

STATE OF THE CORAL TRIANGLE: **Timor-Leste**



**CORAL TRIANGLE
INITIATIVE**
ON CORAL REEFS, FISHERIES AND FOOD SECURITY



STATE OF THE CORAL TRIANGLE: **Timor-Leste**



**CORAL TRIANGLE
INITIATIVE**
ON CORAL REEFS, FISHERIES AND FOOD SECURITY



© 2014 Asian Development Bank

All rights reserved. Published in 2014.
Printed in the Philippines.

ISBN 978-92-9254-526-0 (Print), 978-92-9254-527-7 (PDF)
Publication Stock No. RPT146481-3

Cataloging-in-Publication Data

Asian Development Bank.

State of the coral triangle: Timor-Leste.
Mandaluyong City, Philippines: Asian Development Bank, 2014.

1. Coral Triangle. 2. Marine environment. 3. Marine fisheries. 4. Timor-Leste.
I. Asian Development Bank.

The views expressed in this publication are those of the authors and do not necessarily reflect the views and policies of the Asian Development Bank (ADB) or its Board of Governors or the governments they represent.

ADB does not guarantee the accuracy of the data included in this publication and accepts no responsibility for any consequence of their use.

By making any designation of or reference to a particular territory or geographic area, or by using the term "country" in this document, ADB does not intend to make any judgments as to the legal or other status of any territory or area.

ADB encourages printing or copying information exclusively for personal and noncommercial use with proper acknowledgment of ADB. Users are restricted from reselling, redistributing, or creating derivative works for commercial purposes without the express, written consent of ADB.

Note:

In this publication, "\$" refers to US dollars, unless otherwise stated.

Photo credit

All photos in this report are by Rui Pinto unless otherwise noted.

Front cover (*from left to right*): ADB photo library and Roger Pullin

Back cover: ADB photo library

6 ADB Avenue, Mandaluyong City
1550 Metro Manila, Philippines
Tel +63 2 632 4444
Fax +63 2 636 2444
www.adb.org

For orders, please contact:
Public Information Center
Fax +63 2 636 2584
adbpub@adb.org

 Printed on recycled paper

Contents

Foreword	vi
Acknowledgments	viii
Executive Summary	ix
Abbreviations	xiii
Introduction	1
Regional Fisheries Livelihood Programme for South and Southeast Asia	2
Coral Triangle Support Partnership	2
Regional Technical Assistance for the Coral Triangle of the Pacific	2
Arafura and Timor Seas Expert Forum	3
Partnerships in Environmental Management for the Seas of East Asia	3
Agricultural Cooperative Development International/Volunteers in Overseas Cooperative Assistance	4
Biophysical Characteristics	5
Geography	5
Biodiversity of Coastal and Marine Ecosystems	9
Governance	16
Policy and Legislation	17
Compliance	18
Socioeconomic Characteristics	20
Fisheries Sector	21
Aquaculture	23
Coastal Tourism	24
Minerals, Oil, and Gas	24
Transport and Shipping	25
Traditional Knowledge Management	25
Gender Issues	25
Payment for Ecosystem Services	26
Threats and Vulnerabilities	27
Current Issues for Marine Resource Management	28
Emerging Issues Facing Timor-Leste's Use of Marine Resources	31

National Plan of Action Initiatives and Future Plans	34
Goal 1: Designation and Effective Management of Priority Seascapes	35
Goal 2: Application of an Ecosystem Approach to Management of Fisheries and Other Marine Resources	35
Goal 3: Establishment and Effective Management of Marine Protected Areas	36
Goal 4: Application of Climate Change Adaptation Measures	37
Goal 5: Improvement of the Status of Threatened Species	37
References	38

Tables and Figure

Table

1	Mangrove Species Recorded during the 2007 Survey of Timor-Leste's Northern Coast	13
2	Timor-Leste Fisheries Legislation	17
3	Number and Location of Timor-Leste Fishers	22
4	Timor-Leste Fauna	31
5	Endangered Animals and Plants of Timor-Leste	32

Figure

1	National Directorate of Fisheries and Aquaculture Organization Chart	16
---	--	----

Foreword

The Coral Triangle Initiative on Coral Reefs, Fisheries, and Food Security (referred to in this report as Coral Triangle Initiative [CTI]) was launched in 2007 as a multilateral partnership of the governments of Indonesia, Malaysia, Papua New Guinea, the Philippines, Solomon Islands, and Timor-Leste. The CTI recognizes the need to safeguard the coastal and marine resources of the seas that surround these countries, which together constitute a uniquely diverse and economically important region often referred to as the Coral Triangle. In 2009, these six countries adopted a 10-year, five-point CTI regional plan of action for improving management of the region's coastal and marine resources.

The State of the Coral Triangle (SCT) reports describe the current condition of coastal ecosystems—and their exploited resources—in each Coral Triangle country. As these are the first SCT reports to be published, they provide a baseline against which progress in improving and sustaining Coral Triangle marine resources can be measured. These reports also document and promote the commitments of Coral Triangle countries through elaboration of goals and a national plan of action for achieving sustainable use of marine resources within the region.

Through its technical assistance—Regional Cooperation on Knowledge Management, Policy, and Institutional Support to the CTI—the Asian Development Bank (ADB) helps (i) strengthen regional policy dialogue and coordination among the six Coral Triangle countries (CT6), (ii) facilitate CTI-wide information exchange and learning, and (iii) encourage policy and program development based on global best practices. As part of this technical assistance, ADB is publishing a number of CTI knowledge products, including the SCT report for each member country, and a regional SCT report that promotes regional and international understanding of current ecological, political, and socioeconomic issues in the region. Some of the CT6 have also published a detailed version of their report, which addresses sustainable resource management issues at the national level.

ADB is also helping three Coral Triangle Pacific countries (Papua New Guinea, Solomon Islands, and Timor-Leste) attain particular CTI goals, such as implementing the ecosystem approach to fisheries management, and establishing the Coral Triangle Marine Protected Area System and initiatives that help these countries adapt to climate change. Additional assistance is also being provided to Fiji and Vanuatu. While not technically CTI members, these countries border the Coral Triangle and share similar concerns.

Through these national and regional SCT reports, we hope to reach a wide audience that includes CT6 and those outside the Coral Triangle that benefit from the region's resources, whether through fisheries, shipping, or tourism, or as consumers of the great volume of fisheries products that originate from within the Coral Triangle, but are exported worldwide.



Xianbin Yao
Director General
Pacific Department
Asian Development Bank

Acknowledgments

This State of the Coral Triangle report for Timor-Leste was prepared by Rui Pinto.

Timor-Leste's Coral Triangle Initiative National Coordinating Committee appreciates the support of the Coral Triangle Pacific technical coordination unit of the Asian Development Bank in preparing and completing this report. Technical review and revisions were made by Robert Guild, Marilou Drilon, Lea Tamayo, and Jay Maclean. Lynette Mallery edited this report.

Executive Summary

Having achieved 10 years of independence in 2012, Timor-Leste is the most recent country to be established in the Coral Triangle. It is located in a transitional region known as Wallacea, which lies between Asia and Australia. Environmentalists recognize this region to be extremely abundant of marine biodiversity.

Several donor-assisted coastal management projects are active in Timor-Leste: the Regional Fisheries Livelihoods Programme for South and Southeast Asia (RFLP), the Coral Triangle Support Partnership (CTSP), Partnerships in Environmental Management for the Seas of East Asia (PEMSEA), the Arafura and Timor Seas Expert Forum (ATSEF), and many others. A wide range of donors sponsor these projects, including the Asian Development Bank, Charles Darwin University of Australia, the Food and Agriculture Organization of the United Nations (FAO), the National Oceanic and Atmospheric Administration (NOAA) of the United States, and many other agencies.

These coastal resource management initiatives have helped Timor-Leste meet its national goals relating to food security and sustainable development of its fisheries resources, coral reefs, and related ecosystems. As Timor-Leste improves its capacity for collecting and reporting coastal resources data, tracking the country's progress in reaching its sustainable development goals would increasingly be easier.

Biophysical Characteristics

Timor-Leste is a small island state with land area of about 14,874 square kilometers (km²). It occupies the eastern half of Timor Island, bordering Indonesia to the west. To the south lies the Timor Sea, and to the north, the Banda Sea. While Timor-Leste's two coastlines total only 706 kilometers in length, their oceanographic and topographical features differ dramatically, which makes the marine habitats they comprise quite different.

In terms of geographic size, Timor-Leste's Banda Sea coast contains the country's largest areas of coral reefs, seagrass meadows, and mangroves. While the total fringing reef area of this locale is approximately 146 km², the width of the reefs there is only 20–100 meters, beyond which they drop off sharply to the open ocean. No comprehensive surveys of the species that live in this habitat are currently available. However, as with other reefs in the region, these reefs are likely to be quite species-rich. In 2008, the total mangrove area associated with these reef systems was approximately 18 km², which represents a steep decline from the 90 km² reported in the earlier part of the 20th century.

