This index considers the percentage weight, frequency and number of individuals landed of a particular species to determine its relative importance compared to all captured species ($\%IRI = \%weight + \%number \times \%frequency$). Landings information collected as part of PeskAAS shows that the most important species captured during the sampling period was the short-bodied mackerel (*Rastrelliger brachysoma*) (Figure 9), a nearshore species commonly caught on gill nets while feeding on plankton in estuarine habitats (fishbase.org). However, given the little ecological knowledge

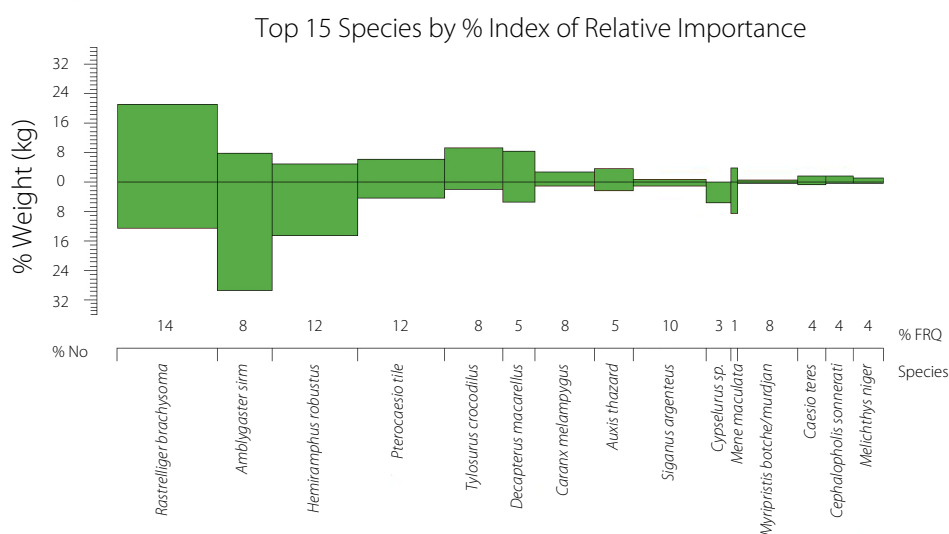


Source: Gillett 2016 Timor-Leste data from PeskAAS 2019.

Figure 8. Volume of coastal subsistence fishery production for Pacific small islands in 2014 and 2017 for Timor-Leste.

of Timor-Leste's fisheries and the limited capacity of data collectors to delineate closely related species, these classifications should be considered species groupings (e.g. "scads and mackerels"). The second-most important species was the spotted sardine (*Amblygaster sirm*), a reef-associated marine species. Again, this is likely to represent all locally occurring sardine species because of difficulties in identification. Finally, a needlefish was the third-most important species in Timorese landings, the three-by-two garfish (*Hemiramphus robustus*) which inhabits inshore turbid waters and estuaries (Figure 9).

In terms of nearshore species (landed in reef or mangrove habitats), the reef-associated dark-banded fusilier (*Pterocaesio tile*) dominates landings (Figure 10). Large numbers of juveniles of this species appear in shallow lagoons and on reef flats and so can be caught by artisanal fishers. The second- and third-most important species are three-by-two garfish (*Hemiramphus robustus*) and Northern pilchard (*Amblygaster sirm*) respectively. Sardines are commonly found in the turbid, nutrient rich waters of estuaries and river mouths. As these species inhabit nearshore areas, such as reefs, beaches,



Note: The area of each box is the proportional relative importance of the species of all species captured. This is constructed using the percentage of trips a species was landed on (%FREQUENCY), the proportion of total weight that a species represented (%Weight), and the number of individual fish landed (%No).
Source: PeskAAS database.

Figure 9. Most targeted fish species by small-scale fishers across 19 landing sites in Timor-Leste between 2016 and 2018.

Location	Biomass (kg/ha)		Mean
	2016	2018	
Adara	2,444.0	1,971.6	2,207.8
Adarai	1,922.5	- *	1,922.5
Beloi	1,922.4	1,981.3	1,951.9
Uaroana	1,053.9	864.7	959.3
Vemasse	1,431.9	1,027.3	1,229.6
Mean	1,754.9	1,461.2	1,624.4

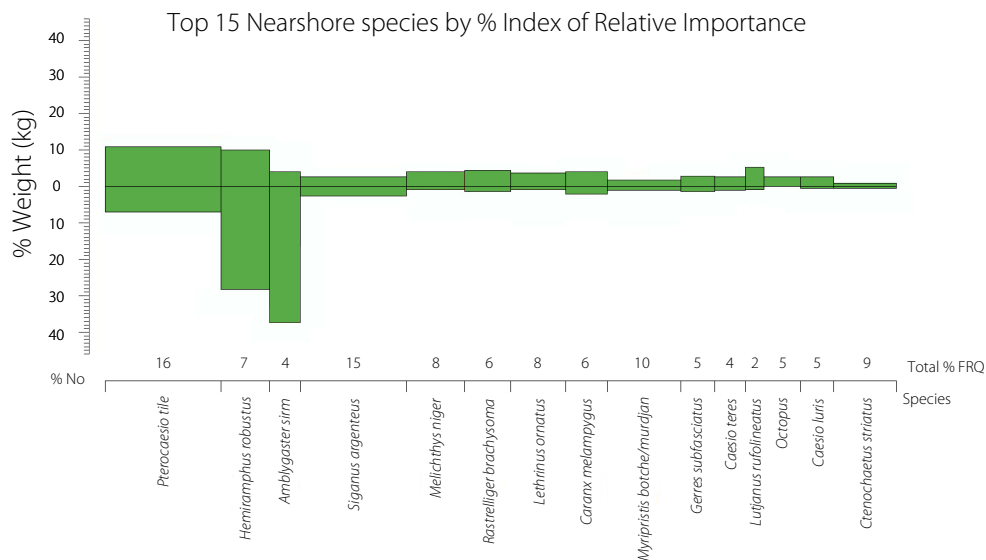
* Sampling not possible for logistical reasons.

Table 6. Reef fish biomass for 2016 and 2018 calculated through underwater visual census in five different reef locations in the north and south coasts of Timor-Leste.

mangroves and seagrass, they are most likely to be captured using low technology gear, such as gill nets or hand lines from small wooden canoes.

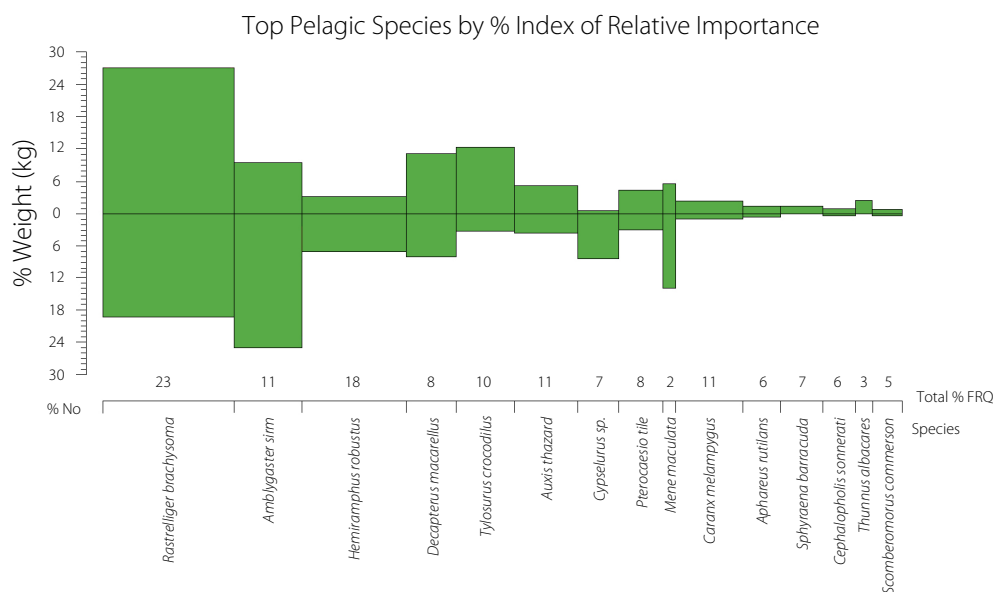
For pelagic or oceanic fish, the most important species by %IRI was the short-bodied mackerel (*Rastrelliger brachysoma*) (Figure 11). The spotted sardine (*Amblygaster sirm*) and the two-by-two garfish (*Hemiramphus robustus*) are also of great importance in the pelagic fish catches, as they also frequent offshore waters (Figure 11). These were followed by the mackerel scad (*Decapterus*

macarellus), commonly found in local markets. Other important pelagic species present in landings were fish of large sizes, such as the frigate tuna or frigate mackerel (*Auxis thazard*), yellowfin tuna (*Thunnus albacares*), great barracuda (*Sphyaena barracuda*) and the largest member of the needlefish family, the houndfish (*Tylosurus crocodilus*). Generally, to capture these pelagic species, fishers use gear such as hand lines and longlines, using motorboats to travel farther away from the coast. Pelagic species are increasingly also captured close to shore and from wooden canoes using FADs (Box 1).



Source: PeskAAS.

Figure 10. Most important fish species captured in reef and mangrove habitats by small-scale fishers across 19 landing sites in Timor-Leste between 2016 and 2018.



Source: PeskAAS.

Figure 11. Most targeted pelagic fish species by small-scale fishers across 19 landing sites in Timor-Leste between 2016 and 2018.

Small pelagic fish are particularly important in Timor-Leste fisheries. They comprise eight of the top 15 most important fish in 2017 landings, including the top three. Similarly, small pelagic fish make up seven of the countrywide top 10 fish that fishers consider important for trade and five of the top 10 important for consumption. Small pelagic fish tend to be more productive, more mobile and generally less vulnerable to overfishing than coral reef fish. The vulnerability of small pelagic fish stocks to climate change, given their link with

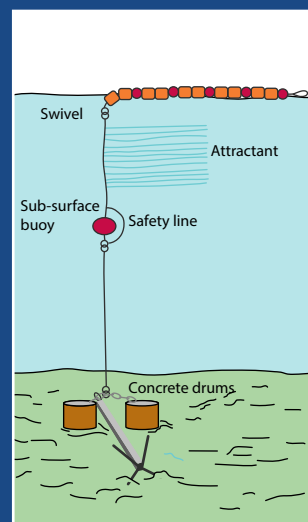
climatic and environmental factors, is unknown but will likely represent significant vulnerability for people that depend on them for income and food (Bell et al. 2016).

Catch per unit effort trends

The CPUE can be used as an indirect measure of the relative abundance of fish, as it provides the amount of fish harvested in a unit of effort, such as fisher hours (one fisher fishing for 1 hour). According to

Box 1. Fish aggregating devices.

Nearshore FADs (e.g. anchored or drifting objects deployed in the ocean to attract fish) are used in artisanal fisheries to attract oceanic fish within reach of fishers in small boats or paddle canoes (Albert et al. 2014). Pelagic fish gather around FADs (either for refuge or to hunt smaller fish), which makes it easier to find and catch them. This can have important benefits to sustainability. Studies in Micronesia and Vanuatu show that 50%–75% of fishing effort can be transferred from reefs to FADs (Bell et al. 2015). Additionally, FADs make fishing more efficient by allowing fishers to spend less time fishing, which increases the CPUE (Davies et al. 2014). As such, they play an important role in food security (Bell et al. 2015) and multiple livelihood settings. Studies in Solomon Islands show that nearshore FADs increased the supply of fish and contributed up to 45% of the catch of SSF, with villagers reporting that FADs increased household income and nutrition (Albert et al. 2014).



In Timor-Leste, some communities have traditionally built their own artisanal version of FADs made of bamboo (*rumpon*) (Poblacion 2013). Enhancing FAD technology in Timor-Leste could be a powerful tool to increase the productivity of SSF while contributing to food security. Currently, WorldFish and the DGP are pioneering FAD research in the country, and catch rates (kg/fisher hour) have been significantly higher for FAD fishing than fishing in all other habitats (Figure 12). Furthermore, catch species diversity from FAD fishing is significantly lower than from reef fishing with FAD catches comprised almost entirely of small-bodied, semi-pelagic mackerel scad (Tilley, Wilkinson et al in press). This represents a viable alternative to reef fisheries.

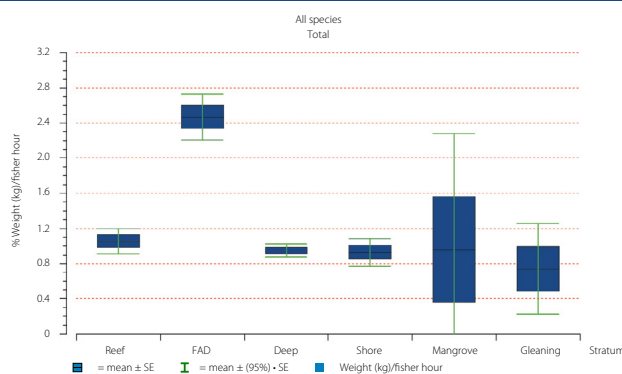


Figure 12. Average catch per unit effort (kg/hr) by habitat type and gleaning across 19 landing sites in Timor-Leste between 2016 and 2018.

WorldFish landings data, mean monthly CPUE (kg/hour) for 2017 shows that production peaks toward the end of the rainy season (April–August) (Figure 13). However, the same data in 2018 shows different seasonal patterns with the high in February, which may be as a result of improved sardine catches. Longer-term data collected using consistent methodology will provide a measure of change in abundance that can be used for assessing the relative health of fish stocks.

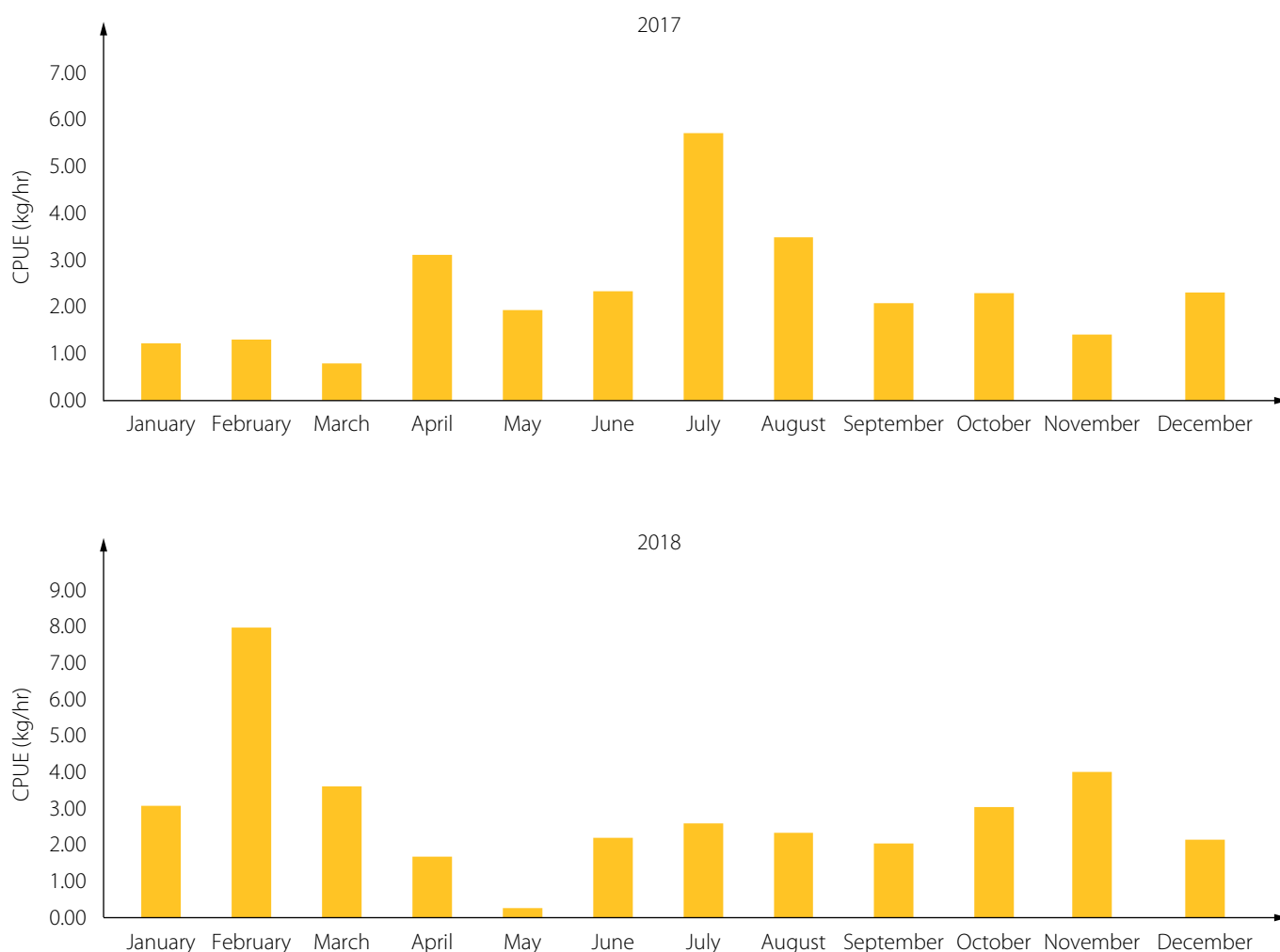
2.4.3 Total fishing area and fishing grounds

In terms of availability of suitable habitats for fishing, despite Timor-Leste being at the core of the Coral Triangle, its narrow continental shelf limits the total area of shallow waters for fish habitats such as coral reefs and seagrass beds. Coral reef area has been estimated at around 146 km² (ADB 2014). Along the northern coastline, where narrow fringing reefs and coral reefs can be found, the nearshore littoral zone is steep with the seafloor dropping off sharply into a 3 km deep marine trench. In contrast, the

continental shelf along the south coast is wide and gently sloping, with low profile, extensive coastal margin and plains (Boggs 2009).