The Timor Sea to the country's south is shallower than the Banda Sea, with wider coastal plains. This probably facilitates retention of river-borne sediment and nutrients, which stimulates pelagic and benthic productivity in the area, which is adjacent to most of Timor-Leste's oil and gas deposits. The country has experienced few or no tropical cyclones since 1970. However, the coral reefs on Timor-Leste's southern coastline are exposed to heavy seas from frequent cyclones that originate in the Indian Ocean and reach the country's southern coastline through the Timor Gap. Mangrove forests on the south coast thus tend to be sparse and small.

Timor-Leste has two outlying islands: Atauro Island with a land area of approximately 144 km², and smaller uninhabited Jaco Island, which has a land area of only about 8 km². Seaweed culture is the major income-generating activity on Atauro Island. In 2009, seaweed exports generated \$19,130 in revenue.

Governance

The government owns all of Timor-Leste's natural resources. Fisheries and protected area management are the responsibility of the Ministry of Agriculture and Fisheries. The country has passed numerous laws regulating fishing since independence in 2002. It also plans to formulate an integrated fisheries strategic plan that will (i) guide sustainable development of its fishing and aquaculture industries, (ii) increase the livelihood opportunities available to its coastal populations, and (iii) maintain the current level of its marine biodiversity.

The Constitution of the Democratic Republic of Timor-Leste recognizes traditional natural resource management practices that originate in its *adat* (traditional) system of sacred laws and beliefs. These include *tara bandu*, or seasonal prohibitions against resource extraction. Thus, management of Timor-Leste's proposed marine protected area network can be community-based. Establishment of this network has already begun with the declaration of Nino Konis Santana National Park, the country's first. Community-based management of this proposed marine protected area network is consistent with the principles of the Coral Triangle Initiative (CTI).

Socioeconomic Characteristics

Not much data that detail the contribution of coral reefs and fisheries to food security and the livelihood of Timor-Leste's citizenry currently exist. However, fishing and other forms of marine resource extraction have been commonplace since the earliest human settlements in Timor-Leste. With the exception of Dili, the capital city, few urban settlements are located on the coast. Thus, despite the country's relatively long coastline and apparently abundant marine resources, its fisheries sector remains underdeveloped. For example, while the government has issued a few semi-industrial fishing licenses, Timor-Leste has no commercial fisheries.

In 2010, agriculture (including fisheries) contributed nearly 94% of the income of the country's subsistence farming communities, which comprise about 85% of the total population. This notwithstanding, at current annual population growth rates estimated at 3%–4%, the rate at which marine resources are extracted will inevitably increase, putting environmental pressure on the country's natural resource base.

The commercial fishery—that is, of fish that were sold—was estimated at about 2,000 tons in 2009, while subsistence catches that year were estimated at about 3,500 tons. Estimates of the number of fishers vary widely. For example, while a 2002 study places this number at 20,000, recent surveys estimate the number of artisanal fishers nationwide to be 5,415, though if part-time subsistence fishers were included in this estimate, it would likely be higher. In addition to artisanal fishers as traditionally defined, women and children collect crabs, juvenile fish, mollusks, and sea urchins through shoreline resource extraction activities known as *meti*, which use rotenone-based piscicides (i.e., substances that kill or stun fish or other marine organisms) derived from derris root. The artisanal catch is generally sold at roadside markets at an average price of \$5 per kilogram.

Despite the prohibitive prices of seafood in local markets, fisheries may play a critical role in the food security of subsistence households. Nevertheless, about 30% of the Timor-Leste population experiences hunger, and nearly half lives in poverty as judged by international standards. Thus, the rates of poverty and hunger in fishing communities would be relatively high.

Aquaculture and associated activities are beginning to expand in Timor-Leste. Projects such as the FAO-sponsored Regional Fisheries Livelihoods Programme for South and Southeast Asia are facilitating livelihood diversification in coastal communities. Similarly, seaweed culture is expanding because of a project sponsored by the National Directorate of Fisheries and Aquaculture. A project funded by the United States government is testing the commercial viability of other seafood products. On a broader scale, Timor-Leste is devising a national aquaculture strategy and action plan for developing sustainable aquaculture with assistance from the WorldFish Center. Finally, as a result of the CTI, the government is considering introduction of a payment for ecosystem services scheme to create incentives for sustainable management of the country's marine resources.

Threats, Vulnerabilities, and Emerging Issues

Many of Timor-Leste's marine ecosystems have been negatively impacted by erosion from deforestation, the country's mangrove forests and riparian vegetation in particular. Mangroves continue to be harvested for fuel and food, despite some local attempts at rehabilitation. The country's fish stocks are likewise under threat. Foreign fleets illegally fishing in Timor-Leste waters exploit capacity gaps in enforcement of the country's oceanic boundaries, which results in an estimated loss of \$40 million annually to the Timorese economy. Similarly, illegal fishing by encroaching fishers that use destructive fish-harvesting techniques, such as dynamiting of coral reefs, permanently destroy fish habitats.

Under Indonesian administration, the Indonesian government's "go east" policy officially encouraged transmigration to Timor-Leste. Unfortunately, some transmigrants brought with them fishing practices that, according to indigenous fisher communities, included dynamiting of coral reefs, using cyanide to kill fish, using compressors to aid the extraction of *Trochus* (top shells), and harvesting of sea cucumbers.

Population density along Timor-Leste's north coast is increasing, largely because of growth in the country's overall population. However, the country's largest coral reef areas are located

in this area. Such growth will inevitably put environmental pressure on the northern coast's marine resources in one of two ways: (i) directly, through increased rates of harvesting of marine resources, or (ii) indirectly, through increased erosion resulting from settlement and thence deforestation of steeper and more marginal lands. Ultimately, the impact of these threats will be substantial if Timor-Leste's capacity to implement the policies and programs under its National Plan of Action (NPOA) remains at its current level.

National Plan of Action

Timor-Leste's activities under the CTI include establishing baseline data, and putting into place policies and legislation for strengthening management of the country's fisheries and protected areas. Mapping and habitat assessment is currently being carried out with assistance from international scientific institutions. Upon completion of these initiatives, Timor-Leste will have baseline data that will allow it to report the progress it has achieved in marine resource management in future country-level State of the Coral Triangle reports. Similarly, assessment of the degree to which Timor-Leste's endangered species are threatened is currently in progress. Policies and management plans for the country's proposed marine protected area network are likewise being formulated. Implementing these policies and management plans will represent Timor-Leste's greatest challenge with regard to sustainably managing its marine resource base.

Effective management is the key to protecting Timor-Leste's reef systems. This is apparent from several quantitative indicators that confirm that these systems are under environmental threat. The degree of abundance of valuable commercial and upper trophic-level species, such as the snapper and grouper, is notably low in these reef systems, confirming that these fish populations have been exposed to extraction rates that far exceed sustainable levels. Similarly, destructive fishing practices, such as dynamite fishing, which physically destroy the marine habitat itself, likewise confirm lack of sustainability of current extraction rates. As a result, formulating and enforcing appropriate fishing regulations, and establishing the proposed marine protected area network are imperative if future extraction rates are to be kept within sustainable limits. Managing upland threats through integrated catchment management and rehabilitation of mangrove forests are likewise priorities, since such initiatives will enable stabilization and even growth in the abundance of species that can support the country's coastal populations, as well as the country at large.

Food security is a particularly pressing concern for Timor-Leste, as an estimated 30% of the country's population experiences hunger daily, and many live in poverty. In this regard, site-specific integrated coastal management demonstration projects and other livelihood adaptation initiatives supported under the Partnerships in Environmental Management for the Seas of East Asia and Coral Triangle initiatives are currently helping Timor-Leste build a foundation for sustainably managing the country's marine resources.

Expansion of fee-for-access arrangements that permit environmentally responsible extraction of Timor-Leste's offshore oil and gas resources could likewise help fund management of the country's marine resources. Revenues from this funding source could as well be used to increase availability of food to the general population as part of a broad-based national development strategy.

Abbreviations

ADB	–	Asian Development Bank
ATSEF	–	Arafura and Timor Seas Expert Forum
CTI	–	Coral Triangle Initiative on Coral Reefs, Fisheries, and Food Security (also referred to as Coral Triangle Initiative)
CT Pacific	–	Coral Triangle of the Pacific
CTSP	–	Coral Triangle Support Partnership
EAFM	–	ecosystem approach to fisheries management
FAO	–	Food and Agriculture Organization of the United Nations
ha	–	hectare
ICM	–	integrated coastal management
IUCN	–	International Union for Conservation of Nature
km	–	kilometer
km ²	–	square kilometer
m	–	meter
mm	–	millimeter
MAF	–	Ministry of Agriculture and Fisheries
MPA	–	marine protected area
NCC	–	Coral Triangle Initiative National Coordinating Committee
NDFA	–	National Directorate of Fisheries and Aquaculture
NGO	–	nongovernment organization
NOAA	–	National Oceanic and Atmospheric Administration
NPOA	–	National Plan of Action
PEMSEA	–	Partnerships in Environmental Management for the Seas of East Asia
RFLP	–	Regional Fisheries Livelihoods Programme for South and Southeast Asia
SCT	–	State of the Coral Triangle
WFC	–	WorldFish Center

Introduction

The Coral Triangle describes a marine expanse that straddles the Indian and Pacific oceans. This area is known to environmentalists to be extremely abundant of marine life and significant biodiversity. With regard to political boundaries, the Coral Triangle includes some or all of the land and oceanic area of six countries: Indonesia, Malaysia, Papua New Guinea, the Philippines, Solomon Islands, and Timor-Leste. While it comprises only a scant 1.6% of the total area of the earth's oceans, the Coral Triangle is home to 76% of all known coral species, 37% of all known coral-reef fish species, 53% of the world's coral reefs, and the most extensive mangrove forests in the world, which are spawning and juvenile growth areas for tuna and other commercial fish species of global importance. These rich marine and coastal resources provide significant economic and social benefits—food, income, recreation, and culture—to the 360 million residents of the Coral Triangle, particularly the 120 million residents who live on or near the region's coastlines. These resources also protect the coastline and its residents from the damaging impacts of extreme weather events.