Timorese villages with high levels of boat ownership corresponded geographically with coral reef locations (Mills et al. 2013). This highlights the importance and dependence on these limited reef ecosystems for fishing, which makes fishers' livelihoods vulnerable to overfishing and the effects of climate change (Duffy et al. 2016). The limited extent of coral reef habitats on the north coast of Timor-Leste imposes strong limits on available marine resources and harvest levels for reef fisheries.

Data from geospatial vessel tracking devices deployed by WorldFish on 85 canoes and motorboats across nine communities since February 2018 provides a first insight into the movements and extent of the Timorese small-scale fleet. The tracking devices provide a location point



Source: PesKAAS.

Figure 13. CPUE (kg/hour) in 19 communities of Timor-Leste for 2017 and 2018.

continuously every 10 seconds, allowing not only for accurate fishing effort calculations, but also for developing pattern recognition of fishing behavior and modeling of production over time and space (Plate 2). Results so far show that most boats do not travel more than 5 km from shore.

2.4.4 Livelihoods

Occupations and diversity

Fishers

There is no current figure for the proportion of the population dedicated to fishing as a primary occupation. In the 2015 census, 5% (9940) of the total private households surveyed reported engaging in fishing activities in the previous 12 months.¹⁴ Of these fishing households, 87% were located in rural areas. The RFLP supported the first National Census of Fishers and Boats in 2011, which recorded 4723 sea fishers, excluding fish traders, fish processors, inland fishers and reef gleaners (Población 2013). Previous estimates are similar, with 4940 fishers in 2004, and 5300 fishers in 2009 (FAO 2009). Recent data provided directly by the DGP supports these figures, with the number of fishers in the country at 5185 (DIGPRP 2018). FAO statistics suggest that in 2009 direct employment in the primary sector related to fisheries and aquaculture in Timor-Leste was 7600 jobs (FAO 2009). It is not clear how this figure was estimated, and there is no comprehensive data on formal and informal employment in the country's fisheries sector.

Like most SSF in developing countries, artisanal fishing in Timor-Leste is one component of a diverse set of livelihoods for rural communities. The RFLP baseline survey¹⁵ reported that 40% of respondents complement fishing with other activities, mostly with crop and animal farming (Figure 14). This was recently corroborated by Mills et al. (2017), who found livelihood diversity to be a key feature of communities in Atauro Island, the place with the strongest fishing and fish trading traditions in the country (Población 2013).

If we compare Timor-Leste's household engagement in fisheries with other small island countries, the limited development of the fisheries sector is evident (Figure 15). For example, in Solomon Islands, 83% of households engage in fishing activities, with 90% of males and 50% of women participating directly in fisheries (Gillett 2009), and in Vanuatu 72% of rural households engage in fishing activities, with 73% of these fishing mainly for home consumption (Gillett 2009). Culturally, Timorese people consider themselves farmers; even among those who do fish, many do so as part of a multiple livelihood strategy focused predominantly on farming (Mills et al. 2017).

Fish traders

SSF in Timor-Leste also provide important livelihoods to numerous fish traders. Fish trading is differentiated from the sale of a household's own catch. Fish traders act as "middlemen" in fish value



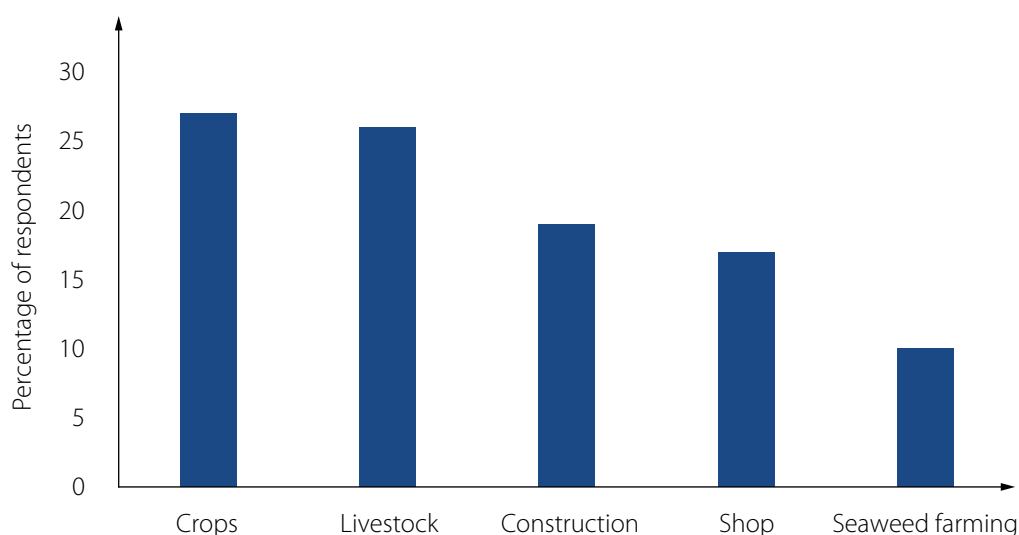
Note: Activity areas only represent certain sites where boats are installed with tracking devices, not the fishing area of the entire national fleet. Data are from ~330 boats installed with tracking devices since February 2018.

Plate 2. Spatial pattern of the fishing activity of small-scale fishers in Timor-Leste.

chains and usually sell fish purchased from several fishers (Mills et al. 2017). There are different types of traders along the value chain in Timor-Leste: some traders in coastal communities operate as “collectors” (sometimes referred to as *pengumpul*) with capacity to transport and trade comparatively larger volumes of fish and coordinate with a network of mobile traders and Dili-based collectors; others operate as individual “traders” (*papalele*, *tengkulak*), “buyers” (*pembeli*) and/or “sellers” (*penjual*) and trade comparatively smaller volumes (Steenbergen et al. in review).

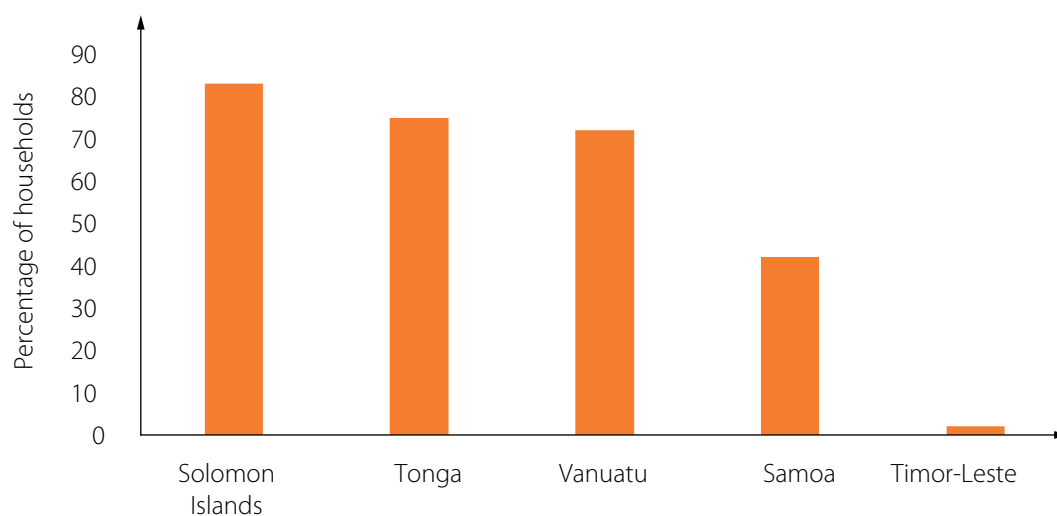
The number of people engaged in fish trading activities in Timor-Leste is unknown. On Atauro Island, 5.7% of households surveyed were engaged in fish trading activities, with 4.6% identifying it as

their primary source of income (Mills et al. 2017). A recent study on fish value chains originating from a mainland coastal community (Beacou Aldeia in Bobonaro Municipality) identified, at the time, three main larger-volume collectors from that one community alone along with three main Dili-based collectors who obtained fish from communities along the north coast for sale in Dili. The number of people involved in smaller-volume trade is much higher and is done by people living in coastal as well as inland communities (Steenbergen et al. in review). Both men and women trade fish, but female fish traders appear to generally sell within or near their home communities, while male traders use bicycles, motorbikes or trucks to transport fish to both urban centers and inland rural communities.



Source: RFLP 2011.

Figure 14. Most prevalent occupations for households that also engage in fishing.



Note: Tonga’s value is presented as an average among Tongatapu (64%), Vava’u (80%) and Ha’apai (82%).

Figure 15. Percentage of households engaged in small-scale and subsistence fishing activities.

Fish traders generally purchase fish at beach landing sites. While some fishers sell their catch to whomever is waiting at the landing site when they return to shore, others have exclusive arrangements with certain traders (often the larger-volume collectors). The limited research in Timor-Leste describing such arrangements found that fishers generally felt free to choose whom they sold to, and that while some regular fisher-trader arrangements are based on debt repayment, the arrangements observed were not comparable to the coercive patron-client relations seen elsewhere in Southeast Asia (Steenbergen et al. in review).

Fish are generally bought directly from fishers because there are few cooperatives or agents representing fishers in Timor-Leste. Price is normally negotiated based on catch assemblage and current market availability. Agreement relationships can exist between fishers and specific traders, with informal pledges to sell or buy the catch in advance. Business can be competitive, and relationship building does not necessarily lead to better business. Intermediaries who operate in Dili often receive a catch only once or twice

per week, but this depends on the season (high seas, currents, etc.). Intermediaries who own boats (generally larger boats) will often receive a catch several times per week, allowing them to dominate the Dili marketplace. Also, having access to larger vessels gives them freedom to travel farther than nearby Atauro Island to find supply to meet their demand in Dili. Farther locations include neighboring Indonesian islands of Liran, Wetar and Alor, and routes do not always take them through Atauro Island waters.

Retailers

Points of sale (POS) to the final consumer differ greatly when comparing Atauro to urban and mountain communities. The retailer is the actor who sells the fish product in whole, part or in a processed form, where the buyer will consume the product. In Atauro, retailers are generally in the market place, selling fresh or dried fish and squid in small quantities. Setting up a *baraka* (cooked fish) stall in the market is also considered retail. Customers are generally from non-fisher households. In the mountain districts of Aileu and Ermera, retailers



Sorting and distributing the sardine catch in Beacou, Timor-Leste.

are most commonly *warungs* (restaurants) who cook fish products and serve them to customers. Additionally, there are some small-scale vendors of dried fish available on local market days, while fresh fish roadside vendors infrequently set up POS. Because of seasonality, it is expected that fresh fish is not available at certain times. The urban area of Dili provides the greatest number and variety of POS of fish and fish products. Points include hotels, restaurants, markets, roadside and ambulant vendors and supermarkets. To date, there has been no thorough analysis of the availability of fish in Dili, but fish come through formal and informal chains.

Gleaning

Gleaning is the collection of shellfish, seaweed and small fish from nearshore habitats such as reefs, mudflats and seagrass beds at low tide without the aid of a boat. It is mostly an informal fishing activity, but targets a diverse range of species¹⁶ and is thought to play an important role in food security for coastal communities (Plate 3). The species can be of high nutritional value, such as octopus, bivalves and crabs. No specialized fishing equipment is required.¹⁷ Gleaning is done in all

coastal municipalities in Timor-Leste, but it occurs more widely in some municipalities than others.¹⁸

Men, women and children are all involved in gleaning, but in many communities, women and children dominate the fishery, which shows its importance for household nutrition.¹⁹ In the RFLP baseline survey of fishing communities (2011), 80% of respondents confirmed children were actively involved in gleaning. This is also the case in many PICTs, where this activity remains the domain of women (Gillett 2011).

Gleaning in Timor-Leste is both a means of obtaining household food as well as income (Tilley, Burgos et al. in review). Managing gleaning has shown great potential to improve livelihoods in other regions. In particular, fishery benefits are high from closing fishing areas to allow species to grow and reproduce before being harvested. Permanent and temporary closures are highly effective for valuable species, such as octopus, lobsters, clams and sea cucumber, where increases in species abundance and individual size have been reported (Gell and Roberts 2003; Benbow et al. 2014). Currently in Timor-Leste, the



Source: A. Tilley.

Plate 3. A cockle picker in Biqueli, Atauro Island, and a man returning from gleaning in Hera showing a traditional trident spear.

potential to increase food security from gleaning remains unknown because there are no studies documenting what gleaners are catching and what they do with it, or the environmental impact and sustainability of these gleaning activities. However, preliminary analysis by WorldFish suggest that gleaning may act as an important buffer to climatic and social shocks affecting fish and crop production (Tilley, Burgos et al. in review).

Apart from intertidal reefs flats, other coastal ecosystems that likely play an important role for gleaning are mangroves, because they are habitat for target species such as crabs, bivalves, snails and juvenile fish. The illegal harvest and loss of mangroves remains a critical coastal management issue in Timor-Leste since the impacts of mangrove deforestation on local livelihoods are not yet understood. The country has high rates of historical mangrove loss. Since 1940, total mangrove cover has decreased approximately 80%, to just 1802 ha recorded in 2008 (Boggs et al. 2009). Yet, according to regional studies, deforestation rates between 2000 and 2012 were very low (0.19% of mangroves lost) compared to rates in Southeast Asia (Richards and Friess 2015). Mangrove trees are harvested for timber and fuel wood. Despite their small total area in Timor-Leste, they are highly diverse ecosystems, with 19 species of trees (Boggs et al. 2009). Mangrove deforestation is likely to have significant impacts for communities in terms of coastal protection and food security, as it has been widely documented that mangroves contribute positively in these aspects (Alongi 2008; Aburto-Oropeza et al. 2008; Igulu et al. 2014).

2.4.5 Gender and fishing

There is a general lack of recognition and understanding surrounding women's fisheries in the country. Women and the fishing activities they engage in have until recently been ignored in national policy discussions, stemming from women's low levels of participation in community decision-making about coastal resources and fisheries.

While boat-based fishing is almost exclusively done by men in most parts of the country, women in Timor-Leste do participate directly in fishing activities, including shore-based line fishing, catching fish with hands and hand nets in shallow waters, spearfishing, seaweed farming as well as gleaning (Tilley, Burgos et al. in review); some women also use boats for line fishing (e.g. in Atauro and Bobonaro municipalities). Women also directly support the fishing efforts of their husbands, fathers or brothers through activities such as assisting with the launch and return of boats, removing fish from nets, counting fish for sale to traders, carrying fish from landing sites, and assembling and fixing nets; women in several municipalities also report directly assisting with putting out nets and lines. Women are also involved as fish traders, selling both fresh and cooked fish, as well as activities such as fish drying, smoking and processing other fish and seaweed products²⁰ (Plate 4).

In the RFLP baseline survey, 18% of households reported at least one woman working as a fisher, but this varied significantly between municipalities



Plate 4. A woman selling small pelagic fish in Beacou.