This report describes the biophysical characteristics of Timor-Leste's marine and coastal ecosystems, their governance under the prevailing legal and policy framework, and the institutional arrangements for ensuring compliance with the provisions of that framework. It also describes the socioeconomic characteristics of the populations these ecosystems serve, and the pattern of resource use of these populations. In addition, this report summarizes the threats to, and vulnerabilities of these coastal and marine ecosystems, and how the country proposes to address these to ensure sustainable use of its ecosystems in the future. From an operational perspective, future sustainable use of these ecosystems is to occur through implementation of a national plan of action, which aims to improve governance and marine resource management. Notably, the latter is to include an ecosystem-based marine resource management regime, and adaptation to the negative impacts of climate change.

The Government of Timor-Leste is working with some donor agencies to ensure that the development of its fisheries proceeds in a sustainable and participatory manner. The country's major programs in this regard, both ongoing and envisioned, are described below.

Regional Fisheries Livelihood Programme for South and Southeast Asia

The Regional Fisheries Livelihood Programme for South and Southeast Asia (RFLP)¹ aims to improve livelihood opportunities and sustainable fisheries management in Timor-Leste. Sponsored by the Food and Agriculture Organization of the United Nations (FAO), this initiative helps facilitate development of a cold chain for Timor-Leste's fisheries products, which will facilitate marketing of fisheries products by improving preservation techniques and overall postharvest and handling practices. The RFLP will improve comanagement mechanisms for ensuring long-term conservation of the country's fisheries resource. The program addresses safety-at-sea issues through specific training and establishment of an accident reporting system. Future activities under the program will help expand livelihood opportunities for the country's coastal populations, and will provide microfinancing support for such expansion. The program gathered information on Timor-Leste's fisheries over the period 2005–2007.

Coral Triangle Support Partnership

The Coral Triangle Support Partnership (CTSP)² supports the regional commitment of the governments of Indonesia, Malaysia, Papua New Guinea, the Philippines, Solomon Islands, and Timor-Leste to ensuring that the marine areas of the Coral Triangle—which are the world's most diverse—are managed in a sustainable manner. Comprising a consortium of international conservation-based nongovernment organizations (NGOs), the CTSP is a 5-year, \$32 million project supported by the United States Agency for International Development (USAID). These NGOs include the WWF, Conservation International, and The Nature Conservancy. The collaborative nature of this partnership encourages development of transformational policies relating to natural resource management. It likewise strengthens the capacity of institutions and local communities in marine resource management, and builds overall institutional capacity in the agencies that manage marine resources. As the CTSP is part of United States (US) support to the Coral Triangle Initiative (CTI), it likewise benefits from the support of other US government agencies such as the National Oceanic and Atmospheric Administration, the program integrator; the US Department of Justice; and the US State Department. Established in 2009, the CTI is a multilateral partnership of the six countries comprising the Coral Triangle. The overall objective of the CTI is addressing the greatest environmental threats to the Coral Triangle, which is one of the most biologically diverse and ecologically rich areas on earth.

Regional Technical Assistance for the Coral Triangle of the Pacific

The Asian Development Bank (ADB)-funded regional technical assistance for Strengthening Coastal and Marine Resources Management in the Coral Triangle of the Pacific (CT Pacific) aims to assist marine resource management by Pacific Island Coral Triangle countries including

¹ <http://www.fao.org/fileadmin/templates/rap/files/epublications/TimorLesteedocFINAL.pdf>

² <http://www.uscti.org>

Papua New Guinea, Solomon Islands, and Timor-Leste, as well as Vanuatu and Fiji as additional focal countries. A 5-year project, the CT Pacific supports the goals of the CTI as these relate to (i) the ecosystem approach to fisheries management, (ii) the Coral Triangle Marine Protected Area System, and (iii) climate change adaptation. The CT Pacific will achieve this goal by strengthening the capacity of the national and local government institutions responsible for protecting and conserving coastal and marine resources. The CT Pacific also assists local communities in formulating and implementing sustainable resource management and climate change adaptation programs. Such programs aim to improve ecosystem resilience, thereby contributing to food security.

Arafura and Timor Seas Expert Forum

The Arafura and Timor Seas Expert Forum (ATSEF) strengthens information-sharing arrangements among the states bordering the Arafura and Timor seas, thereby assisting identification of cooperative research agendas and arrangements that would improve the region's ability to manage these marine systems in an environmentally sustainable way. In particular, ATSEF promotes information exchange, and ultimately, scientific, institutional, and policy links that augment existing arrangements between littoral states, thereby strengthening regional cooperation in the sustainable management of the marine resource. The forum envisioned (i) agreements or protocols that address information exchange, (ii) agreement on marine resource management priorities for the Arafura and Timor seas, (iii) identification of the information required for supporting these agreed marine resource management priorities as an input to defining an agreed research agenda, and (iv) exchange of information regarding institutions and policies necessary for sustainably managing the marine resource.

Partnerships in Environmental Management for the Seas of East Asia

Partnerships in Environmental Management for the Seas of East Asia (PEMSEA) is a joint initiative of the Global Environment Facility, the International Maritime Organization, and the United Nations Development Programme (UNDP). It aims to strengthen interagency, intersector, and intergovernment partnerships to achieve sustainable development of the seas of East Asia. PEMSEA has developed a broad range of methodologies, techniques, working models, and standards for improving coastal management, which includes an integrated coastal management framework.³ Signing the Haikou Partnership Agreement for implementing the Sustainable Development Strategy for the Seas of East Asia enabled the Government of Timor-Leste to become a PEMSEA member state.

³ L. Wever, 2005. *Assessing Management Challenges and Options in the Coastal Zone of Timor-Leste*. Gold Coast, Queensland: Griffith Centre for Coastal Management.

Agricultural Cooperative Development International/ Volunteers in Overseas Cooperative Assistance

Under grant funding by the US Department of Agriculture, the Agricultural Cooperative Development International/Volunteers in Overseas Cooperative Assistance⁴ is formulating a 3-year project that will introduce cultivation of mud crabs and milkfish to the residents of villages on Timor-Leste's northern coast. In collaboration with the Fisheries Department of the Ministry of Agriculture and Fisheries, and the Ministry of Tourism, Commerce, and Industry, the project will establish fisheries cooperatives in 20 villages along Timor-Leste's northern coast to establish and manage crab and fish nurseries. These cooperatives will select beneficiary families who wish to raise crabs or fish. Most of the participants will be women. As demand for crabmeat is strong in Timor-Leste, its price is relatively high. This suggests not only relatively high rates of economic return for this activity, but also that crab and milkfish culture could easily become a sustainable industry.

Timor-Leste has ongoing projects assisted by Charles Darwin University of Australia, the US National Oceanic and Atmospheric Administration (NOAA), and other donor agencies, which complement the initiatives described above.

⁴ <http://www.acdivoca.org/site/ID/easttimorMudCrabandMilkfishCultivation/>

Biophysical Characteristics

Geography

Timor-Leste is located in a transition region known as Wallacea, which lies between Australia and Asia. Extending from the Wallace Line to the west all the way to the Weber and Lydekker Lines to the east, the Wallacea transition region includes the area east of Bali and west of the island of New Guinea.⁵ It includes the Maluku and Lesser Sundas island groups, and the island of Sulawesi. Because of its location within the Coral Triangle, the Wallacea is an oceanic expanse of extreme marine biodiversity because species from Asia and Australia mingle here.

Timor-Leste covers approximately 14,874 square kilometers (km²). Most of the country's land area is located on the eastern part of the island of Timor, an important exception to this being the Oecusse enclave (2,500 km²). The country also includes two outlying islands, Atauro Island (144 km²) and uninhabited Jaco Island (8 km²) (Sandlund et al. 2001). In all, the country has a coastline of 706 kilometers (km).

The country is surrounded by the Timor Sea to the south, and the Banda Sea to the north. At Timor-Leste's eastern tip, these two seas converge, which supports diverse biota. This eastern tip is home to the country's first declared national nature reserve, the Nino Konis Santana National Park.

The northern coast is rocky and steep, with arid woodlands dominating the vegetation that grows there. Most of the coastal plains tend to be narrow, with relatively wide coastal plains found only in Dili and Manatuto districts (Boggs et al. 2009).

The northern coast has numerous white sandy beaches interspersed with rocky outcrops. The waters here are deeper, calmer, and more transparent than those off the southern coast. An important undersea feature of the northern coast is a 3-kilometer deep marine trench that extends all the way to the Wetar Strait. As the northern coast's littoral zone is quite narrow, the sea floor drops sharply downward at its outer edge (Boggs et al. 2009).