(AMSAT International 2011). Fisher women were usually wives or daughters of male fishers. Most women fishers were reported from households in Dili municipality (including Atauro Island). The survey showed a clear separation of gender roles with regards to fisheries related activities. Trading (42%) and processing (27%) were identified as the most prevalent activities women performed (Figure 16). In cases where women were the head of their household, trading was their main fisheries related livelihood (66%). More effort is needed to determine the role and the contribution of women to Timorese fisheries and seafood value chains. Globally almost 50% of the 116 million people directly depending on capture fisheries for their livelihoods are women (World Bank 2012).

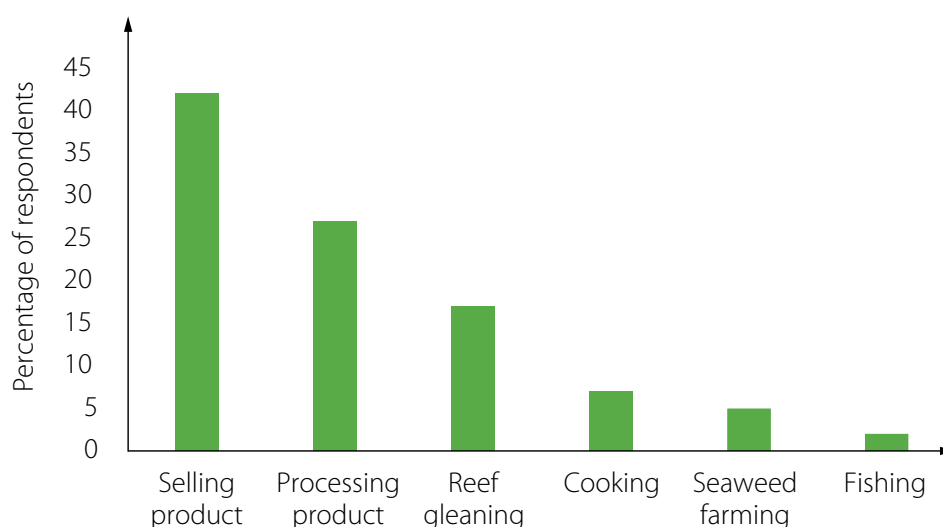
2.5 Offshore fisheries

2.5.1 Characterization

The large-scale and offshore fishing sector in Timor-Leste remains relatively undeveloped compared with neighboring countries, specifically PICTs, that receive significant revenue flows from offshore fishing access fees paid by foreign fishing nations (SPC 2011). To assess the potential of commercial fishing in Timor-Leste, the country first needs to invest in baseline studies to generate knowledge of offshore resources. However, it is possible that the importance of this sector will not match those of neighboring PICTs. Preliminary fishing trials conducted by WorldFish and DGP suggest that Timor-Leste waters are not likely to possess high densities of valuable tuna, which is the primary resource supporting PICTs offshore fisheries.

Throughout its short history, Timor-Leste's offshore fisheries have always been exploited by foreign fleets. In November 2016, 15 Chinese vessels from the Hong Long Company licensed to fish in Timorese waters started fishing for demersal species, using a total of 400 km of bottom set gill nets and trammel nets (Plate 5).²¹ These boats were at sea for about 3 months at a time, returning to the port of Com for inspection by the Fisheries Inspections Department (catch volume and species). All catch was exported directly, so the fish was never landed in Timor-Leste.

Three vessels from Chinese company Best Seafood started fishing in April 2017 and targeted pelagic and demersal species, using pelagic gill nets and demersal fish traps. The licensing conditions state that the fishing quota per year per boat must not exceed 100 t. All boats are currently monitored remotely via a vessel monitoring system (VMS), a real-time satellite tracking system fitted to each boat, funded initially as a trial by the Japan International Cooperation Agency (JICA) and a Japanese private sector company. At the time of publication, no foreign vessels were fishing in Timorese waters given that licenses were suspended while the fishing law was being reviewed. Hong Long vessels returned to China for maintenance in 2017 and have not returned, while Best Seafood did not renew their fishing license for 2018 since one of their vessels was confiscated by Indonesian authorities for border violations on the south coast.



Source: RFLP 2011.

Figure 16. Roles of women in fisheries related activities.

2.5.2 Income and employment from the offshore industry

Income from the commercial fishing sector comes from licenses to the Chinese vessels exploiting Timorese waters and tax from exported catches. Licenses are issued every year and must be paid prior to fishing. The specific price of the license depends on the targeted species. In 2016, Timor-Leste received USD 225,000 from commercial demersal fishing licenses and a further USD 60,000 for pelagic fisheries in 2017 (Table 7). Each commercial boat has a crew of 16 to 20 people receiving wages of about USD 250 per month. The revenue collected from licenses goes directly to consolidated government revenue and is not made available to improve management of these fisheries.

Initially there were 75 Timorese nationals employed as boat crew in the Chinese fishing fleet described above. The commercial fishing industry employs a total of 133 people of which the majority are Chinese (69) and Filipino (61). At the end of 2017, There were only three Timorese because of high resignation rates of Timorese crew given low wages and arduous conditions onboard for fishers unaccustomed to offshore fishing.

The DGP reports that commercial fishing licensing involves a total of USD 100 million in investment given that the licenses were granted based on commitments from the company to develop a fish processing unit and 60 ha of ponds designed for prawn farming.²² (No progress on these agreements has been made.) If Timorese commercial fisheries are to grow, they must act as a source of employment for locals, as in other small island nations, where the subsector provides formal jobs on vessels and inshore processing facilities.

2.6 Value chains and nutrition

2.6.1 Fish exports and imports

SDP 2011–2030: In the medium term (2016 to 2020), actions will focus on ocean-based fishing and be oriented toward exports and the development of fishery centers along the southern coastline, especially in Lore (Lautem District).

In post-colonial history, Timor-Leste exported fish in 2006 and 2007 under bilateral fishing agreements,

Company/No. of boats	License price per vessel	Allowable quota per year	Total license fees per year
Hong Long/15	USD 150 per metric ton for demersal fishing	100	USD 225,000
Best Seafood/3	USD 200 per metric ton for pelagic fishing	100	USD 60,000

Source: Decree Law No. 2/2005.

Table 7. License prices, allowable quota and total income received from licenses for the commercial offshore fleet.



Plate 5. Five of the fifteen Chinese offshore commercial fishing vessels licensed to fish in Timorese waters.

with Thailand being the majority market (Figure 17). Between 2009 and 2015, most exports were dry seaweed (mainly to Vietnam), while small quantities of lobster, shark fins, tuna, sea cucumber and shellfish were exported (MAF 2017). Timor-Leste's fish exports decreased as fishing agreements with foreign fishing fleets were canceled or expired in 2007, but new agreements signed in 2016 generated a significant increase in 2017 (Figure 17). According to the DGP, 379.1 t of fish from the Chinese vessels were exported in 2017. In 2016, there were no fishery associated exports.

Seaweed exports initially peaked at 70 t in 2010 but rapidly decreased to 30 t in 2011 as disease affected production (MAF 2012). By 2013, production had rebuilt to similar levels but has since stabilized at 50–70 t (Figure 17). Seaweed is in high demand across Asian markets. It requires low initial investment, is not labor intensive, has low harvest technology and is usually conducted by women. Taken together, this makes seaweed farming one of the most sustainable examples of aquaculture. Farmers sell the produce to intermediary buyers who deal with overseas customers. Seaweed produced in Timor-Leste is reportedly good quality and has potential for the international markets (Heath et al. 2013), but it is also exposed to fluctuations in global market pricing.

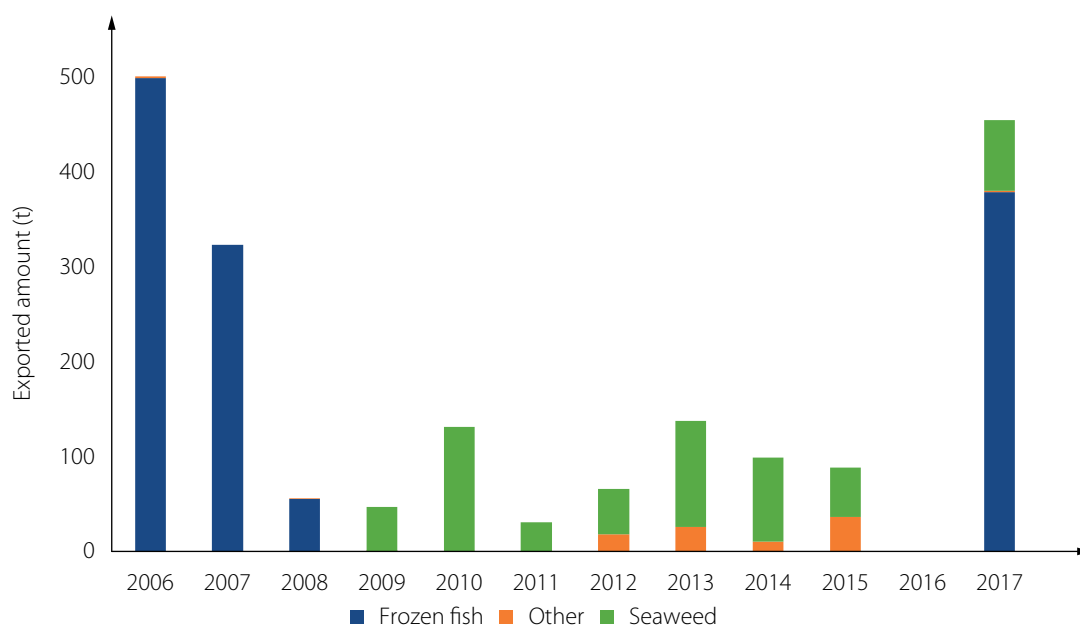
In general, there is no foreseen significant expansion of exports of fishery products beyond the current

offshore commercial fishing agreements, because the country's priorities lie in addressing domestic food security and poverty issues.

Most fish imports are frozen fish bought by supermarkets in Dili, meeting the demand of consumers that find local fish expensive or of low quality. Fish imports have increased since 2011 and are classified as frozen or processed fish, crustaceans, mollusks and other aquatic invertebrates. Between 2009 and 2011, fish imports represented an average of 1% of the total value of imported food items per year (Figure 18). Some fishers have raised concerns about the impact of imported fish on local markets, suggesting that the cheap imports have reduced demand for local produce.²³ It is likely that significant quantities of dried and fresh fish traded informally from Indonesia are not represented in these statistics.

2.6.2 Postharvest

In Timor-Leste consumers generally prefer unprocessed fish, and 75% of fish landed is sold fresh (Andersen et al. 2013). When processing is present, it is mainly for household consumption purposes or when there is an excess of catch left unsold. Interestingly, the RFLP baseline survey, 40% of fishers processed their catch instead of selling it fresh, with 96% using salting methods and the rest smoked or mashed and then salted. Nearly all (92%) of the respondents learned how to salt fish through family tradition (AMSAT International, 2011b).



Source: MAF 2017 (unpublished data).

Figure 17. Total annual export of Timor-Leste's fisheries and aquaculture sectors between 2006 and May 2017.

The proportion of catch that is spoiled and discarded is unknown, but such losses are likely mitigated by common practices such as sharing and gifting, preservation and household consumption of unsold catch. However, fishers across the country have identified that unsold catches do occur and that lack of consumers and lack of access to markets are significant problems in many of their communities. In addition, the vast majority of fish is traded in open air markets or on the side of the road. There are a lack of freezers and cool boxes, and some coastal communities still lack reliable access to electricity and clean water.²⁴

Market studies are needed to provide more information on postharvest losses. In turn, this can be used to measure the potential impact of value chain enhancement interventions.

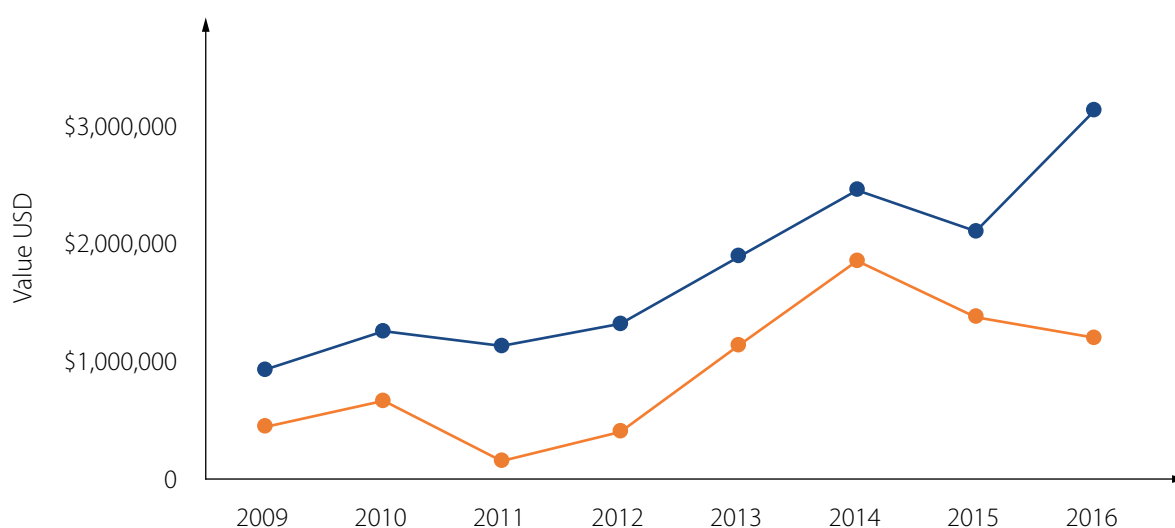
2.6.3 Catch sales and operating costs

Timor-Leste's poor road infrastructure and limited transportation services create high transaction costs for fish producers (coastal fishers and fish farmers). The development of the Timorese fishery sector is influenced by market constraints and a lack of economic incentives to increase production, so fishers generally limit catches to what they can sell each day (Población 2013). Fishers can sell their produce directly to consumers (when the catch is small), to small local traders (who pay 75% to 80% of the market price) or to large traders who transport the fish to a large population center (which pays 50% of the market price) (Población 2013). The market chain is

affected by infrastructure, particularly by the lack of ice, poor road conditions and the distance to market. When more than one fisher is involved, profit is shared, and operational expenditures (e.g. fuel, gear repairs and food) are subtracted from the daily catch. The catch is generally sold at roadside markets at an average price of USD 5/kg (2018).

Data on the value of vessels shows that fiberglass motorboats provided through government programs are the most expensive, at an average value of USD 3288 (NSD 2014). Non-motorized wooden boats (USD 231), basic canoes (USD 303) and canoes with sails (USD 387) are more affordable for fishers than timber motorboats (USD 1100). Boat prices varied between municipalities, with Dili and ROEOA showing the highest prices and Viqueque and Liquica the lowest. Fuel cost is a major constraint for fishers using motorized boats, despite having the potential to access more productive fishing grounds than nearshore coral reefs.

Fuel and repair and maintenance costs were the largest operating expenditures, followed by repairing and maintaining fishing nets and traps (NSD 2014). Artisanal fishers are generally the most exposed fleets to fluctuating fuel prices (Gillett 2009). Particularly in PICTs, many SSF facing higher fuel costs reduced the distance traveled and changed fishing gears to minimize fuel use. Comparing fuel prices of Timor-Leste to other countries, prices steadily increased from 2004 to be higher than neighbors in 2008, but decreased from 2012 to 2014 (Figure 19). High resolution vessel



Note: Processed seafood is shown as a blue line and unprocessed as an orange line.
Source: MOF 2017 (www.statistics.gov.tl/category/survey-indicators/external-trade-statistics/).

Figure 18. Seafood product imports for Timor-Leste.

tracking devices used on the artisanal fleet in Timor-Leste will enable research on the impact of fuel price fluctuation on fishing behavior in the coming years.

2.7 Governance

2.7.1 Governance systems: Country structure

Timor-Leste's constitution stipulates, "Everyone has the right to a humane, healthy, and ecologically balanced environment and the duty to protect it and improve it for the benefit of the future generations" (Article 61 n.º 1). The DGP, under the MAF, is the main government institution responsible for fisheries management.