No scientific studies of the northern coast's beach type or morphology exist. However, the creeping beach vine *Pes-caprae* is found along many of its sandy beaches, and grasses such as *Spinifex* are common on drier portions of the coast.

⁵ Interestingly, the Weber Line seems to coincide with the Timor Trough, an important bathymetric feature, as explained elsewhere in this report.

Most of the rivers on the northern coast are choked with gravel. The steep shelf there causes sediments carried by rivers to be transported out to sea and deposited in deep water (Sandlund et al. 2001). As a result, the northern coast has few river deltas.

The shelf on Timor-Leste's southern coast is wider and relatively shallower, with gentler slopes than the northern coast. The southern coastal plains are also wider, with slopes ranging from 3% to 6% (GERTIL 2002). As a result, this area is home to many deltas, floodplains, lagoons, and swamps.

Long stretches of sandy beach with heavy waves and surf are common on the southern coast. As a result, the nearshore waters there are turbid most of the time (Sandlund et al. 2001). Most of Timor-Leste's oil and gas deposits are located on the sedimentary and hydrogen-producing basin on which the entire southern coast sits (Patmosukismo et al. 1989, cited in Tomascik et al. 1997).

The oceanography of the southern coast—more specifically, the Timor Sea—seems to be different from that of other seas in the Indonesian archipelago. Surveys of the southern coast confirm its unique topography, with deep water in the coastal areas that becomes abruptly shallower offshore (TDCA 2004). Many observers believe that the southern coast's wider, shallower shelf facilitates retention of river-borne sediments and nutrients, thereby stimulating pelagic and benthic productivity (Alongi et al. 2009).

Persistent onshore currents and wave action in the southern coast have resulted in the development of beach ridge plains that run parallel to the shore. These form lagoons in which mangrove colonization thrives. Unlike the distribution of mangrove forests on the northern coast, the southern coast's mangroves are sparse and small (Alongi et al. 2009).

Timor Island has been described as a "tectonic chaos," because of its extraordinary formation and ongoing geomorphological processes. While earthquakes of a range of magnitudes frequently occur in Timor-Leste, most of their hypocenters lie 100 km below ground (Katili 1985, cited by Tomascik et al. 1997). In fact, approximately 10% of the world's seismicity occurs in the Indonesian archipelago (Tomascik et al. 1997). It is thus unsurprising that the island of Atauro and the enclave of Oecusse are prone to tsunamis, which could be capable of generating waves of up to an estimated 4 meters (m) in height (GERTIL 2002).

Timor-Leste is strongly influenced by the Inter-Tropical Convergence Zone, the Asian and Australian landmasses, and the Indian and Pacific oceans' air masses. Given its location in the Indonesian archipelago, which is home to many mountainous islands, Timor-Leste experiences some deviations to the wind field.

The climate is marked by two seasons, wet and dry, which may or may not be separated by a transition period. The dry season from June to September is mainly influenced by the Australian continent air masses coinciding with the southwest monsoon. The wet season from December to March is mainly influenced by the Pacific Ocean and Asian continent air masses. The wet season coincides with the time of the northeast monsoon.

The El Niño-Southern Oscillation affects Timor-Leste's rainfall patterns. In particular, during El Niño periods, onset of the monsoon is delayed, and the wet season ends earlier. As a result, less rainfall occurs. However, during La Niña periods when the El Niño-Southern Oscillation

conditions reverse, the wet season is extended. As a result, rainfall levels increase, and flooding often occurs.

While Timor-Leste has experienced few or no tropical cyclones since 1970, its coral reefs on the southern coast are exposed to heavy seas caused by frequent cyclones that originate in the Indian Ocean and reach the country's southern coastline through the Timor Gap. This phenomenon often intensifies during years when La Niña predominates. Nevertheless, Timor-Leste's probability of suffering a direct hit by a cyclone is relatively low (Da Silva and Moniz 2011). However, strong winds generally occur in Timor-Leste during the periods March–April and September–October.

No studies of sunshine and cloud cover have been conducted in Timor-Leste. However, the average cloud cover ranges between 5 and 6 oktas, with maximum cloud cover occurring during the afternoon. Atmospheric pressure is generally low December–March and high May–October, the period of the southwest monsoon.

Timor-Leste has a distinct mountainous spine running from west to east. This causes the rainfall patterns and climates on the northern and southern coasts to differ considerably. As a result, Timor-Leste can be grouped into six distinct agro-ecological zones.

Diverse microclimates occur at different altitudes in Timor-Leste, which results in a diverse agro-ecological system. Rice is commonly grown in warmer lowland areas, maize at intermediate altitudes, and root crops at higher, and therefore cooler altitudes.

Rainfall patterns in Timor-Leste are heterogeneous, with the highest rainfall occurring in the central and western parts of the country. Timor-Leste's eastern tip tends to be drier, particularly along the northern coast. The mountainous areas (Ermera, the areas south of Bobonaro and east of Covalima, and some areas of Ainaro and Manufahi districts) receive the greatest amount of rainfall, which on average exceeds 1,600 millimeters (mm) annually. Apart from some drier areas on the northern coast that receive only about 1,000 mm, the remainder of the country receives a minimum of 1,500 mm annually.

Indonesian government estimates suggest that 67% of the total land area of Timor Island (including Timor-Leste) is likely to be affected by landslides, with 6% of the area likely to experience floods (Regional Physical Planning Programme for Transmigration 1989).

Flash flooding on steep slopes causes landslides that often damage both infrastructure and agricultural land. In 1999, landslides affected nearly 30% (2,332 km) of the country's roads (GERTIL 2002). When combined with deforestation, such flash flooding causes flooding in Timor-Leste's coastal areas.

Surface currents in Timor-Leste are influenced by the southeast monsoon May–November and the northwest monsoon November–March. However, a weak drift current flows through the Arafura Sea throughout the year. In the Timor Sea, a southwesterly current prevails all year round, its axis running close to the coast (Salm and Halim 1984, cited in Tomascik et al. 1997).

Two major currents influence the waters surrounding Timor-Leste: the Indonesian monsoon current and the Indonesian Throughflow (Wagey and Arifin 2008). The Indonesian Throughflow,

which plays a significant role in mid-latitude circulation in the Pacific, is strongest in June–August and weakest December–February.

The prevailing path of the Indonesian Throughflow is from the Pacific to the Indian Ocean. While it causes some movement of Indian Ocean water from the south into the eastern seas, most of this water ends up being recycled southward as it flows past Timor Island and back into the Indian Ocean.

The deep flow through the Timor Trough originates in the Indian Ocean and contributes to the formation of a recirculation pattern into the Seram Sea, the North Banda Sea, and back into the South Banda Sea before moving back into the Indian Ocean. Flows through the Timor Straits provide links to the Indian Ocean.

The Indonesian Throughflow is characterized by large internal waves and tides, which are thought to cause the intermittent high primary production events experienced in the predominantly oligotrophic sea (McKinnon et al. 2011).

In Timor-Leste, local winds appear to generate much of the wave action. The northern coast tends to experience low-energy waves, while the southern coast experiences larger waves, particularly during April–November (Wyrski 1961, cited in Tomascik 1993).

River inputs into the coastal zone along the northern coast are limited to rapid wet season pulses that extend as a relatively confined plume running perpendicular to the mouths of the rivers. Nutrients in these plumes probably lead to limited plankton blooms, and to reproductive synchrony by some fish and epibenthic organisms such as prawns and gastropods (Alongi et al. 2009). Overall, most marine productivity appears to be centered on the surf zone ecosystem, where fish and other edible organisms are easily caught (Alongi et al. 2009).

Upwelling occurs in response to the seasonal development of the Asian monsoon and the Southeast Trades (Kailola 1993) from May to September (Wagey and Arafin 2008). Interestingly, all seven upwelling sites occur within the Wallacea area of the Indonesian archipelago (Wagey and Arafin 2008). Lowering of the sea level during August–September marks the end of the upwelling season.

Variations in temperature and salinity patterns occur in the Timor Sea during the southeast monsoon (June–August). During the northwest monsoon (December–February) surface waters are warmer (by 3°C). During this period, the surface salinity of the Timor Sea has been shown to reach 35.1 practical salinity units (Tomascik 1993).⁶

At the end of Timor-Leste's dry season, interstitial salinities at high tidal elevations are less than those of normal seawater because of input from freshwater wetlands and bare tidal flats that are sometimes found behind mangrove forests (Alongi et al. 2009).

Tides are known to influence the vertical water structure. Tides in the Indonesian archipelago are caused by wave propagation across the shelves and into the basins from the Pacific and

⁶ Reference and datasets for analysis can be downloaded for free from the NOAA coast watch website: <http://coastwatch.pfeg.noaa.gov/erddap/search/index.html?page=1&itemsPerPage=1000&searchFor=Indonesia>

Indian Oceans. Timor-Leste has mixed tides with prevailing semidiurnal tides. Tides, together with currents, play an important role in providing a continuous supply of oxygen to reef communities. The most obvious effect of tides on coral reefs is the cyclic nature of exposure and inundation of reef flat areas (Tomascik et al. 1997).