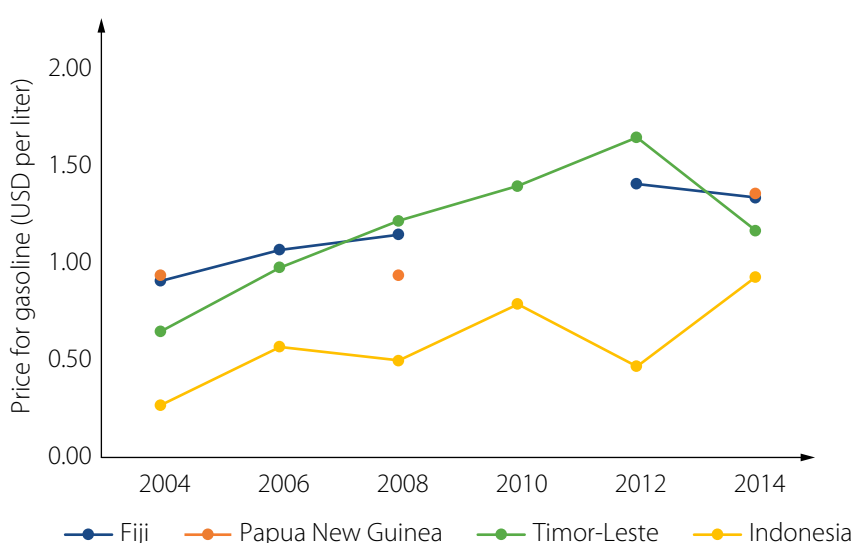
Governance functions and spending are still highly centralized, despite decentralization being a specific priority in Timor-Leste's constitution, and budget allocations to municipalities are often not according to their operational needs (World Bank 2017). Budget execution, of even the smallest task, is built on complex, centralized administrative processes that require senior management approval at different steps, and a mismatch between budget and municipalities requirements is common (World Bank 2017). At a human resource level, staff have insufficient relevant training and limited practical experience with marine fisheries. The fisheries department has staff based in the municipalities, but these are generally recruited from the local community with little additional technical training, and few fishers have knowledge on the existence of bodies responsible for marine resources management (FAO 2013).

Best management approaches suited to the Timorese context should consider fishers as active and responsible actors in the sector. In addition, existent local systems of resource need to be formally integrated into governance systems to pave the way for co-management and community-based resource management in fisheries management (Alonso et al. 2012; Mills et al. 2013). One of these local systems is *tara bandu*; a set of rules or taboos that regulate access and the behavior of individuals in certain domains under the threat of material or spiritual sanctions. *Tara bandu* has been used in number of places, including Adara, Berao, Beloi, Uaroana and Biacou. However, there is concerning evidence that the overemphasis on closed areas may enable external NGO actors to influence the process for their own conservation outcomes (Tilley et al, in review).

Following these lines, formulating new fisheries policy requires implementing community level adaptive management and monitoring, aligned with guidelines from FAO, such as the Voluntary Guidelines for Securing Sustainable Small-Scale Fisheries, the Code of Conduct for Responsible Fisheries,²⁵ and the Ecosystems Approach to Fisheries Management.²⁶

2.7.2 Co-management

Coastal co-management in Timor-Leste is relatively new, but recent evidence suggests that the use of *tara bandu* is an effective mechanism to engage communities in resource management and contribute to fisher well-being (Tilley et al. in



Source: World Bank WDI 2017.

Figure 19. Pump price for gasoline (USD per liter) for Timor-Leste and other island nations in the Pacific between 2004 and 2014.

review). *Tara bandu* represents a point of interaction between the customary and contemporary, and between innate and appropriated cultural practices for fisheries management. The importance of strong community institutions is paramount, but drivers of compliance are highly context-specific.

Tara bandu is now recognized by the state-based Environmental Framework Law (Article 8). This law affirms that *tara bandu* may be established through local common law to conserve the environment and promote the sustainable use of natural resources and, importantly, declares that the state will ensure the regulated area is effectively protected. More generally, the Constitution (Article 2 n.º 4) affirms, "The State shall recognize and value the norms and customs of East Timor that are not contrary to the Constitution and to any legislation dealing specifically with customary law."

In the past 20 years, various attempts have been made to develop and introduce co-management as a mechanism to decentralize marine governance in Timor-Leste (Table 8).

Considerable risk exists relating to the appropriation of *tara bandu* for resource management to fulfill the objectives of external actors. It is important that the sector institutes regulations that ensure the voices of all stakeholders and community members are central in the development of *tara bandu* and that processes are not unduly forced or rushed because of the requirements of external entities. Similarly, principles of adaptive co-management (Andrew et al. 2007) require that resource owners must be able to review and revise management measures as new information on resources status or community impacts come to light. Practices that see "community-based" regulations cemented in ministerial diplomas are counter to the principles of adaptive co-management. The sector must develop a contextualized approach to co-management that guarantees the agency of men and women resource owners in the processes of managing and that regularly reviewing rules and management measures.

2.7.3 National Fisheries Strategy

Between 2017 and 2018, the DGP and WorldFish conducted national consultations with fishers in every municipality of Timor-Leste to inform the drafting of the NFS according to the process on the next page:

Two primary strategic actions were crucial to improved, transparent and accountable sector governance:

1. Update and harmonize the legal and regulatory frameworks of the sector.
2. Develop an institutional framework conducive to participatory and transparent co-management of marine fisheries.

Existing institutional capacity can be strengthened by creating a statutory body, such as an advisory council or board, hosted at the MAF as a platform for dialogue and exchange between all relevant stakeholders, including non-state actors and donors. This statutory body would be legally mandated to build and sustain the governance capacity required to actively and effectively co-manage fisheries based on human rights. The present institutional landscape includes, *pro forma*, such a body, but it has never been convened. In addition to being legally mandated, it is essential for the proposed statutory body to function following clear and transparent terms of reference (ToR) and to have a budget sufficient to sustain the consultative process, particularly in the coastal communities. Participation in the meetings would be obligatory for donors and NGOs involved in marine and coastal resource management and development.

The ToR would be developed jointly among stakeholders, with its principle aim of providing informed advice and guidance on fisheries co-management to government. Advice and guidance would be based on policy dialogue among stakeholders, along with expert advice from subject matter specialists, regional and international fisheries management organizations and academic institutions. Advice would include improving and heightening Timor-Leste's profile in regional fisheries management organizations and regional cooperation overall.

2.7.4 Fisheries legal regime

The present Decree-Law No. 6/2004 of 21 April 2004 and the Government Decree No 5/2004 of July 2004 have important provisions for good sector governance. These include putting the goals of sustainability of resource use ahead of short-term economic and political gains, and allowing full participation of communities and other stakeholders in resource management. However, there are

<p>Scoping mission February 2017</p>	<ul style="list-style-type: none"> • Analyze political, economic, social, technical, legal and environmental (PESTLE) aspects. • Evaluate strengths, weaknesses, opportunities and threats (SWOT) relevant to managing and developing Timor-Leste's fisheries sector. • Conduct analyses with DGP senior staff and use them to develop the strategy's vision, overall and specific objectives, as well as assumptions and risks.
<p>Initial validation workshop October 2017</p>	<ul style="list-style-type: none"> • Validate scoping mission outputs and logical framework with the MAF, DGP and stakeholders. • Prepare the zero draft of the NFS, including a theory of change and tentative strategy areas.
<p>First review by technical working group December 2017</p>	<ul style="list-style-type: none"> • Review the zero draft by a technical working group. • Validate four strategy areas and review or revise a tentative list of strategic actions. • Prepare the first draft of the NFS.
<p>Second review by technical working group March 2018</p>	<ul style="list-style-type: none"> • Stakeholders, development partners and participants of the second technical working group meeting review the first draft. • Hold group discussions on each strategy area to further develop and prioritize strategic actions. • Prepare the second draft of the NFS.
<p>Pre-consultation meetings July–September 2018</p>	<ul style="list-style-type: none"> • Hold 30 meetings with fishers, their communities and other stakeholders in all 11 coastal municipalities to disseminate information about the regional and national consultation meetings. • Hold group discussions on main fishing activities, species caught, existing group and communication channels, current issues, challenges and priorities, illegal fishing and existing local management of marine and coastal resources.
<p>Regional consultation meetings September–October 2018</p>	<ul style="list-style-type: none"> • Conduct structured, participatory, inclusive dialogue with fishers, their communities and other stakeholders in five regional meetings. • Use outputs to develop the final draft of the NFS.
<p>National consultation meeting October 2018</p>	<ul style="list-style-type: none"> • Conduct structured, participatory, inclusive dialogue at the National Fisheries Forum attended by representatives of fishing communities, public and private sector stakeholders, NGOs, academia and development partners. • Use outputs to develop the final draft of the NFS.
<p>National Fisheries Strategy Ongoing review</p>	<ul style="list-style-type: none"> • Prepare and launch the NFS as a “living document” that is updated through regular discussions with fishers (men and women), leaders of their community organizations and stakeholders.

From the draft of the NFS (WorldFish 2018).

What	Year	Who	Description and co-management development	Comment
Fish for the Future: First national fisheries policy	2001	MAF	Focused on nascent state priorities such as staff capacity building, assertion of jurisdiction and development of legislation.	
Co-management or community-based, coastal resource management framework	2001	MAF under the World Bank's second Agriculture Rehabilitation Project	Detailed proposed community-based, coastal resource management scheme.	No follow-up or implementation
Law Decree 6/2004 of 21 April: Establishes the general basis of the legal regime for fisheries and aquaculture management and regulation	2004	MAF	Provides for the creation of co-management committees with powers related, among other things, to "compliance with conservation and management measures of fishing resources, protection of the marine environment, assistance in controlling illegal fishing and compliance with the fisheries legislation" (Article 114).	Currently under review (2018)
Fish for Sustainability: Our Strategic Plan for Fisheries, 2006–2011: A new fisheries strategy	2005 (drafted) 2007 (released)	MAF	Encourages and facilitates community-based, fisheries management initiatives and aims at establishing a network of local, community-supported marine protected areas and encouraging involvement of NGOs.	Not approved by the Council of Ministers nor legally endorsed by the government
Development and establishment of Timor-Leste's first marine protected area, Nino Konis Santana National Park (NKSNP)	2006–2009	MAF in partnership with a consortium of Australian agencies	Project included a planning workshop for the NKSNP marine component, which endorsed a community-based approach to planning (i.e. Locally Managed Marine Area (LMMA) model) to build local support, stewardship and provide for co-management.	The adoption and implementation success of management process has not been critically assessed
	2009–2013	USAID's Coral Triangle Support Partnership, implemented by Conservation International in partnership with the MAF and a local NGO	The Indonesian national LMMA network supported development and planning of LMMAs at Manatuto and Hera, including exchange visits, community surveys and participatory planning in 2011–2012. It worked with communities of the NKSNP to identify priority resources and develop management solutions, leading to the development of a multiple-use marine park zoning and regulatory scheme, and community-based management plans. As part of this work, a manual was produced called Guidelines for Establishing Co-Management of Natural Resources in Timor-Leste.	
Regional Fisheries Livelihoods Program for South and Southeast Asia (RFLP): A regional program, implemented in six Asia-Pacific countries	2009–2013	Implemented by FAO in close collaboration with the Timor-Leste government, funded by the Kingdom of Spain	Aimed at "strengthening capacity among participating small-scale fishing communities and their supporting institutions toward improved livelihoods and sustainable fisheries resources management," including the establishment and strengthening of a co-management mechanism. In Timor-Leste, the RFLP focused on building basic governance systems, such as the development of the National Fisheries Statistics System and the National Census of Fishers and Boats, among other activities. DGP staff gathered information from communities on informal management arrangements and governing mechanisms in coastal areas. Through this exercise, the community of Biacou was identified as interested in re-enacting its <i>tara bandu</i> for management purposes.	Further details in Tilley et al. (in review)
Participatory development of the first exclusively marine tara bandu in the community of Adara on Atauro Island	2015–2016	Implemented by WorldFish funded by the Australian Center for International Agricultural Research	A highly participatory approach involving all stakeholders in Adara, as well as relevant government agencies. Regulations, boundaries and fine structure were devised by the community, including a closed area with a "reef tax" for diving and snorkel groups wanting to enter.	Further details on the Adara case study are provided below.
National Fisheries Strategy	2017–2018	MAF and WorldFish funded by Norway and the Asian Development Bank.	Between 2017 and 2018, the DGP and WorldFish conducted national consultations with fishers in every municipality of Timor-Leste to inform the drafting of the NFS. The two primary strategic actions identified were 1) to update and harmonize the legal and regulatory frameworks of the sector; and 2) to develop an institutional framework conducive to participatory and transparent co-management of marine fisheries.	

Source: Tilley et al. in review.

Table 8. A timeline of fisheries co-management developments and projects in Timor-Leste since 2000.

inconsistencies and certain regulations unbefitting the characteristics of the sector in Timor-Leste that need revision. Current fisheries policy has failed to promote growth of the sector and regulate it effectively because it is state-oriented, built upon unsuitable foreign examples and uses a top-down regulation approach (Alonso et al. 2012).

Since March 2018, WorldFish has assisted the MAF in revising the fisheries legal framework. A natural resources lawyer carried out a review of fisheries legislation, and working groups were convened to draft a revised decree for ratification in 2019.

2.8 Development priorities

During the consultation process of the NFS, fishers and community members identified a number of priorities for the fisheries sector (Table 9).

This section presents a deeper explanation of some of the key challenges to achieving broader development goals through developing the fisheries sector along with opportunities and recommendations to overcome them.

2.8.1 Increasing sustainable small-scale fisheries production

Harnessing the potential of fish and fisheries to combat malnutrition in Timor-Leste will rely on scaling up fish production and distribution nationwide. There are multisectoral challenges to achieving this, such as poor road infrastructure that inhibits effective distribution of fish inland and across the country. We will focus on sector specific constraints as far as possible.

Key challenges

Lack of data

- Fisheries data to guide adaptive management decision-making and track the success of interventions has, in the past, been completely lacking. National production figures have been estimates generated from approximations of total fishing capacity (number of boats), but there is no long-term data from selected landing sites to calibrate these figures. PesKAAS is now providing this functionality.

Priorities	# of fisher centers with issue	% of fisher centers at meetings	
Boats, motors and fishing gear	74	100%	
Storage, processing and selling equipment	72	97%	
Maintenance training	69	93%	
Training on fishing techniques	61	82%	
Fish processing and marketing training	59	80%	
Safety at sea	53	72%	
Financial management training	46	62%	
Threat from crocodiles (management)	44	59%	
Access to markets and buyers	35	47%	
Improved govt. assistance process	32	43%	
Fishing by outsiders causing conflict	20	27%	
Govt. communication and coordination	15	20%	
Decline of fish stocks	12	16%	
Fish pricing problems in market	8	11%	
Other priorities	16	22%	

- Issues in "other" category
- access to electricity
 - access to water
 - road access
 - prolonged roadworks resulting in loss of income
 - foreigners diving in local area without asking local permission
 - climate change
 - lack of communication from such authority.

Discontent with fishers from Atauro was reported in consultations in Dili (mainland), Manatuto, Baucau, Lautem and the RAEOA for fishing in their area (i.e. not Atauro) with methods that scared away fish.

Source: National Fisheries Strategy pre-consultation meetings 2018.

Table 9. Summary of priorities for the fishery sector as selected by fishers in consultation meetings for developing the National Fishery Strategy.

- In addition to landings data, there is an urgent need for a new census of the SSF fleet in Timor-Leste. The RFLP started registering fishers, but the registration system is seldom updated because of DGP budget constraints, so data on the number of boats and distribution of fishing effort is patchy. Without this, it is difficult to prioritize areas for intervention from government and NGOs.
- A catch documentation and monitoring system for SSF will let science inform management and policy decisions and allow for continued evaluation and impact assessment of interventions over time and space.

Lack of capacity

- In NFS consultations, 100% of fish centers identified inadequate boats and fishing gear as a main constraint to earning higher income. Also, the need for training in areas of new fishing techniques and technology, as well as engine maintenance and fish processing, was highlighted at more than 80% of fish centers in all regions. Fishers highlighted that when they need financial assistance, it is mainly for replacing fishing gear (81%) and to cover operational costs of fishing. Equipment such as boats, engines and gear are prohibitively expensive for small-scale fishers in Timor-Leste, and there are few sources of information available to them on novel fishing techniques, equipment, market information and sea conditions. As a result, SSF are currently limited in range and fishing capacity.
- Fishers are constrained by poor access to credit. Few are aware of microfinance providers, so only a minority use existing savings and loan services (FAO 2013). Most fishers prefer borrowing money from family or friends instead of using formal financial institutions. According to the RFLP baseline survey, 41% of respondents considered the official application process difficult to understand, 32% felt interest rates were too high and 23% were fearful of not being able to repay loans (AMSAT International 2011b). In general, however, fishers simply did not consider they had enough money to save (FAO 2013). Saving is generally done on a monthly basis, and most of the amount saved is spent on fishing-related expenditures, especially operational costs for fishing, or to purchase livestock as a savings mechanism.