Biodiversity of Coastal and Marine Ecosystems

Few studies of the biodiversity of the eastern part of Timor Island exist. One of the first such studies (Sandlund et al., 2001) is arguably the most complete that has been performed during Timor-Leste's post-independence period. Wagey and Arifin (2008) conducted the first marine biodiversity review of the Arafura and Timor seas.

A significant portion of the work performed by Sandlund et al. (2001) was based on the seminal study performed by Monk et al. (1997), which classified Timor's coastal and marine ecosystems into four biotopes:

- (i) the oceanic and subtidal marine environment, which includes pelagic water columns, deep-sea bottoms, shallower rocky bottoms, sandy-muddy bottoms, seagrass beds, and coral reefs;
- (ii) the intertidal zone, which includes rocky intertidal shelves, sandy-muddy tidal flats, and mangrove forests;
- (iii) the shoreline, which includes sandy beaches, dunes, rocky outcrops, limestone cliffs, river estuaries, and brackish lagoons; and
- (iv) the nearshore zone, which includes coastal drylands, natural forests, and wetlands.

Further studies conducted under the auspices of the Arafura and Timor Sea Expert Forum (ATSEF) have enabled a better understanding of the species assemblages and composition of coastal and marine habitats of Timor-Leste's northern coast. Despite this program's pioneering mapping efforts, a significant area of the northern coast remains unmapped.

The coastal and marine habitat classification system used by Boggs et al. (2009) during the ATSEF study introduced the first marine and coastal habitat classification system used for Timor-Leste, which incorporated rugosity, relief, and height of corals, as well as a benthic habitat classification adapted from English et al. (1997).

The recent training program in mapping conducted by the Timor-Leste government with assistance from the government of South Australia and the Coral Triangle Support Partnership (CTSP) has prompted the government to formulate a standard marine and habitat classification system to ensure standardized map classification for the entire country. Despite such efforts, significant information gaps regarding the country's southern coast remain.

From 2007 to 2009, Timor-Leste's Ministry of Agriculture and Fisheries (MAF) and Charles Darwin University, in partnership with the Australian Institute of Maritime Science, Australia National University, and Australia's Northern Territory Government conducted a broad-scale survey and mapping of the marine and coastal habitats of Timor-Leste's northern coast. This study generated marine and coastal habitat maps that identified six marine habitat types and seven coastal habitat types (Boggs et al. 2009). The survey undertaken by the study confirmed

the limited extent of Timor-Leste's coral reef, seagrass, and mangrove habitats, and the significant pace of degradation of these ecosystems. Such findings underscore the need for a precautionary approach to exploiting these habitats, and effectively conserving and managing these sites.

The survey team also assessed the degree of biodiversity at these sites to assess their potential for coastal and marine ecotourism. The study found that Timor-Leste's degree of coastal and marine biodiversity offers significant potential for development of ecotourism in Timor-Leste, coral reef diving and interactions with marine wildlife, such as whale watching and turtle tourism, in particular. The MAF plans to undertake a similar exercise focusing on the country's southern coastline to assess the potential for marine ecotourism there.⁷

The government intends to closely coordinate these studies to ensure that they complement one another, and that they produce outputs that can be used in government planning, and in compiling a Coral Triangle Atlas. Similarly, the government intends to obtain additional socioeconomic and biological datasets that can be used as inputs into overall planning and its development initiatives. The government plans to produce these datasets in partnership with the CT Pacific project, the CTSP, and similar initiatives. These studies will give priority to (i) assessing the current status of resources (e.g., quantitative assessment of reef fish and marine benthic cover), (ii) understanding the level of dependence of coastal communities on marine resources within the planned marine protected area network, and (iii) assessing the potential for livelihood diversification and adaptation. These studies will be carried out in tandem with mapping and ground truthing of coastal and marine habitats in priority sites.

Coral Reefs

The Indonesian archipelago has euphotic zone depths that vary from 100 m in the Banda Sea, to 60 m or more in the Flores Sea, to less than 15 m in some coastal areas. Most reef surveys in Timor-Leste have been performed at depths of 15–25 m.

Fringing reefs are the most visible type of coral reefs in Timor-Leste. They persist even in stressed coastal environments on the country's northern coast. In areas exposed to strong coastal currents, fringing reefs may even be found in river mouths. As in eastern Indonesia, they form a narrow reef flat (20–100 m wide) with a steep drop-off (40–60 m depth). An interesting feature of Timor-Leste's fringing reef systems is a rubble zone located immediately below the reef crest (at 2–3 m depth). Often interpreted as evidence of fish bombing, a brief study cited by Tomascik et al. (1997) postulates that this rubble area may result from relatively high bioerosion rates of rapid-growing branching corals (*Porites cylindrica*, *P. nigrescens*, *Acropora aspera*, and *A. nobilis*). These branching corals produce high fragment levels that are then deposited at the base of the upper reef slope.

While Timor-Leste's fringing reef has been classified as an oceanic fringing reef similar to the fringing reefs of Sulawesi and Flores (Tomascik et al. 1997), insufficient quantitative information is available to allow rigorous comparisons with the fringing reef types found elsewhere in the Indonesian archipelago (e.g., Borneo, Java, and Sumatra).

⁷ The Timor-Leste Agricultural and Land-use Geographic Information System (ALGIS) has a proposal to survey part of the northern coast not covered under past surveys to address some of the data gaps.

Most of the reefs are located on Timor-Leste's northern coast, which is characterized by karst geology and uplifted ancient coral reefs (Audley-Charles 2004, Hamson 2004, Keep et al. 2009). Fringing reefs, coral reefs, and seagrass meadows occur on this coast. While localized studies of coral reefs have been performed (Hodgson 1999, Deutsch 2003, Wong and Chou 2004, Dutra and Taboada 2006), only Boggs et al. (2009) attempted to map Timor-Leste's corals.

The shallow coral reefs on Timor-Leste's northern coast occupy an area estimated to not exceed 3,000 hectares (ha). While more than 60,000 ha of potential coral habitat in the deeper waters of the northern coast have been mapped (Boggs et al. 2009), more deep-water studies and surveys are necessary if these deeper-water corals are to be accurately mapped.

Most of the corals found in the deep fore-reef slope tend to be encrusting, as a means of maximizing their surface area and exposure to light. Here, a diverse assemblage of sponges and whip corals can be found. Reef slopes are more diverse than the fore-reef slopes in number of species and growth-form diversity (branching, massive, and encrusting).

On reef crests, where wave energy is a dominant environmental factor, fast-growing branching and tabulate corals are common. *Acropora* tends to be the dominant group of reef-crest hard corals in fringing reefs with moderate to high wave exposure, while *Porites* dominate fringing reefs with low levels of wave exposure. Encrusted coralline algae are found on reef flats.

Corals on Timor-Leste's northern coast tend to have higher cover of *Acropora* corals, *Porites* corals, and *Heliopora*, *Millepora*, *Xenia*, and *Briarium*. In contrast, coral reefs on the southern coast appear to have a higher cover of sponges, hydroids, algal groups, ascidians, and *Montipora* corals. *Montipora* colonies with black line disease have been recorded on the southern coast of Jaco Island, as have some coral colonies partially damaged by *Drupella* grazing (Ayling and Ayling 2009).

Run-off appears to be a key factor responsible for the absence of major reef development in many islands of the Indonesian archipelago (Tomascik et al. 1997). Recent studies have shown that some of Timor-Leste's catchment areas have naturally high rates of erosion and sediment yield (Alongi et al. 2009). Given that most of the country's rivers are located on the southern coast (GERTIL 2002), the naturally high sediment yield may be one of the determining factors in coral reef development in that area. However, zonation is likely to be influenced by a combination of other variables such as rainfall, evaporation, surface current patterns, and substrate type.

The southern coast is not climatically homogenous. Some areas of the southern coast experience high rainfall levels, which lower water salinity—a factor that affects fertilization success in corals. This may also be a factor limiting coral distribution in certain areas of the southern coast. However, little is known of the extent of coral reefs on the southern coast.

Coral reefs in Timor-Leste appear to be able to withstand high temperatures without any observed damage. This may be because of tidally induced upwelling events that are known to lower water temperature. These may also play an important role in the overall productivity of Timor-Leste's coastal waters.

Mangroves

Mangrove forests constitute an important marine habitat along tropical coasts, including Timor-Leste's northern and southern coasts (Alongi et al. 2009). Timor-Leste's mangrove forests are thought to occupy an area of 1,800 ha, of which 750 ha are located on the northern coast (Boggs et al. 2009). Boggs et al. (2009) identified 19 mangrove species, and indicated a clearly defined pattern of zonation, which is typical in mangroves. The mangrove communities occupying the greatest area include *Rhizophora*-dominated closed forest (+/- *Sonneratia*), *Sonneratia alba* closed/open forest (+/- *Rhizophora*), *Sonneratia alba* closed forest, and *Ceriops*-dominated low closed forest (+/- *Avicennia/Lumnitzera*).