Opportunities and recommendations

- The consultations that took place throughout the country to inform the drafting of the NFS were timely and highlighted important needs and priorities of fishers to government.
- Since 2016, WorldFish and the DGP have been developing and piloting an SSF catch monitoring system (PeskaAS) that generates automated summaries of landings on a decision dashboard in near real-time for the DGP. The DGP has access to the outputs and has begun to adopt the system and employ 11 data collectors with tablets (one per coastal district) as of May 2019.
- A gender-disaggregated catch documentation system will quantify the contribution of women to fisheries, particularly in ordinarily informal fisheries like gleaning. Engaging and empowering women to make decisions about their marine resources will improve coastal stewardship and harness their potential to drive improvements to household nutrition and local economies.
- FADs have improved catch rates in three out of four early trial sites and return investment in the FAD within 5 months (Tilley, Wilkinson et al. in press). DGP officers have been trained in constructing and deploying FADs and are now leading further deployments. Scaling up these simple fisheries technologies by the DGP across the country, combined with rolling out training on forming fishing groups and cooperatives, will strengthen fisher market competitiveness and boost organic growth and investment in the sector.
- South coast snapper fisheries provide considerable potential for expanding local fleets and enterprises, providing new livelihoods as well as contributing substantially to availability of high-quality protein and micronutrients.
- Exploratory fishing should be continued in both the north and south coasts to provide for alternative fisheries of potentially higher value or diversified sources of fish-based income.
- A dedicated national agricultural census planned for 2019 should include a section on fisheries and aquaculture to quantify the importance of the sector. Household Income and Expenditure Surveys (HIES) have been used effectively in other countries to obtain a better estimation of production and consumption levels with little or no expense to fisheries agencies. Guidance on how to design HIES to provide reliable information on fisheries should be prioritized.

2.8.2 Improving distribution networks and value chains

Key challenges

- One of the key elements of fish value chains is access to ice. According to fishers interviewed in the RFLP baseline survey, 90% of respondents do not use ice. A lack of local producers and limited ice production were seen as major constraints for fishers to sell their produce (FAO 2013). Also, 55% of fishers did not have access to modern fish processing tools, and 39% did not have adequate equipment to process their product. When asked what equipment they needed the most, 57% of fishers identified modern processing equipment as their most pressing need (AMSAT International 2011b).
- Major investments by the Timorese government and later by the RFLP program to construct infrastructure (fisheries centers, *Lotes de peska*) for wide community use to support improved handling and cold practices were unsuccessful. Unclear access arrangements to these facilities are inhibiting their use, and most are on a trajectory into disrepair. Current fish distribution networks operate largely on social relationships.
- Constraints to fisher income highlighted in the RFLP baseline survey were low market support or low buying power (30%), limited market channels (26%), low education (23%) and no capital (21%) (FAO 2013). Furthermore, 87% of respondents said that training, additional skills and information to increase the quality of their produce were greatly needed, as most fishers considered that the poor product quality was a major obstacle in selling processed fish products.
- Limited ice-making equipment and cold chain transportation are not available for use by fishers and vendors, resulting in spoilage and a reduced consumption date. Ice initiatives have started in the past, with limited success. In some areas, this challenge is coupled with unreliable electricity supply, though rapid roll-out of electricity infrastructure in the past 5 years has reduced this issue.
- Some actors do not have sufficient business skills in practical aspects or bookkeeping.

Opportunities and recommendations

- Value chain improvements, such as access to ice, better landings facilities, broader distribution networks, improved handling, and

processing of produce will be crucial once a more regular supply from small-scale fishers is achieved.

- Technological development in fish processing and packaging would generate value-adding and employment opportunities.
- Fish traders must be supported to innovate and build on their ideas for stronger market chains to inland areas.
- The government should prioritize dedicated training for fisher communities in forming cooperatives to strengthen market competitiveness of fishers and maintain a viable value for fish if increased production leads to lower prices when the system cannot commercialize the amount of fish produced.
- Key intermediaries must actively encourage and support distribution to markets in inland municipalities. If possible, during the time of high fish surplus, a market should be established in Aileu and Gleno, with consistent, good quality supply at affordable prices. Once a market has been established, existing supply routes should be leveraged from large supermarkets that travel to and through Aileu and Gleno when purchasing vegetables for sale in Dili. This will provide cheap, cool and regular transport to these areas.

2.8.3 Improving consumption and nutrition

Key challenges

- Low fish supply remains the primary factor limiting fish consumption. Low supply, in turn, leads to high prices, which further limit consumption.
- Market economy and nonmarket exchanges influence the current development status of Timor-Leste's fishery sector. Fish consumption is constrained by cultural preferences in consuming meat over fish because of the importance of meat in traditional rituals. In most of the country, fishing remains a secondary livelihood in a diverse set of household activities, so engagement in fishing is low compared to what is seen in other small island developing nations, where fishing is commonly central to local culture.
- There remain traditional norms that limit fish consumption in some areas, and more broadly there is a lack of awareness of the nutritional value of fish, particularly for children.

Opportunities and recommendations

- Diverse approaches to increase sustainable fish production are required to improve supply and improve affordability.
- Government institutions and NGOs should prioritize awareness-raising campaigns regarding the nutritional value of eating fish, paying particular attention to countering traditional beliefs that limit consumption of fish by certain groups or in particular areas. WorldFish recently produced a short film for distribution on this topic (bit.ly/2IJE6O1).
- Advocate fish consumption especially in lactating mothers as well as children under 5 years old through developing local recipe books and diversifying products containing fish products and crucial micronutrients.
- Data-gathering pilot exercises on the gleaning subsector can be used as a tool for augmenting and transforming the role of women and youths in the fisheries sector. This can be achieved by focusing on activities that promote knowledge, recognition and professionalization of women and youths in gleaning and other small-scale fishing activities.
- Foreign licensed vessels should be obliged to land and sell a proportion of the catch in Timor-Leste to boost the quantity of fish being sold on the market.

2.8.4 Governance

Key challenges

Legal and institutional capacity

- The fisheries regulatory framework contains many inconsistencies and articles that are irrelevant to the characteristics of the country's fisheries.
- Timor-Leste has many fisheries and environmental laws in place, but with little or no enforcement action, most marine and coastal resources are effectually open-access, as there are no specific rules restricting physical access to fishing areas, except in locally managed marine areas.
- Despite agriculture being the most important sector nationally by proportion of the population employed, either formally or informally, and in terms of food and nutrition security, the proportion of government funding supporting the MAF is disproportionately small. Furthermore, the fisheries and aquaculture

sectors obtain a very small piece of this already small pie. To attempt to meet objectives set out in the SDP and increase fish consumption by 2030, the government needs to prioritize investment in the fisheries sector.

- The development of the fisheries sector is highly constrained by the limited human capacity (training and number) at the national and district level. The MAF has received limited benefits from the Human Capital Development Fund, and funds allocated for civil servants training have been steadily decreasing (World Bank, In prep).

Co-management

- Co-management is a new concept in Timor-Leste, so substantial capacity building among managers, resource owners and stakeholders is required.
- Government decentralization is hugely complex in a legally pluralistic society such as Timor-Leste.
- Various fisheries strategies have been developed and drafted since Timorese independence, but all have so far failed to be implemented (see Table 8).
- Approaches to co-management that follow basic principles of adaptive co-management need to be contextualized for Timor-Leste.

Opportunities and recommendations

Legal and institutional capacity

- Governance structures and legislation appropriate for Timor-Leste need to be revised to include original policies and legal frameworks adapted to the structural conditions of the sector. Since March 2018 WorldFish has been providing assistance to a government working group to revise and amend the current fisheries legal regime. A final revision will be submitted in 2019.
- Capacity building and awareness raising of the revised fisheries regulations with national and municipal level DGP staff and fish workers is necessary to strengthen the sector.

Co-management

- Combining new fisheries technologies, such as FADs, with the development of co-management processes in communities can provide useful incentives for fishers to engage in co-management and conservation processes by providing alternative fishing grounds.

- Institutionalizing stakeholder engagement in governance is essential. This can be achieved by developing governance systems based on co-management and community based fisheries management. This will increase ownership of rules by communities, create collective action and communication channels and provide opportunities for participatory monitoring.
- Concepts and terminology of co-management are poorly understood by local fisher groups (FAO 2013) and government staff. But the nascent expansion of *tara bandu* for marine and fisheries management should be further developed as a mechanism that people understand and one that is already mandated by law.
- Conducting fisheries independent stock assessment data on offshore stocks is extremely costly.

Legal and institutional capacity

- Despite having a VMS in place, Timor-Leste has neither the capacity to enforce fishing regulations with licensed vessels nor the onboard observers to ensure accurate catch reporting for stock assessment and management. Similarly, knowledge of the scale of illegal fishing by foreign vessels is limited, as is the enforcement capacity to combat it.
- The current fishing quota of 100 t per boat per year is counterproductive. Without onboard observation, low value fish may be discarded to make the weight quota optimally profitable, or transshipment may be occurring.
- The terms and conditions of the commercial fishing licenses need to be reviewed to ensure good fishing practices (transitioning to less damaging gear, such as long lines) and fair revenue for the country. A licensing regime should be developed with pricing based on the market value of fish.
- The income generated by the offshore licenses does not return to the MAF or the fisheries department. Instead, it goes to the central government, so there is little incentive or financial capacity to improve management and monitoring of the foreign vessels' activities.

2.8.5 Offshore fisheries and foreign vessel licensing

The following two policy principles from the National Fisheries Strategy 2018 help to frame the consideration of offshore and foreign fishing in Timor-Leste:

1. All Timorese fisheries resources which can be caught by small-scale and artisanal fishers should be caught by small-scale and artisanal fishers.
2. All Timorese fisheries resources which can be caught by Timorese fishers should be caught by Timorese fishers.

However, there is of course very little, if any, capacity to access and fish offshore stocks in Timor-Leste at present, so these resources should be sustainably harvested to the benefit of Timorese people. If this means by licensing reputable foreign fleets to access them, then sufficiently rigorous licensing agreements should be undertaken by the DGP. The recent revision of the Fisheries Decree Law will enable these licenses to be issued and enforced with confidence according to the national law.

Key challenges

Lack of data

- Monitoring the movements of the offshore commercial fleet is currently done using a VMS. However, this system costs approximately one-fifth of the fisheries budget and was initiated as a trial paid by JICA and a Japanese private sector company, so the sustainability of this monitoring effort is unknown. Without a VMS in place, the government does not have the capacity to regulate the commercial fishing fleets currently operating.

Opportunities and recommendations

Lack of data

- The allowable quota per year should be a reference for license payment; any additional production should generate extra payment. In issuing licenses, payment should be preferred over promises of infrastructure development, such as processing plants.
- A potential route to determine the state and health of offshore fish stocks is to obtain verified data from the current catch of the Chinese vessels. This needs to be implemented via onboard fisheries observers rather than as a government regulatory approach (i.e. inspection of catch every 3 months) to avoid potential underreporting of catch volumes and species identification.

Legal and institutional capacity

- Carry out Port States Measures training for DGP inspectors to improve inspection protocols in line with regional standards.
- There are opportunities to leverage assistance from regional expertise (e.g. through existing agreements with neighboring countries such as the joint jurisdiction of the EEZ with Australia) in monitoring, controlling and surveillance of capture fisheries. The Australian government has already committed to providing and maintaining two Guardian-class patrol boats for Timor-Leste by late 2023 as part of a \$2 billion commitment to regional maritime security through the Pacific Maritime Security Program.
- Investigate options for creating an autonomous government agency under the DGP that will be funded by offshore license fees with financial independence over revenues. Revenues must be invested in fisheries management, such as monitoring the fleet and enforcing laws. But given that this may create incentives to favor fishing access agreements toward local interest, this approach can only be implemented once data on offshore stocks is available, monitoring is in place and there is political will for enforcement. Offshore resources need to be assessed and the total allowable catches set based on precautionary principles.



Plate 6. Reef spear fisher in Adara, Atauro Island.

3. Aquaculture

3.1 Background

Aquaculture is a relatively new sector in Timor-Leste. During Indonesian rule (1975–1999), freshwater fish hatcheries were established in some municipalities to grow common carp, while brackish aquaculture ponds reared tiger shrimp and milkfish, but all activities collapsed during the conflict and upheaval of Indonesian withdrawal in 1999. Since then, the government has gradually revitalized aquaculture activities in different regions of the country in collaboration with external agencies by restoring fish hatcheries and coastal aquaculture ponds and providing fingerlings to some households. The SDP (2011–2030) recognizes the importance of the sector stating that aquaculture activities “could offer income generating opportunities for coastal communities.”

One of the most significant initiatives toward developing aquaculture was the Combatting Malnutrition and Poverty through Aquaculture in

Timor-Leste (COMPAC-TL) program implemented between 2013 and 2016 by WorldFish, Mercy Corps, and Hivos in six rural municipalities (Lautem, Baucau, Viqueque, Manufahi, Ainaro and Covalima) (Figure 20). This program, funded by the Norwegian Ministry of Foreign Affairs, aimed at developing integrated farming to diversify food systems and livelihood options. It provided training to 1555 households in tilapia farming, while providing ongoing extension resources and advice to farmers. Complementing this project is the Partnership for Aquaculture Development in Timor-Leste (PADTL) funded by the Ministry of Foreign Affairs and Trade, New Zealand, with the aim to develop sustainable small-scale aquaculture (Figure 20).

Other initiatives in aquaculture have been led by Catholic Relief Services and the MAF’s “1 hectare pond” project (Figure 20), with the aim of constructing a total of 1 ha of ponds in each of 10 selected locations: Sare (Ermera), Meligo (Bobonaro), Lactos (Covalima), Salao (Manatuto),

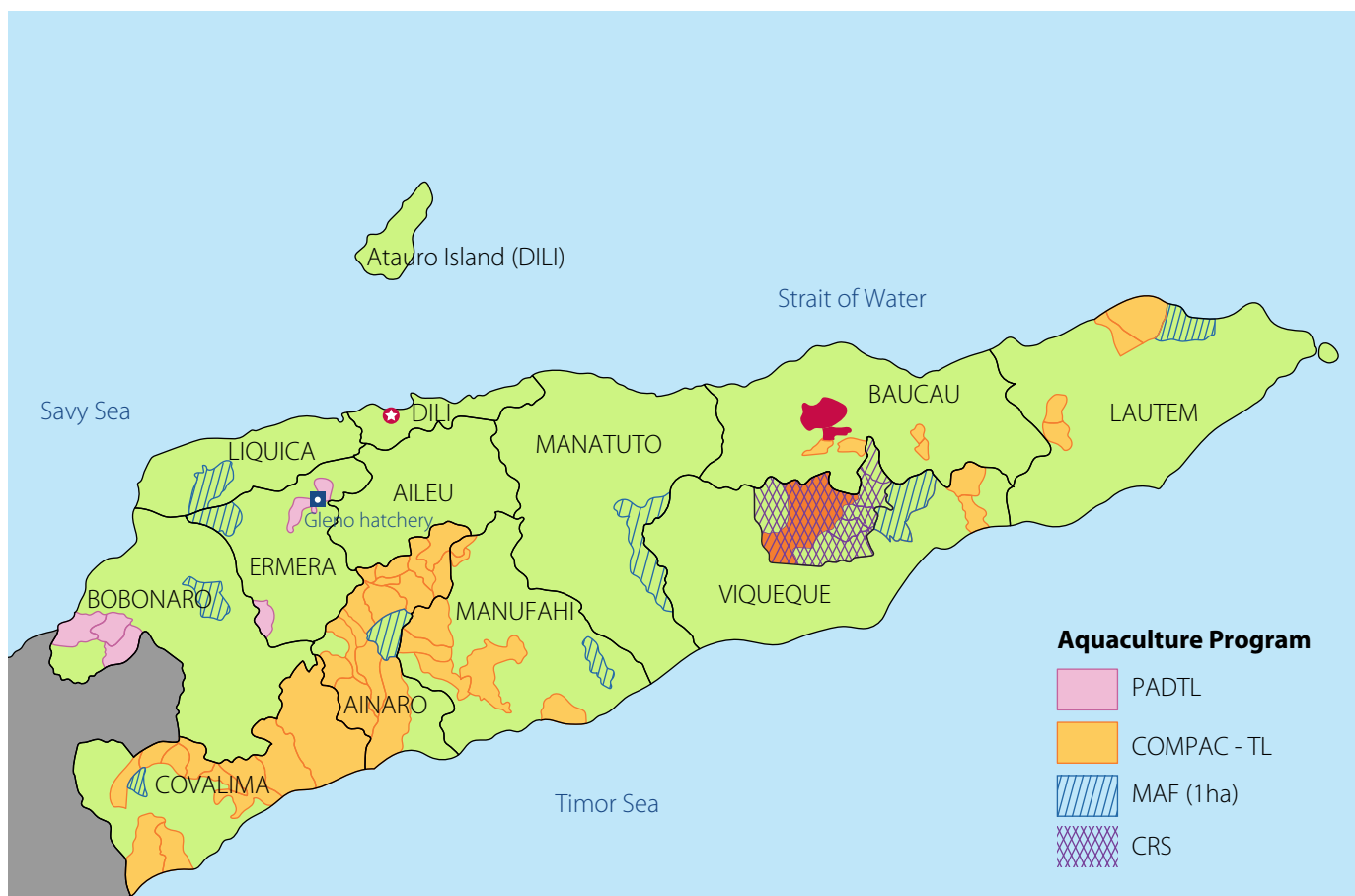


Figure 20. Municipalities in Timor-Leste with previous or current aquaculture projects.

Edemumo (Viqueque), Com (Lautem), Sebagulau (Ainaro), Gariwai (Baucau), Caicasa (Manufahi) and Lisadila (Liquica) (Figure 20).

Currently, most widespread farmed freshwater species are tilapia and carp (Plate 7). Brackish water aquaculture could be developed through rehabilitation of existing milkfish and shrimp pond infrastructure (22 ha in total), but there are no fingerlings for these species in Timor-Leste. Collecting fingerlings or larvae from wild stocks and expanding brackish aquaculture in coastal habitats such as mangrove forests is unsustainable as it damages ecosystem health. There is potential to expand shrimp and milkfish farming in the

medium and long term, but expansion must not further impact threatened coastal mangrove areas.

Mariculture activities are limited to seaweed farming mostly produced in Atauro Island. The government has shown interest in developing farming of high value species, but these have failed so far. Two examples are the blue crab and offshore grouper ranching. These were unsuccessful because the scale of production was unable to compete with imported crabs from large-scale operations in Southeast Asian countries such as Vietnam, low abundance of local broodstock and a lack of locally available feed products (no supply of trash fish for fishmeal in Timor-Leste, as in other Asian fisheries).



Plate 7. A harvest ceremony at the Gleno tilapia hatchery. Ermera, Timor-Leste.

The following sections describe Timor-Leste's aquaculture sector, exploring the governance, area under production, livelihoods of fish farmers, income and sustainability.

3.2 Governance

Aquaculture is one of three national departments under the DGP in the MAF. Currently, there is no regulatory framework or law that governs aquaculture practices in Timor-Leste. Since March 2018, however, WorldFish has supported the MAF in drafting the Aquaculture Legal Regime (Amador 2018).

National Aquaculture Development Strategy

In 2012, the MAF, with technical assistance from WorldFish, launched the National Aquaculture Development Strategy (NADS) 2012–2030. The NADS, aligned with the goals of the SDP 2011 - 2030, was developed based on outcomes from a multi-dimensions analysis of the aquaculture sector and its development potential. This analysis included geospatial data analysis, field visits and government and stakeholder consultations.

The overall objective of the NADS is to improve food and nutrition security, diversify livelihoods of inland and coastal communities and contribute to economic growth in Timor-Leste.

The NADS is based on the following principles (MAF 2012):

- Aquaculture development in Timor-Leste is centered on the country's goal of addressing the problem of chronic food insecurity and malnutrition.
- The NADS is in harmony with the SDP and will be implemented in three phases.
- An ecosystem approach will develop sustainable aquaculture, considering the following technical, social, economic and environmental aspects:
 - Aquaculture will be concentrated in agro-ecological pockets with potential for development and in harmony with other users.
 - Aquaculture development, following the principles of an ecosystem approach, will be based on the judicious use of natural resources and will be benign to the environment.

- Aquaculture development will contribute to the diversification of livelihood opportunities of inland as well as coastal communities.
- Gender equality and social inclusion will be addressed as crosscutting themes.
- Viable aquaculture technologies will be developed through participatory applied field research that is validated, disseminated and promoted.
- The strategy envisions a coordinated approach with joint ventures between the government, local communities, international and national NGOs, the private sector, and development partners. These will be critical components to realize success.

To implement the strategy, stakeholders must take actions that are designed to lead to the following nine key outcomes (MAF 2012):

1. Identify suitable agro-ecological zones for aquaculture development.
2. Develop and disseminate viable aquaculture technologies.
3. Strengthen institutional capacity of the NDFA.
4. Establish sustainable input supply systems.
5. Connect aquaculture producers to markets.
6. Use aquaculture to improve household food and nutrition security.
7. Create effective partnerships between government agencies, NGOs, communities, the private sector and donors.
8. Empower aquaculture farmer groups and representative institutions.
9. Put favorable policies in place for environmentally responsible aquaculture development.

The NADS has a specific short-term target of "raising per capita fish consumption in Timor-Leste from 6.1 kg to 15 kg by 2020" while long term the expectation is that "aquaculture will by 2030 contribute up to 40% of domestic fish supplies."

The NDFA has promoted the development of the aquaculture sector by restoring fish hatcheries and extension services, providing fingerlings free of charge, rehabilitating brackish aquaculture ponds and encouraging seaweed farming (MAF 2012).

Suitable agro-ecological zones for freshwater aquaculture development in Timor-Leste have

already been identified, taking agro-ecological as well and social, economic and institutional aspects into account (Figure 21).

3.3 Area under aquaculture

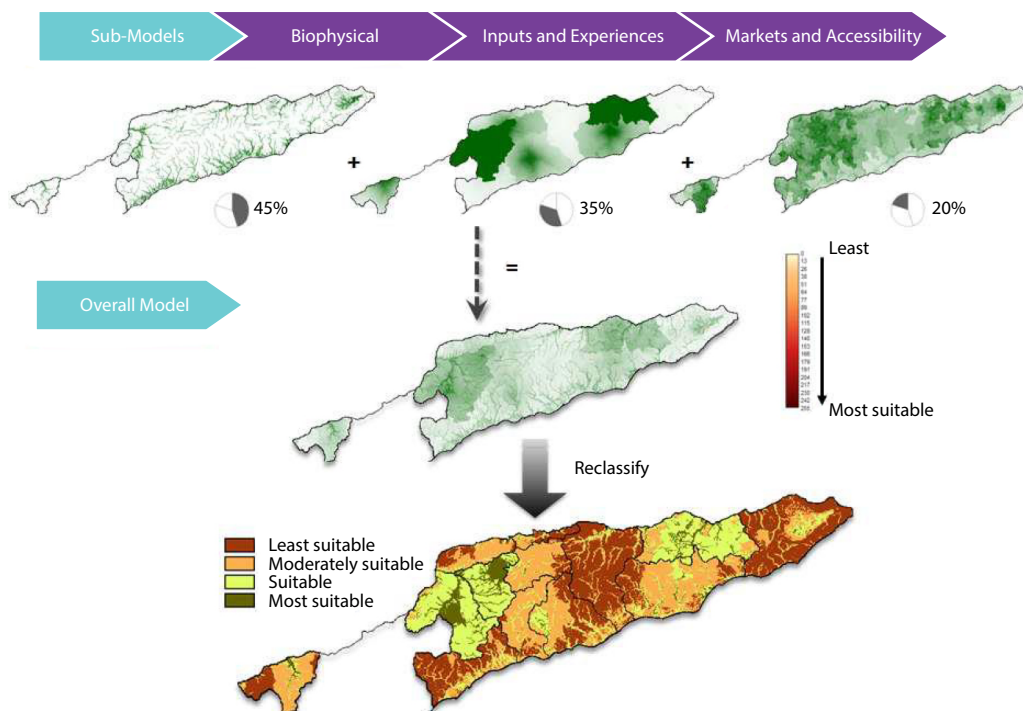
According to FAO, in 2007 there were 28.5 ha used for freshwater aquaculture in Timor-Leste. Based on findings from the background study toward the NADS, this increased to 41 ha in 2012. To date, the government has not consolidated information from different projects to provide aquaculture statistics at the national scale, so exact numbers of households engaged in aquaculture, areas under production, and yield are unavailable. Particularly, there are no accurate GPS locations for active aquaculture ponds, only for the area of training clusters, so calculating the total area of ponds in the country is challenging.

The NADS background study revealed that there is high potential for freshwater aquaculture development in Timor-Leste, taking into account biophysical and socioeconomic indicators across all municipalities (MAF 2012). According to this study, there are 4800 ha (about 5% of the total area of the country), concentrated in the municipalities of Bobonaro, Ermera and Baucau (Figure 21), that are highly suitable for aquaculture. These areas all have easy access to freshwater; are major rice

based farming systems; are low-lying and flat or slightly sloping; have easy access to a hatchery; have existing fish farming experiences and markets (MAF 2012).

To increase the productivity of homestead aquaculture systems for food security and household income, the sector needs to develop the capacity of freshwater hatcheries to increase fingerling production and maintain viable broodstocks. It also must source or produce high protein feeds. This can be achieved by (i) identifying low-cost feeding technologies that use locally available resources, (ii) introducing quality broodstock, (iii) training MAF officers on breeding, nursing, hatchery technologies and broodstock management (vital to the production of quality fingerlings), (iv) improving physical facilities and increasing resources available for feeding and management, and (v) decentralizing fish seed production.

Freshwater aquaculture of tilapia and carp has been promoted with more emphasis in municipalities with suitable agro-ecologies for freshwater aquaculture development. Refer Figure 20, if considers all AQ programs, it would covers all municipalities, except Dili. Most aquaculture is practiced in major rice producing municipalities because of the readily available freshwater in rice-



Source: NDFA/MAF 2012.

Figure 21. Freshwater aquaculture suitability classification and map of Timor-Leste.

based farming systems. Water used comes from natural springs and irrigation systems. The average size of a fishpond is around 100–200 m², farming mainly common carp and Nile tilapia. Each of the households involved in the COMPAC-TL had an average pond size of 97 m², making up a total of 15 ha of area developed as aquaculture ponds across six municipalities during the program.

It is thought that the efforts of different projects and programs across Timor-Leste have brought about a steady increase in the total area of aquaculture and the number of farmers involved and benefiting from newly introduced techniques and fingerling supply. However, the difficulties in collecting adequate data on pond size, stocking rates, harvest yields or even the number of active fish farmers continues to hamper effective evaluation of progress in the sector. According to figures from the 2015 National Census (GOTL 2015), almost one third of households in the country are involved in aquaculture. But this is clearly erroneous. The COMPACT-TL and PADTL projects report training interactions with approximately 1555 and 253 farmers respectively.

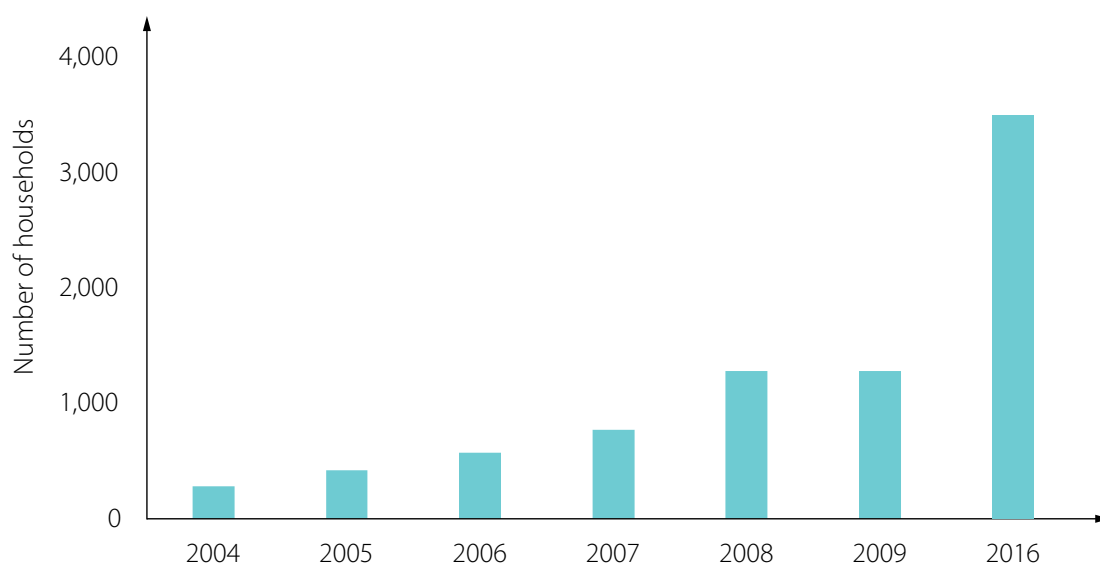
3.4 Livelihoods and income

Given that aquaculture development is still in its early days, there is not a robust estimate of the number of households engaged in fish farming, and the current figure provided by the 2015 census is incorrect.²⁷ There is an increasing historical trend of households involved in aquaculture. According to WorldFish estimates,

there may be 3000–4000 households engaged in aquaculture as a part-time farming activity in the country (Figure 22). The rapid increase of fish farming households since 2009 corresponds to different efforts led by NGOs and government, fueled by the formulation and implementation of the NADS. Recently, the number of households engaged correspond to the COMPACT-TL project in 2013–2016 (1553 households), the PADTL project²⁸ and efforts by the WorldFish hatchery in Gleno, which provided 655 farmers with fingerlings in 2016. These numbers are just estimates based on households engaged in different projects.

Fish farming has had a positive impact on livelihoods of the Timorese. Overall, in households where aquaculture is present, fish consumption frequency has risen notably. The COMPACT-TL program reported that more than 75% of households were aware of the health benefits of eating fish (i.e. improved nutrition along with essential nutrients for children’s early brain development), and were eating fish, especially tilapia, at the end of the project. Moreover, program farmers stocked mixed tilapia and monosex GIFT for their own consumption, and sold the surplus to the market and in their communities

Freshwater aquaculture farmers involved in government projects have managed to augment their household income by selling farmed fish. Fresh tilapia is sold at USD 4–5/kg, while common carp sells for up to USD 10 per fish (average 1 kg). The latest information based on ongoing on-farm trials carried out by WorldFish across Ermera,



Source: MAF 2012.

Figure 22. Number of fish farming households in Timor-Leste between 2004 and 2016.

Baucau and Bobonaro municipalities indicates that ponds are yielding about 3 t of fish per hectare per year, of which 63% is sold locally, 32% consumed and 5% given as gifts.²⁹ Fish productivity was dependent on the feeding practice employed by the farmer. Data from a cost-benefit study in trial tilapia ponds from WorldFish shows that with the price of tilapia at USD 4/kg, production costs per kilogram are USD 1.50, so the gross margin is USD 2.50.³⁰ Nevertheless, further work is needed to increase productivity and reduce production costs since the price of fish is likely to go down with the increase in fish supply in the future. WorldFish, in partnership with the MAF, is attempting to develop

guideline for better management practices for aquaculture in Timor-Leste to realize a sustainable increase in fish productivity.

Mariculture

Seaweed farming in Timor-Leste started in 2003–2004 on Atauro Island with only 20 farmers. It was initially successful, with numbers increasing to 1282 farmers in 2009 (MAF 2012) as it spread along the mainland's north coast (Plate 8). Scaling up seaweed production in Timor-Leste is currently limited by low local demand, high export prices compared to neighboring market leader Indonesia, and inadequate production volume to



Plate 8. Seaweed farmers collecting, transporting and drying their produce in the community of Uaroana, Atauro Island.

attract large companies or overseas buyers. There are opportunities to increase the international competitiveness of the country's seaweed through improved product handling and the introduction of drying, grinding and packaging systems. Developing postharvest value adding, such as processing seaweed to produce semi-refined carrageenan, would also markedly raise the product value by volume, making it more efficient to ship. Although still an important livelihood in Atauro, seaweed aquaculture in Timor-Leste faces several challenges: (i) production is small-scale, because year-round production is limited by challenging weather conditions, (ii) production and market chain are not well organized, (iii) low technical capacity with processing and storage has led to poor quality and low prices, driving down demand from buyers, and (iv) there is no formalized agreement with exporters and intermediary buyers. Despite these challenges, seaweed has provided coastal communities of Atauro with an alternative source of income in a context where opportunities are scarce.