Comparison of previous coastal mapping exercises with more current ones reveals significant ongoing coastal habitat loss in Timor-Leste. For example, the total extent of the mangrove forest decreased from 9,000 ha in 1940, to 3,035 ha in 2000 (FAO 2003), and then to 1,802 ha, the latter figure being recorded in 2008 (Boggs et al. 2009). In all, these results show a staggering loss of 40% of Timor-Leste's mangrove cover over the period 2000–2008. More disturbingly, they indicate an 80% loss of total mangrove habitat since 1940. As elsewhere, mangrove trees in Timor-Leste are harvested for timber and fuelwood, and hinterland mangroves are often cleared to make way for brackish water shrimp or fish ponds.

Mangrove forests provide a valuable ecologic and economic resource as nursery grounds for many commercially important fish, shellfish, and crustaceans, as well as preventing coastal erosion (Alongi et al. 2009). Those along Timor-Leste's northern coast are, as noted by Alongi et al. (2009), sparse and located in small, "quiescent embayments." Mangroves on the northern coast do not appear to be directly influenced or impacted by river run-off or sedimentation rates.

In seaward areas, mangroves tend to be dominated by one or more species of *Avicennia*, which usually form a narrow fringe; species of *Sonneratia* are commonly associated with this fringe. The *Rhizophora* zone follows, and finally, the *Bruguiera* zone. Mangrove forests may also display a *Ceriops* zone, which may include *Heritiera* and *Lumnitzera*. *Nypa fruticans* stands can sometimes be found growing in estuaries along with other genera (*Avicennia*, *Sonneratia*, or *Rhizophora*) (Cinnati 1987).

The majority of Timor-Leste's mangroves do not appear to be associated with seaward coral reefs. Instead, seagrass-coral-fringing reef associations seem to be more common. However, exceptions to this general rule exist in sites less surveyed (e.g., Lamsana, Suco Ma'abat, Manatuto district) (Cliff Maralessy, personal communication, 2012). Table 1 presents a list of mangrove species found in Timor-Leste.

The greatest negative impact on Timor-Leste's mangrove forests results from wood being taken from mangrove forests for use as fuel and food. In the Metinaro mangrove forest, an internally displaced people's camp has contributed to a noteworthy decrease in Timor-Leste's largest mangrove forest.

Table 1 Mangrove Species Recorded during the 2007 Survey of Timor-Leste's Northern Coast

Acanthus ilicifolius	Heritiera littoralis
Acrostichum aureum	Lumnitzera racemosa
Aegiceras corniculatum	Pemphis acidula
Avicennia marina	Rhizophora apiculata
Bruguiera gymnorhiza	Rhizophora stylosa
Bruguiera parviflora	Scyphiphora hydrophyllacea
Ceriops australis	Sonneratia alba
Ceriops decandra	Sonneratia caseolaris
Excoecaria agallocha	Xylocarpus mekongensis
Excoecaria ovalis	

Source: G. Boggs, et al. 2009. Marine and Coastal Habitat Mapping in Timor-Leste (North Coast) - Final Report. Project 1 of the Timor-Leste Coastal-Marine Habitat Mapping, Tourism and Fisheries Development Project. Ministry of Agriculture and Fisheries, Government of Timor-Leste.

Seagrass Meadows

Seagrass meadows help stabilize coastlines and provide shelter for a wide range of economically important marine organisms. Further, they are a critical habitat for some endangered marine species (e.g., dugongs [a large herbivorous mammal that feeds almost exclusively on seagrass] and green turtles). They support a rich and diverse fauna (Tomascik et al. 1997).

Seagrass beds grow in sheltered, soft-bottomed, shallow sublittoral water in the euphotic zone (Monk et al. 1997), making a broad zone on the shore between the beach or mangrove and the edge of the coral reef. While few publications on seagrass exist, members of the following genera are believed to be found in Timor-Leste: *Enhalus*, *Cymodocea*, *Halodule*, *Halophila*, *Syringodium*, *Thalassia*, and *Thalassodendron*.

The northern coast hosts extensive seagrass meadows (2,200 ha) alongside 1,266 ha of mixed coral-seagrass and open reef flat. Mixed seagrass communities in Timor-Leste comprise seven species, and are often associated with fringing reefs (Tomascik et al. 1997, Wagey and Arifin 2008). They tend to reach their peak density in shallow-water, back-reef environments (reef flats), and lagoons. These estimates are similar to the results of previous surveys conducted on islands nearby, such as Lombok, (Kiswara and Winardi 1994), Komodo, and Sumbawa (Suharsono et al. 1993, cited in Tomascik 1993), as well as the results of studies conducted in northern Australia (Roelofs et al. 2005).

The low levels of species diversity of seagrass may be partly due to relatively homogenous seawater temperatures. Monospecific seagrass meadows of *Thalassia hemprichii*, *Halophila ovalis*, and *H. uninervis* are known to occur (Nienhuis et al. 1989).

Echinoderms (sea cucumbers and sea urchins) are noticeably common, and an economically important component of benthic seagrass communities.

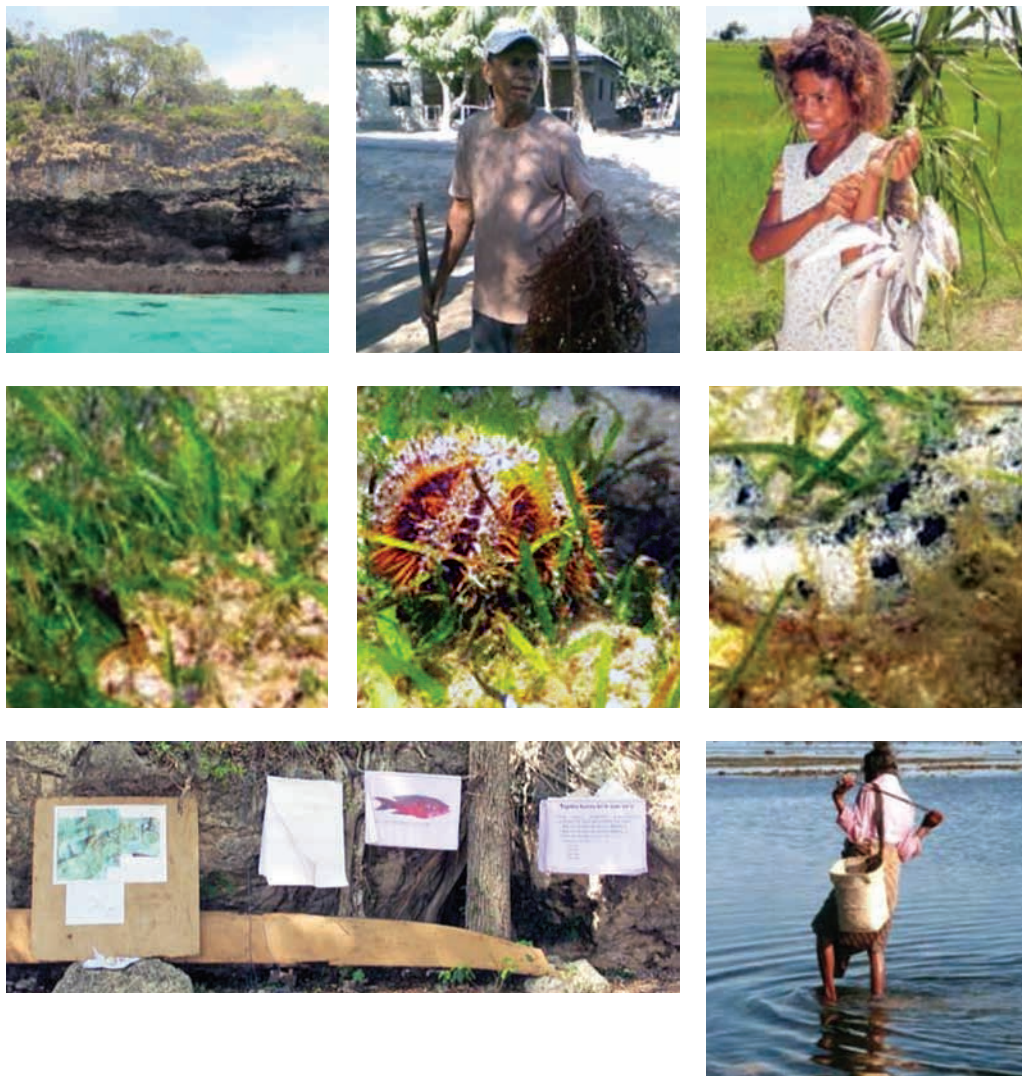
Despite its relatively small area of seagrass, a survey of Nino Konis Santana National Park confirmed the presence of *Syringodium isoetifolium*, *Cymodocea rotundata*, *Halophila ovalis*, and *Halodule uninervis* (Unpublished program technical data from CTSP).