Exporting seaweed offers farmers in Atauro relatively significant cash revenues, with an annual average household income estimated at USD 360–420 in 2012 (MAF 2012). However, the volume of production is small, while drying conditions and techniques are poor.

3.5 Productivity and sustainability

Current aquaculture production is low (Table 10) relative to the estimated potential yield. Based on a potential yield of 3 t/ha, the development of only 5% (4800 ha) of the area considered suitable for aquaculture would potentially produce 14,000 t of freshwater fish using either a semi-intensive or intensive approach (MAF 2012).

In the NADS, the government aims to increase annual fish supply from aquaculture to 12,000 t by

2030, contributing 40% of the national domestic fish consumption (NDFA 2013). Achieving this target will largely depend on providing improved access to and availability of quality aquaculture input (seeds and feed) and putting services in place.

Currently, freshwater aquaculture in Timor-Leste functions largely without input feed systems, Production is currently at an average of 4.3 t per hectare per cycle. Fertilizing ponds to enhance the *in situ* production of natural food and using formulated feeds from locally sourced materials are likely to improve fish productivity to over 5 t ha/yr. To achieve this, private sector engagement in feed and seed along with donor subsidies in terms of technology development, capacity building and extension services will be required to achieve the production scale necessary to lower the price of feeds sufficiently to make them accessible to farmers.

3.6 Advances in fish consumption and aquaculture

Globally, aquaculture has grown faster than any other major food production sector (FAO 2018) with Asia leading in production volume. Following the implementation of the NADS, Timor-Leste has made significant advances toward the goals set out in its SDP. The NADS set ambitious goals for aquaculture development, and despite its implementation being gradual, important progress has been made. The number of fish farmers and households involved in aquaculture has steadily increased, as well as the total area under production. As a result, expanding aquaculture activities has brought meaningful improvements to farmer household diets and nutrition.

One major limitation to quantifying the sector's performance and evaluating progress is the lack of

Year	Production (t)			Source
	Freshwater	Brackish	Marine	
2007	27.3	3.7	37	FAO (2009) country profile
2008	45.6	4.5	100	MAF (2012)
2017	350	-	-	WorldFish unpublished data

Table 10. Aquaculture production in Timor-Leste according to official reports and NGOs.

sound data, such as the area under production and production volume. Figures provided in this report represent estimates based on the knowledge of experts working actively in the field, so they should be interpreted as such. However, a good indicator of the significant progress of aquaculture in the country is the increasing engagement of donors and partners (compared to before the formulation of the NADS) that are committed to boosting the development of aquaculture in the country.

The small successes seen at the farmer household level indicate that significant progress can be made if we can sufficiently scale up production by increasing the total pond area and through the distribution of ponds in the country. The success of harvest events and local sales by farmers show that demand is sufficient to allow for substantial scaling, so the major challenges remain the sourcing of seed and feed inputs at sufficiently low costs for farmers to allow for economically sustainable production over the long term.

Seed: Hatchery production of fingerlings

At the national scale, there are five hatchery stations that produce different species: (1) the monosex Genetically Improved Farmed Tilapia (GIFT) hatchery in Gleno, Ermera, (2) mud crabs hatchery in Vemasse, (3) catfish and tilapia hatchery in Mugis, (4) tilapia hatchery in Viqueque, and (5) the tilapia and carp hatchery in Manufahi.

The GIFT hatchery in Gleno was established by the PADTL Project, implemented by WorldFish and the MAF, with the funding from New Zealand Aid Program. The hatchery maintains four cohorts of

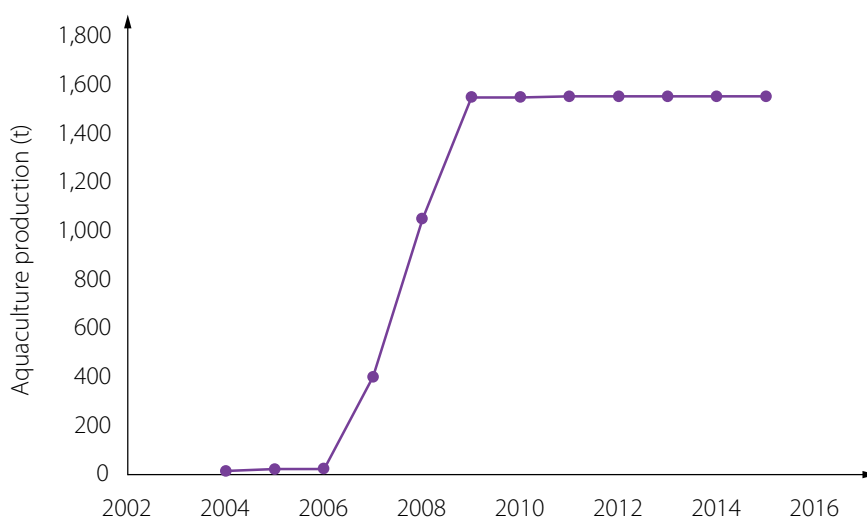
GIFT and follows a rotational breeding program to minimize inbreeding in subsequent generations. The hatchery has state of the art facilities, and its staff are provided with adequate training and mentoring on tilapia hatchery operation. The hatchery started operating 2016 and has been producing 800,000 to 1 million monosex GIFT fingerlings annually.

According to the results in the COMPAC-TL, beneficiary fish farmers need at least 3–5 years of continued support in extension services (such as provision of fingerlings) to produce and market fish independently. Therefore, the coverage of hatchery stations needs to increase across the country to expand aquaculture activities and fish production.

Feed

Tilapia in fertilized ponds grow faster when provided with supplemental feed. For example, with fertilization alone (no supplemental feed), tilapia production is about 3000 kg/ha every 5 months. With supplementary feeding, production can increase up to 6000 kg/ha every 5 months (Shrestha et al. 2014).

Aquaculture production in Timor-Leste is largely restricted by the lack of quality and quantity of feeds. Nutrient-augmented feeds are necessary to expand current production levels, but locally available resources and ingredients are sparse. One potential avenue being examined is to encourage farmers to prepare feed pellets using on-farm resources, such as crop and animal by-products, that allow sustainable fish production without fully



Source: World Bank WDI 2016.

Figure 23. Timor-Leste's annual aquaculture production over time according to FAO.

subsidized inputs (Pant et al. 2011). But Timorese farmers are reluctant to commit time and crop resources to producing feed supplements, and the costs of importing suitable products from neighboring countries are prohibitive. Continued external support is needed to develop techniques to produce feeds made from local sustainable yet reliable sources of ingredients and also to work with farmers groups to improve capacity in feed production but also to illustrate the yield benefits of supplemental feeds.

3.7 Development priorities

The key challenges related to boosting fish consumption and nutrition from aquaculture in Timor-Leste are equivalent to those for capture fisheries (see section 2.8.3).

3.7.1 Scaling aquaculture

Key challenges

Lack of data

- No data is available on the number of farmers or households involved in aquaculture in Timor-Leste, the total pond area or average yield estimates.
- The soil composition, water quality and risk of flood damage and other biophysical factors influencing aquaculture development across Timor-Leste are largely unknown.

Institutional and legal capacity

- There is no legal framework regulating aquaculture in Timor-Leste.
- Expansion and intensification of freshwater aquaculture is largely constrained by the unavailability of production inputs and inadequate human resources with relevant expertise in aquaculture within the MAF.
- Freshwater pond aquaculture in Timor-Leste is characterized by “low-input and low-output” systems, working at a low stocking density. A lack of technical expertise, fingerlings and fish feed availability hinders higher production. And in some areas, access to water sources restricts the development of aquaculture.
- Aquaculture involves a relatively long transformation process and high initial investment for pond construction, so there is an expectation for production to repay the initial efforts. However, inevitable recouping of costs is currently hindered by a lack of extension

services. The extension services that the government provides are limited to distributing fingerlings based on their availability from the hatcheries, providing small quantities of subsidized pellet feeds to selected farmers and offering some technical advice on stocking, feeding and pond management.

- At the household level, fish farmers are constrained by a lack of training in how to feed and take care of fish and by limited access to hatcheries and feed availability.

Mariculture

- Seaweed production in Timor-Leste is currently too low to compete with nearby countries to attract private or foreign investment, and there is little support for farmers from current local buyers. Purchases are sporadic and communities do not know when buyers will come, so they accumulate stockpiles of dried seaweed, compromising quality.
- Given the low value per kilogram of seaweed, the high fixed cost of shipping has undermined the extension of seaweed aquaculture.
- Production of value-added products requires investment in facilities and inputs (chemicals and freshwater to produce carrageenan) that limit the possibilities of production on Atauro Island, where the main producers are.
- However global prices are at an all-time high and there is substantial and growing unmet demand. It is therefore timely to revisit the potential of the industry, and possibly links to developments in west Timor.

Opportunities and recommendations

Institutional and legal capacity

- With assistance from WorldFish, the government made great progress developing a national strategy for a socially and environmentally responsible aquaculture sector through the guidance of WorldFish and other organizations. But more support is needed for implementing the practical aspects of the NADS and its contribution to the broader SDP.
- Since March 2018, WorldFish has assisted the MAF in drafting an aquaculture legal regime (Amador 2018) that will be completed in 2019.
- Aquaculture development must be prioritized in areas identified as most suitable according to MAF and WorldFish studies, where pond construction does not negatively impact

natural resources and ecosystem services, such as mangrove forests.

- Farmers' participation in on-farm trials is the best way to test and validate pond aquaculture technologies in Timor-Leste. Such trials also help in spreading training and proven technologies to other households. Priority trials include on-farm feed preparation using different combinations of locally available resources, such as crop by-products.
- Providing inputs (seed, feed) and services (technical support, empowerment) is crucial for households in the first 3 to 5 years to sustain aquaculture for food security, given that high initial investment (pond construction) and low initial returns (low level of fish production in new ponds) are common.

Sociocultural factors

- Culturally, animal meat is generally preferred to fish. The respondents of AMSAT (2011) reported that farming (37%) and livestock (29%) are the activities that had most potential to increase income. Some households may choose not to invest in fish production because raising fish is perceived as less economically and culturally valuable than raising livestock.
- Initial trials suggest that all farmed fish at current production can be sold locally on the day of harvest.

Mariculture

- Mariculture of fish and crustaceans is discouraged because of the obstacles to economic and biological sustainability in Timor-Leste.
- Seaweed farmers should approach the market collectively by forming a national seaweed

association to establish greater market presence and negotiate better prices.

- Additionally, training farmers in quality drying and harvesting at the right time is essential for the product to be competitive.
- Improved coordination between procurers may bring about a regular supply to the international market.

Notes

- ¹ Results may be biased following the structure of the survey. Participants were asked to provide the name of the fish, and it is unlikely that all species mentioned were identified accurately by the interviewers. The high representation of prawns may be an indication of this, as it was the second item named after fish in the survey answers. We also note that the survey was conducted only once (January 2011) and would therefore reflect availability at that time of year.
- ² The catch documentation system developed by WorldFish in Timor-Leste. PeskAAS is a pseudo-acronym for *peskas*, which is the Tetum word for fisheries combined with AAS for Automated Analytics System.
- ³ Development Partners and MAF meeting minutes, 30 January 2017.
- ⁴ The Regional Fisheries Livelihood Program for South and Southeast Asia (RFLP) aimed to strengthen the capacity of small-scale fishing communities. The RFLP was funded by the Kingdom of Spain and implemented by FAO working in close collaboration with national authorities in Timor-Leste between 2009 and 2013. A baseline survey to fishers (N=330) was undertaken in 2011 in the focal areas of the RFLP: Baucau, Dili, Bobonaro, Covalima and RAEOA municipalities.
- ⁵ As per discussions with fishers carried out by WorldFish and the MAF as part of the consultation process for the Timor-Leste National Fisheries Strategy. A total of 27 community consultation meetings were held in all 11 coastal municipalities from July to September 2018.
- ⁶ National Fisheries Strategy community consultation meetings, 2018.
- ⁷ National Fisheries Strategy community consultation meetings, 2018.
- ⁸ Boat models introduced were very heavy, so they consumed more fuel and were slow, increasing the time and costs per fishing trip compared to wooden canoes and making them inappropriate for longline fishing.
- ⁹ National Fisheries Strategy community consultation meetings (2018). Of the 74 fisher centers consulted, line fishing and net fishing were reportedly carried out in 74 (100%) and 73 (99%) respectively. Fishing using *rumpon* was reported by 11 (15%) of the fisher centers consulted, located in Baucau, Lautem, Bobonaro and Viqueque. But *rumpon* are also known to be used in part of Liquica municipality.
- ¹⁰ National Fisheries Strategy community consultation meetings (2018). A total of 56 (76%) of the fisher centers consulted reported that gleaning occurred in their communities. Diving/spearfishing was reported by 26 (35%) of the centers, the majority of which were located in north coast municipalities (Liquica, Manatuto, Baucau, Lautem and RAEOA) and Atauro Island. Only one centers on the south coast (in Manufahi municipality) reported spearfishing.
- ¹¹ National Fisheries Strategy community consultation meetings (2018).
- ¹² National Fisheries Strategy regional consultation meetings (2018). Groups of fishers (three to five groups per region) listed and ranked five fish they considered most important for sale and five most important for their home consumption. English common names, species and family names were identified from available species lists. Ranked fish from each list were scored (rank 1 = 100, rank 2 = 80, rank 3 = 60, rank 4 = 40, rank 5 = 20) and the average score for each fish and family was calculated for each region. The Timor-Leste ranking is the average across all regions, weighted by the number of municipalities in

each region. Note that results presented are a rough indication of species importance only: there may be discrepancies and/or duplications because of local naming differences and similarities; the overall ranking does not account for differences in level of fishing activity or human population in the different regions. These rankings are also subject to fishers' interpretations of what most important signifies, which may be based on catch quantity, dollar value or other factors.

- ¹³ Adara, Beloi, Biqueli, Vemasse, Adarai, Uaroana, Com, Tutuala, Illilao, Beacou, Tolurika, Atekru, Berao, Iliana, Fatu'u, Doru, Ralketa, Maquer, Lore. At certain sites, data collectors were hired by Conservation International.
- ¹⁴ This figure could be an overrepresentation given that the structure of the question allows the inclusion of households that sporadically fished in the last year.
- ¹⁵ Baseline survey to fishers (N=330) conducted in 2011 in the focal areas of the RFLP project: Baucau, Dili, Bobonaro, Covalima and RAEOA municipalities.
- ¹⁶ National Fisheries Strategy community consultation meetings in 2018. The number of species reportedly collected ranged from six to 29 in each district, with a total species count across Timor-Leste of approximately 90. However, this total is likely an overestimate as it may still include some duplicate species (i.e. using locally specific names).
- ¹⁷ National Fisheries Strategy community consultation meetings in 2018. Commonly used equipment in gleaning includes a spear or sharp metal spike, knife, bucket or basket, hand net and torch (when done at night).
- ¹⁸ National Fisheries Strategy community consultation meetings in 2018. Gleaning was reported by all participating groups of fishers in Lautem, Manufahi, Bobonaro and Atauro; it was also widely reported in Dili (mainland), Baucau and Manatuto. It was less commonly reported as an activity in Viqueque, Ainaro, Covalima and Liquica.
- ¹⁹ National Fisheries Strategy community consultation meetings in 2018. Participating fishers reported that gleaning was carried out by more women and children in 71% of the communities where this information was recorded; men were reported to dominate gleaning in 9% of these communities. Information was recorded from 35 communities and 63% of the 56 participating fisher centers who reported that gleaning occurred in their communities.
- ²⁰ National Fisheries Strategy community consultation meetings in 2018.
- ²¹ Trammel nets are used to fish at the bottom of marine waters and consist of two or three layers of netting with a slack small mesh inner netting between layers within which fish will get entangled. They are kept stationary (or sometimes drifting) in a vertical position by floats and weights (www.fao.org/fishery/geartype/223/en).
- ²² Development Partners and MAF meeting. 30 January. 2017.
- ²³ National Fisheries Strategy community consultation meetings in 2018: Baucau and Bobonaro.
- ²⁴ National Fisheries Strategy community consultation meetings in 2018.
- ²⁵ A collection of principles, goals and elements for action outlining how a country's fishing operations and policies should be designed with a view to achieving long-term sustainable use of fish resources, as a means of assuring resource conservation, continued food supplies and alleviating poverty in fishing communities (www.fao.org/docrep/003/x9066e/x9066e01.htm).