Aspects of Timor-Leste Geography and Natural Resources



(From top left to right): Open beach in Timor-Leste's northern coast, rice field in a coastal area, *Spinifex* growing on a drier part of the coast, and mangrove forest hinterland converted into brackish water fish ponds in Hera.

continued on next page

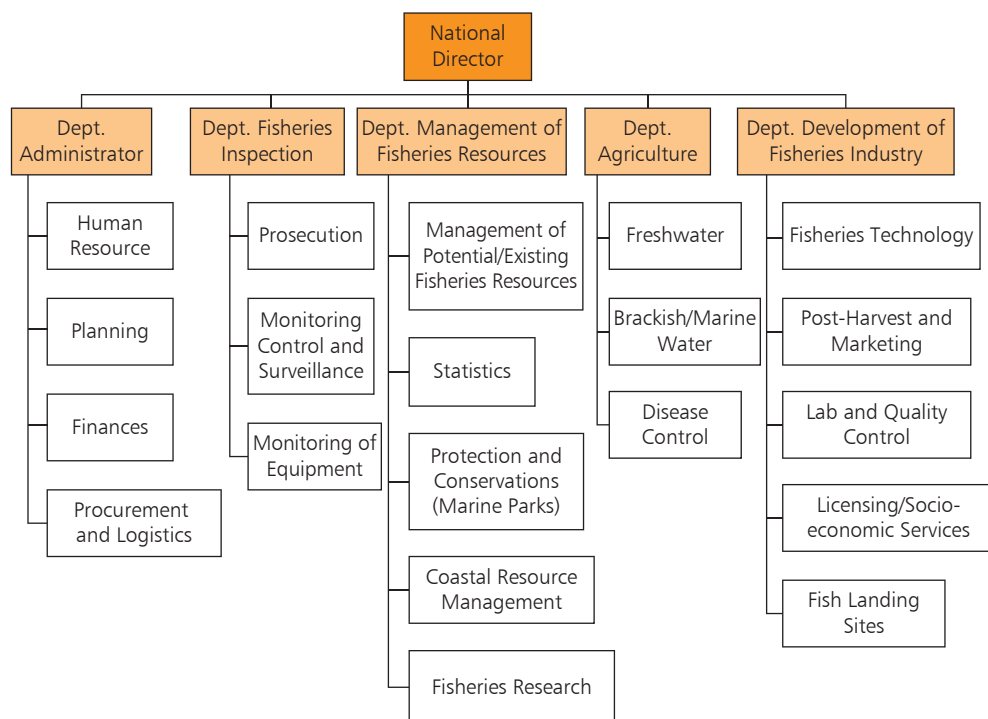


(From top left to right): Timor-Leste's karst geology and uplifted ancient coral reef; Mr. Tomé, a seaweed farmer; a fish vendor; seagrass bed and its inhabitants (seagrass, sea urchin, and common sea cucumber); a typical classroom of the Coral Triangle Support Partnership showing some of the visual aid that is used to explain fishing zones, minimum catch sizes, and the importance of managing spawning aggregation sites; and *meti* gleaning in the intertidal zone.

Governance

The National Directorate of Fisheries and Aquaculture (NDFA) under the Ministry of Agriculture and Fisheries (MAF) is responsible for developing and managing the fisheries industry.

Figure 1 National Directorate of Fisheries and Aquaculture Organization Chart



Source: R. Pinto and C. Da Cunha Barreto. Capacity Needs Assessment for the Department of Fisheries Resource Management and Research, National Directorate of Fisheries and Aquaculture, Ministry of Agriculture and Fisheries, Timor-Leste. Unpublished CTSP Report.

Together with the CT Pacific and CTSP, the NDFA facilitates community-based fisheries management initiatives, and establishment of a network of locally managed marine areas in Timor-Leste. These efforts currently focus on Timor-Leste's Nino Konis Santana National Park, and the marine protected areas (MPAs) to be established on Atauro Island and in Batugade Subdistrict.

Policy and Legislation

The policy objectives of the MAF are to (i) increase food security, (ii) improve animal and fish production, (iii) support agricultural industries through development of agriculture, forestry, and fisheries products and their marketing, (iv) increase export earnings, and (v) create jobs. Sustainability, capacity development, and private sector participation are central to MAF policy making.

Timor-Leste's first constitutional government (2002–2007) sought partnership with aid agencies to (i) improve marine resource planning and management, (ii) develop a fisheries policy, and a legal and regulatory framework for the fisheries sector, (iii) support private sector participation, (iv) construct basic infrastructure, and (v) strengthen the institutional capacity of its staff. In 2006, civil unrest abruptly halted the few ongoing programs at that time, and temporarily prevented formation of partnerships with aid agencies.

While the first constitutional government promulgated most fisheries laws and policies currently in place (Table 2), their implementation requires further strengthening. Currently, the MAF's greatest challenge is effective implementation of these policies and regulations. The Agricultural Rehabilitation Project facilitated development of a decree law, general fishing regulations, draft legislation for addressing fishing crimes, and a decree law for establishing marine parks.

Table 2 Timor-Leste Fisheries Legislation

Title	Legislation and Date Approved
General basis of the legal regime for the management and regulation of fisheries and aquaculture	Decree Law No 6/2004 of 21 April 2004
General regulation on fishing	Government Decree No 5/2004 of 28 July 2004
Altering Government Decree No 5/2004 of 28 July 2004. Government Decree No 3/2005 of 6 July 2005	
Crimes related to fisheries	Law No 12/2004 of 29 December 2004
Establishment of tariffs for fisheries licenses, inspection, related activities, and services of fisheries	Government Decree No 2/2005
Definition of fishing zones	Ministerial Diploma No 01/03/GM/I/2005
Percentages of by-catch tolerated	Ministerial Diploma No 03/05/GM/I/2005
List of protected aquatic species	Ministerial Diploma No 04/115/GM/IV/2005
Minimum sizes of fish species that can be caught	Ministerial Diploma No 05/116/GM/IV/2005
Penalties for fisheries infringements	Ministerial Diploma No 06/42/GM/II/2005

Source: Compiled by authors.

Funding provided by Australian Aid under the Fisheries Management Capacity Building Project helped strengthen the government's capacity for managing deep-sea fishing activities. Since completion of this project in 2006, the Timor-Leste government has achieved considerable progress in preparing to implement its Fisheries Decree Law and associated regulations. This in particular included formulation of the licensing system for offshore fisheries, which allowed the first offshore tuna license to be issued in January 2005. However, issuance of the first offshore tuna license as well as subsequent licenses proved to be disastrous, in that vessels operating under such licenses encountered many armed illegal fishers using the same fishing grounds as those authorized by their licenses.

With assistance from the Agricultural Rehabilitation Project (Phase 2) of the Asian Development Bank (ADB), the government rehabilitated the Hera fishing port, which later became Timor-Leste's first army and navy port. Currently, Com-Lautem is the only port used as a fishing port.

The government has yet to approve The Future for Fisheries, (which comprises a policy and strategy for responsible development and management of Timor-Leste's fisheries). This document includes five major policy objectives:

1. Optimal use and management of Timor-Leste's living aquatic resources, to increase sustainable production, consumption, and export of fisheries products as a means of generating a stream of social and economic benefits over the long term.
2. Conservation and rehabilitation of Timor-Leste's aquatic habitats to enable sustained productivity of fisheries resources.
3. Sustainable, efficient, and profitable industry that meets the needs of the population for availability and affordability of quality fish, and that supplies export markets, mainly from offshore resources.
4. Development of a viable aquaculture industry that meets the needs of the population for availability and affordability of quality fish, and that supplies fish to export markets.
5. Development of fisheries institutions and associations that are staffed by individuals capable of serving the needs of the fishing and aquaculture industries.

These policy objectives relate to five overall areas of fisheries management: (i) optimal use and management of living resources, (ii) habitat conservation, (iii) development of a viable fishing industry, (iv) development of a viable aquaculture industry, and (v) development of fisheries institutions.

In August 2007, Timor-Leste established its first national park. One of the many purposes of establishing Nino Konis Santana National Park was to fulfill the country's international obligation regarding environment and biodiversity conservation. The park covers the entire eastern tip of Timor-Leste, and extends 3 nautical miles out to the sea. Its total area is 123,600 ha, of which 55% comprises terrestrial habitats including forests, grasslands, and wetlands.

Compliance

Despite lack of information concerning government regulations, a survey performed in the early 2000s confirmed that 97% of fishers were inclined to comply with the new regulations, as long as they were consulted during formulation of the regulations, and received an adequate

explanation of their purpose. While only 16% saw enforcement as a joint effort between the government and the fishing community, all fishers interviewed wanted a role in resource management (Baticados 2005).

With assistance from the CTSP, the Coral Triangle Initiative has helped community members in selected sites to better understand how the laws promulgated by the government would better manage the marine resource on which they depended. Further, the program has had some success in the voluntary establishment of community-based management groups that engage in information-sharing and conservation activities.

Socioeconomic Characteristics

Archaeological evidence confirms that not only have humans inhabited Timor-Leste's coastal area for thousands of years, but that extensive interaction between humans and the sea has occurred for nearly that long. As coastal Timor's earliest inhabitants were mobile hunter-gatherers (Spriggs et al. 2003), coastal resources played an important role in their subsistence economy (Oliveira 2008).

The finding of two fishing hooks together with the remains of pelagic fish species (O'Connor and Veth 2005) suggests that Timor's early inhabitants fished in the open sea. However, over time, this human interaction with the sea became weaker (Cinnati 1987). Thus, for reasons not understood, Timorese are no longer oriented toward the sea (McWilliam 2002).

Timor-Leste's greatest population density occurs in the upland *sucos* (group of villages) and *aldeias* (villages) on the northern part of the island. This fact contradicts the generalization with which Monk et al. (1997) described Timor-Leste. The 2002 census reported that while approximately 66% of the population lives below an elevation of 500 meters (m), with the exception of Dili, few urban settlements are located on the coast. A subsequent census performed in 2010 confirmed that this pattern of population distribution has remained unchanged.