- ²⁶ Reference framework for managing fisheries and implementing the principles of sustainable development (www.fao.org/fishery/topic/16034/en).
- ²⁷ In the 2015 census, 64,590 households reported to conduct aquaculture activities in the 12 months prior to the census, representing 30% of the total private households surveyed. Of these households, 90% were located in rural areas. However, 30% of all Timorese households seems a disproportionately high figure given the historical lack of development of this sector and, in particular, because the NADS is aiming to increase the number of households engaging in aquaculture to 40,000 by 2030. So, if the 2015 census is correct, the NADS has not only achieved, but exceeded this goal, 15 years earlier than anticipated.
- ²⁸ Between the New Zealand foreign affairs and trade Aid Programme, NIWA Taihoro Nukurangi, WorldFish and the Timorese government.
- ²⁹ Project management committee meeting. PADTL. May 2017.
- ³⁰ WorldFish, unpublished data. July 2017.

References

- Aburto-Oropeza O, Ezcurra E, Danemann G, Valdez V, Murray J and Sala E. 2008. Mangroves in the Gulf of California increase fishery yields. *Proceedings of the National Academy of Sciences of the United States of America* 105:10,456–59.
- [ADB] Asian Development Bank. 2014. *State of the Coral Triangle: Timor-Leste*. Manila, Philippines: ADB.
- Albert JA, Beare D, Schwarz A-M, Albert S, Warren R, Teri J, Siota F and Andrew NL. 2014. The contribution of nearshore fish aggregating devices (FADs) to food security and livelihoods in Solomon Islands. *PLoS ONE* 9:e115386–19.
- Alongi DM. 2008. Mangrove forests: Resilience, protection from tsunamis, and responses to global climate change. *Estuarine, Coastal and Shelf Science* 76:1–13.
- Alonso E, Wilson C, Rodrigues P, Pereira M and Griffiths D. 2012. Policy and practice: Recommendations for sustainable fisheries development in Timor-Leste. Policy Paper TIM#2. Bangkok, Thailand: RFLP.
- AMSAT International. 2011a. Fish and animal protein consumption and availability in Timor-Leste. Regional Fisheries Livelihoods Programme for South and Southeast Asia (GCP/RAS/237/SPA). Field Project Document 2011/TIM/02. e.g. Rome: FAO.
- AMSAT International. 2011b. Report on fisheries livelihoods baseline survey in Timor-Leste. (GCP/RAS/237/SPA) Field Project Document 2011/TIM/1. e.g. Rome: FAO.
- Andersen AB, Pant J and Thilsted SH. 2013. Food and nutrition security in Timor-Leste. CGIAR. 1–16. Project Report. Aquatic Agricultural Systems-2013-29. WorldFish, Penang, Malaysia.
- Barbosa M and Booth S. 2009. East Timor's fisheries catch reconstruction (1950–2009): Fisheries under different regimes. In Zeller D and Harper S, eds. *Fisheries catch reconstructions Islands, Part I*. Fisheries Centre Research Reports. 39–51.
- Bell JD et al. 2015. Optimising the use of nearshore fish aggregating devices for food security in the Pacific Islands. *Marine Policy* 56:98–105.
- Bell JD, Kronen M, Vunisea A, Nash WJ, Keeble G, Demmke A, Pontifex S and Andréfouët. 2009. Planning the use of fish for food security in the Pacific. *Marine Policy* 33:64–76.
- Benbow S, Humber F, Oliver TA, Oleson K, Raberinary D, Nadon M, Ratsimbazafy H and Harris A. 2014. Lessons learnt from experimental temporary octopus fishing closures in south-west Madagascar: Benefits of concurrent closures. *African Journal of Marine Science* 36:31–37.
- Boggs G et al. 2009. Marine & Coastal Habitat Mapping in Timor Leste (North Coast): Final report. MAF, Government of Timor Leste. 1–74.
- Bogard JR, Farook S, Marks GC, Waid J, Belton B, Ali M, Toufique K, Mamun A and Thilsted SH. 2017. Higher fish but lower micronutrient intakes: Temporal changes in fish consumption from capture fisheries and aquaculture in Bangladesh. *PLoS One* 12: 1–14. doi:10.1371/journal.pone.0175098.
- CARE. 2011. Livelihood security in a changing climate. Insights from a program evaluation in Timor-Leste. 1–28. Canberra, Australia: CARE. (<https://reliefweb.int/sites/reliefweb.int/files/resources>)
- [COMPAC-TL] Combating Poverty and Malnutrition through Aquaculture in Timor-Leste. 2014. Baseline report.
- Da Costa MD, Lopes M, Ximenes A, Ferreira ADR, Spyckerelle L, Williams R, Nesbitt H and Erskine W. 2012. Household food insecurity in Timor-Leste. *Food Security* 5:83–94.

- Davies TK, Mees CC and Milner-Gulland EJ. 2014. The past, present and future use of drifting fish aggregating devices (FADs) in the Indian Ocean. *Marine Policy* 45:163–70.
- Duffy JE, Lefcheck JS, Stuart-Smith RD, Navarrete SA and Edgar GJ. 2016. Biodiversity enhances reef fish biomass and resistance to climate change. *PNAS* 113:6230–35.
- [FAO] Food and Agriculture Organization. 2009. Fishery and aquaculture country profiles. Rome: FAO. Accessed 14 June 2017. www.fao.org/fishery/facp/TLS/en
- [FAO] Food and Agriculture Organization. 2013. Timor-Leste. A visual guide for key baseline survey findings. 1–14. Jakarta, Indonesia: RFLP.
- [FAO] Food and Agriculture Organization. 2018. The state of world fisheries and aquaculture 2018: Meeting the Sustainable Development Goals. License CC BY-NC-SA. IGO: 210. Rome: FAO.
- [GDS] General Directorate of Statistics. 2017. Timor-Leste's national accounts for 2000–2016. Ministry of Planning and Finance Timor-Leste. Dili, Timor-Leste: GDS.
- Gell FR and Roberts CM. 2003. Benefits beyond boundaries: The fishery effects of marine reserves. *Trends in Ecology & Evolution* 18:448–55.
- Gillett R. 2009. Fisheries in the economies of the Pacific island countries and territories. Mandaluyong City, Philippines: ADB. 1–521.
- [GOTL] Government of Timor-Leste. 2015. National Census 2015. <http://www.statistics.gov.tl/category/publications/census-publications/2015-census-publications>.
- Graham NAJ and McClanahan TR. 2013. The last call for marine wilderness? *BioScience* 63:397–402.
- Grebmer von K et al. 2017. 2017 Global Hunger Index: The inequalities of hunger. Washington, D.C.: International Food Policy Research Institute. 1–50.
- Igulu MM, Nagelkerken I, Dorenbosch M, Grol MGG, Harborne AR, Kimirei IA, Mumby PJ, Olds AD and Mgaya YD. 2014. Mangrove habitat use by juvenile reef fish: Meta-analysis reveals that tidal regime matters more than biogeographic region. *PLoS ONE* 9:e114,715–20. Public Library of Science.
- MacNeil MA et al. 2015. Recovery potential of the world's coral reef fishes. *Nature* 520:341–44.
- [MAF] Ministry of Agriculture and Fisheries. 2012. Analyses of the current situation and potential for aquaculture development in Timor-Leste. Dili, Timor-Leste: MAF. 1–80.
- McWilliam A. 2003. Timorese seascapes. *The Asia Pacific Journal of Anthropology* 3:6–32.
- Mills DJ, Abernethy K, King J, Hoddy E, Jiau TS, Larocca P, Gonsalves D, Fernandes A and Park S. 2013. Developing Timor-Leste's coastal economy: Assessing potential climate change impacts and adaptation options. WorldFish. Penang, Malaysia. 142.
- Mills DJ, Tilley A, Pereira M, Hellebrandt D, Fernandes AP and Cohen PJ. 2017. Livelihood diversity and dynamism in Timor-Leste: Insights for coastal resource governance and livelihood development. *Marine Policy* vol 82, 206-215.
- [NDFA] National Directorate of Fisheries and Aquaculture. 2013. Timor-Leste National Aquaculture Development Strategy 2012–2030. Dili, Timor-Leste: GOTL. 1–32.
- Needham S, Alonso-Población E, Wilson C, Rodrigues P, Pereira M and Griffiths D. 2013. Community-based data gathering and co-management of marine resources in Timor-Leste. Dili, Timor-Leste: RFLP.

- [NSD] National Statistics Directorate. 2016. Final statistical abstract: Third Timor-Leste survey of living standards 2014. Dili-Timor-Leste: NSD.
- O'Connor S, Ono R and Clarkson C. 2011. Pelagic fishing at 42,000 years before the present and the maritime skills of modern humans. *Science* 334:1117–21.
- Pant J, Philipps M and Andrew NL. 2011. Aquaculture in Timor-Leste. Jakarta, Indonesia: CTSP. 1–22.
- Población EA. 2013. Fisheries and food security in Timor-Leste: The effects of ritual meat exchanges and market chains on fishing. *Food Security* 5:807–16.
- Richards DR and Friess DA. 2015. Rates and drivers of mangrove deforestation in Southeast Asia, 2000–2012. *Proceedings of the National Academy of Sciences of the United States of America* 113:344–49.
- Shrestha MK, Pandit NP and Pant J. 2014. A technical manual on small-scale tilapia aquaculture. WorldFish. Penang, Malaysia.
- [SPC] Secretariat of the Pacific Community. 2011. Food security in the Pacific and East Timor and its vulnerability to climate change. 1–95. Noumea, New Caledonia: A report to the Australian Government Department of Climate Change and Energy Efficiency.
- Steenbergen DJ, Eriksson H, Hunnam K, Mills DJ and Stacey N. In review. Following the fish inland: Understanding fish distribution networks for rural development and food security in Timor-Leste.
- Tilley A, Burgos A, Duarte A, dos Reis Lopes J, Eriksson H, Mills DJ. In review. Gendered contributions to food and income from small-scale fisheries in Timor-Leste.
- Tilley A, Hunnam K, Mills DJ, Steenbergen DJ, Govan H, Alonso-Poblacion E, Roscher M, Pereira M, Rodrigues P, Amador T et al. In review. Lessons from co-management of small-scale fisheries in Timor-Leste.
- Tilley A, Wilkinson S, Kolding J, Lopez-Angarita J, Pereira M, Mills DJ. (in press). Nearshore fish aggregating devices show positive outcomes for sustainable fisheries development in Timor-Leste. *Frontiers in Marine Science*.
- Tsujimura, TN, Alonso E, Amaral L and Rodrigues P. 2012. Safety at sea assessment in the Timor-Leste small-scale fisheries sector. Technical Report. Bangkok: RFLP (GCP/RAS/237/SPA) doi:10.13140/RG.2.2.35185.28004.
- Wever L. 2008. Assessing management challenges and options in the coastal zone of Timor-Leste. Griffith Center for Coastal Management, Griffith University. Report No. 86
- Williams RL and Goncalves M. 2018. What are the main drivers of childhood stunting in Timor-Leste. Proceedings of the New Research on Timor-Leste: A TLSA Research Conference, Liceu Campus, UNTL, Dili, Timor-Leste, 29–30 June 2017.
- World Bank. 2012. Hidden harvest: The global contribution of capture fisheries. Washington D.C.: World Bank. 1–92.
- World Bank. 2016. World Development Indicators 2016 (English). World Development Indicators. Washington, D.C.: World Bank Group.
- World Bank. 2017. Agriculture Public Expenditure Analysis 2017. Dili, Timor-Leste.
- World Bank. 2017. World Development Indicators 2017. Washington, DC. © World Bank. <https://openknowledge.worldbank.org/handle/10986/26447> License: CC BY 3.0 IGO.
- World Bank. 2018. Timor-Leste systematic country diagnostic: Pathways for a new economy and sustainable livelihoods. Dili, Timor-Leste: World Bank Group.

List of figures

Figure 1. Map of Timor-Leste municipalities and associated demographics.	1
Figure 2. Expenditure and budget (in USD) of the fisheries and aquaculture sector of Timor-Leste (A), and proportion of the MAF budget allocated to fisheries and aquaculture (B).	4
Figure 3. Timor-Leste's capture fisheries production between 1998 and 2016, as reported to FAO. Data for 2017 and 2018 (solid red circles) represents the estimate generated by data from the PeskAAS database	6
Figure 4. Number of boats (A) in 2004, 2009 and 2018, and number of households (B) reported to own a boat for 2010 and 2015.	8
Figure 5. Percentage of motorized and non-motorized boats in the Timorese artisanal fishing fleet (A). Proportion of fishers whose boat is owned, rented or borrowed (B).	8
Figure 6. Fishing methods in Timor-Leste, as reported by fishers at participating fisher centers.	9
Figure 7. Classification of Timor-Leste's regions used during pre-consultation meetings for the National Fisheries Strategy.	11
Figure 8. Volume of coastal subsistence fishery production for Pacific small islands in 2014 and 2017 for Timor-Leste.	13
Figure 9. Most targeted fish species by small-scale fishers across 19 landing sites in Timor-Leste between 2016 and 2018.	14
Figure 10. Most important fish species captured in reef and mangrove habitats by small-scale fishers across 19 landing sites in Timor-Leste between 2016 and 2018.	15
Figure 11. Most targeted pelagic fish species by small-scale fishers across 19 landing sites in Timor-Leste between 2016 and 2018.	15
Figure 12. Average catch per unit effort (kg/hr) by habitat type and gleaning across 19 landing sites in Timor-Leste between 2016 and 2018.	16
Figure 13. CPUE (kg/hour) in 19 communities of Timor-Leste for 2017 and 2018.	17
Figure 14. Most prevalent occupations for households that also engage in fishing.	19
Figure 15. Percentage of households engaged in small-scale and subsistence fishing activities.	19
Figure 16. Roles of women in fisheries related activities.	23
Figure 17. Total annual export of Timor-Leste's fisheries and aquaculture sectors between 2006 and May 2017.	25
Figure 18. Seafood product imports for Timor-Leste.	26

Figure 19. Pump price for gasoline (USD per liter) for Timor-Leste and other island nations in the Pacific between 2004 and 2014.	27
Figure 20. Municipalities in Timor-Leste with previous or current aquaculture projects.	37
Figure 21. Freshwater aquaculture suitability classification and map of Timor-Leste.	40
Figure 22. Number of fish farming households in Timor-Leste between 2004 and 2016.	41
Figure 23. Timor-Leste’s annual aquaculture production over time according to FAO.	44

List of tables

Table 1. Annual per capita fish and meat (including poultry) consumption (kg).	3
Table 2. Annual per capita fish consumption (kg) for Pacific island countries.	3
Table 3. Definitions used to classify fishing fleets.	5
Table 4. Top 10 fish species and families identified by fishers as most important for sale across Timor-Leste.	10
Table 5. Top 10 fish species and families identified by fishers as most important for home consumption.	11
Table 6. Reef fish biomass for 2016 and 2018 calculated through underwater visual census in five different reef locations in the north and south coasts of Timor-Leste.	14
Table 7. License prices, allowable quota and total income received from licenses for the commercial offshore fleet.	24
Table 8. A timeline of fisheries co-management developments and projects in Timor-Leste since 2000.	30
Table 9. Summary of priorities for the fishery sector as selected by fishers in consultation meetings for developing the National Fishery Strategy.	31
Table 10. Aquaculture production in Timor-Leste according to official reports and NGOs.	43

List of plates

- Plate 1.** Wood outrigger canoes in Viqueque municipality. These are the most commonly used fishing vessels in Timor-Leste’s artisanal fishing fleet. 7
- Plate 2.** Spatial pattern of the fishing activity of small-scale fishers in Timor-Leste. 18
- Plate 3.** A cockle picker in Biqueli, Atauro Island, and a man returning from gleaning in Hera showing a traditional trident spear. 21
- Plate 4.** A woman selling small pelagic fish in Beacou. 22
- Plate 5.** Five of the fifteen Chinese offshore commercial fishing vessels licensed to fish in Timorese waters. 24
- Plate 6.** Reef spear fisher in Adara, Atauro Island. 36
- Plate 7.** A harvest ceremony at the Gleno tilapia hatchery. Ermera, Timor-Leste. 38
- Plate 8.** Seaweed farmers collecting, transporting and drying their produce in the community of Uaroana, Atauro Island. 42

About WorldFish

WorldFish is an international, nonprofit research organization that harnesses the potential of fisheries and aquaculture to reduce hunger and poverty. Globally, more than one billion poor people obtain most of their animal protein from fish and 800 million depend on fisheries and aquaculture for their livelihoods. WorldFish is a member of CGIAR, a global research partnership for a food-secure future.