Timor-Leste's 2001 household survey found agriculture (including fisheries) to be the major source of income for 94% of villages (Drysdale 2007), a finding corroborated by the results of the 2010 household census. Nevertheless, one-third of the population experiences food shortages, notably toward the end of the two lean seasons between harvests, which correspond to the periods October–November and February–March (IRIN, 2012). According to 2011 FAO estimates (FAO Emergency Office in Timor-Leste, 2011), the percentage share of the population experiencing food shortages increases to 60%–70% during December–February, a period appropriately referred to as the “hungry months” (FAO Emergency Office in Timor-Leste 2011).

As with Timor-Leste's highland communities, subsistence or semi-subsistence farming systems dominate coastal communities, with up to 85% of the total population depending on agriculture as a source of food. Fishing and gathering of natural resources such as collection and sale of firewood, palm-wine brewing, and honey collection complement agricultural income-generating activities (Fedele and Horjus 2006). The southern-coast communities that inhabit Timor-Leste's most remote areas tend to be even more subsistence-based, as they live at a greater distance from services and markets. The food insecurity and vulnerability rankings of these communities are thus quite high (Fedele and Horjus 2006).

Poverty rates in rural areas (46%) exceed those in urban areas (26%), and lowland rural residents report lower levels of poverty than do residents of other rural areas. The extent to which fisheries contributes to household income in lowland rural Timor-Leste is unknown. Nevertheless, fisheries appear to play a critical role in food security (Baticados 2005).

The CTSP assisted the Department of Fisheries Resource Management in estimating revenue from the Lake Iralalaru inland fishery. Timor-Leste's largest freshwater lake, Lake Iralalaru accounts for more than 75% of the household revenue of fishing families that depend on it as a source of livelihood (CTSP unpublished report).

At current annual population growth rates estimated at 3%–4% per annum (Census 2010), Timor-Leste's population will double in 18–20 years (UniQuest 2010). Such a forecast has serious implications for the country's food security, as its current unstable cash economy would be unable to absorb such an increase in overall population. Nevertheless, over the short to medium term, the number of people that comprise the subsistence sector will grow significantly, which will in turn put additional pressure on the country's natural resource base as compared to today.

The limited extent of coral reef, seagrass, and mangrove habitats on Timor-Leste's northern coast confirms that marine resources there, particularly reef fisheries and mangroves, are constrained. This suggests a relatively low limit on the rate at which extraction from this resource base can occur without becoming unsustainable. In the light of the current rates of population growth and resource extraction, improving management of Timor-Leste's marine and coastal resources and striving for their conservation and management are urgent environmental imperatives.

Fisheries Sector

Nearly all of Timor-Leste's coastal fishing activity is artisanal in nature, as it is nearly always supplemented by other livelihood activities such as agriculture (de Carvalho et al. 2007). As a result, only a few semi-industrial fishing licenses have been issued, all of these to a single company.

Surveys of the Timor Sea (TDCA 2004) confirm the presence of stocks of economically important fish families, including Lutjanidae, Lethrinidae, and Serranidae. Several snapper species (Lutjanidae) were found to be the most common, as these account for 49% of the total catch by weight. Among these are three species of significant economic importance—*Pristipomoides typus*, *P. mutidens*, and *Lutjanus vitta*.

In 2002, Timor-Leste was home to an estimated 20,000 fishers, half of whom depended on fishing as their main source of food and income (Jasarevic 2002). MAF later reviewed these results, and later reestimated the total number of Timor-Leste fishers at nearly 5,500 (Table 3) (Baticados 2005). Most fishing activities are limited to low-technology inshore fishing (Wever 2005).

Table 3 Number and Location of Timor-Leste Fishers

District	Number of Fishing Centers	Number of Fishers
Ainaro	2	25
Ambeno	13	370
Baucao	10	252
Bobonaro	11	315
Covalina	10	254
Dili Mainland	13	1,527
Atauro Island	18	512
Lautem	12	460
Liquica	31	541
Manufahi	5	121
Manatuto	18	370
Viqueque	8	217
Total	151	5,415

Source: D. Baticados. 2005. Socio-economic Issues in Fishing Communities and Socio-Economic Indicator to Monitor and Evaluate Sustainable Fisheries Development in East Timor. Report to FAO.

FAO has supported the government in developing an online database of artisanal fishers (www.peskador.org) through its Regional Fisheries Livelihoods Programme for South and Southeast Asia (RFLP). This database provides the latest information on boats registered in Timor-Leste.

Artisanal fishers target (i) demersal species such as snapper, croaker, and bream; (ii) pelagic fish such as tuna, mackerel, scad, and sardines; and (iii) various prawns, crabs, lobsters, bivalves, and cephalopods (McWilliam 2002). These are often sold at roadside markets at an average price of \$5 per kilogram. The diversity of species found in these markets is astonishing, in that it ranges from eels to triggerfish.

Fishing activities decrease during December, January, July, and August because of strong winds and waves. Reported fish catches in nearshore areas during these months are also smaller. However, because the southern coastline is more exposed than its northern counterpart, this decrease is more evident in the south.

Women and children often engage in *meti*, or the harvesting of juvenile fish, crabs, mollusks, and sea urchins using rotenone-based piscicides derived from derris root (Pinto 2011).

A reconstruction of Timor-Leste fisheries, which estimates catches before and after the country's independence, recently became available (Barbosa and Booth 2009). In the late 1960s, a commercial fishery—in which fish are mostly sold—began to expand and grew from an estimated 60 tons/year in 1974 to 2,800 tons/year in 1998, when conflict destroyed the infrastructure. After independence, the commercial fishery grew again, reaching about 2,000 tons in 2009. Small-scale, or subsistence, catches—which may include some trade between communities—have also grown, since independence, from 2,500 tons in 1999 to about 3,500 tons in 2009.

These data are on average 13 times those of the FAO in years where the FAO has recorded Timor-Leste statistics. The total number of commercial and subsistence fishers was estimated at 5,500 in recent years, in agreement with Table 3.

Catches are dominated by tuna and similar species, making a third of the reconstructed catches, with Lutjanidae and Caesionidae, contributing a further 10% each.

The reconstruction report (Barbosa and Booth 2009) points out that Timor-Leste has a narrow continental shelf, with few reefs and seagrass beds. These mainly occur where fishing already takes place. Also, earlier reports have noted the small size of fish and degraded condition of reefs, indicators that the main fishing areas are overexploited already. Thus, the country's fisheries potential cannot be high. The presently unexploited areas of coastline may simply reflect the low fishery potential of those areas.

Aquaculture

Aquaculture in Timor-Leste (seaweed farming) began in 2003, with a small number of farmers participating in a pilot program sponsored by the National Directorate of Fisheries and Aquaculture (NDFA). Because of the program's success, the number of seaweed farmers steadily increased from 20 in 2004 to nearly 1,500 in 2010 (NDFA and WorldFish Center [WFC] 2011).

The focus of seaweed farming in Timor-Leste is Atauro Island, which lies just north of Dili. It is a major income-generating activity for the island's population of 10,000. Unlike freshwater aquaculture, which caters to the domestic market, seaweed farming targets foreign markets, although a small amount is consumed domestically. In 2009, export earnings from seaweed reached an estimated \$19,130 (NDFA 2010 cited in NDFA and WFC 2011).

NDFA currently has four freshwater fish hatcheries. However, because of financial and logistical constraints in managing the hatcheries, these are modest facilities with minimal seed production capacity. All four of these hatcheries are also in need of urgent renovation. This constitutes a major constraint to development of the aquaculture subsector (NDFA and WFC 2011).

Aquaculture appears to have been government-led, with significant input from the military during the period of Indonesian administration. Timor Timur Dalam Angka (Timor-Leste in Figures) 1997 cites inland fishery production increasing from 18.8 tons in 1986 to a peak of 401.5 tons in 1995, and then falling to 379.4 tons in 1997. However, these statistics appear to be gross miscalculations, in some cases ten times those that appear in Timor logbooks (Cook 2000).

The Timor-Leste government has identified aquaculture as a sector that could significantly contribute to improving food and nutrition security, and to increasing household income in both inland and coastal communities (NDFA and WFC 2011). The WorldFish Center is currently assisting the Ministry of Agriculture's NDFA in formulating a national aquaculture strategy and action plan. The major focus of both is sustainable development of the aquaculture subsector as a means of addressing poverty and food insecurity. The FAO-sponsored Regional Fisheries Livelihoods Programme for South and Southeast Asia and the Coral Triangle Support Program jointly fund this initiative.

Coastal Tourism

As it forms part of the Coral Triangle, Timor-Leste has great potential for ecotourism. However, as with the tourism sector overall, this subsector is still at an early stage of development. The most recent study of tourism in Timor-Leste, which was carried out in 2004, concluded that only 0.35% (55) of Timor-Leste's licensed businesses were tourism-related. Of these, more than 90% operate out of Dili (Pedi 2007).

The foundation of Timor-Leste's developing tourism sector is natural resources such as coral reefs, diving and fishing at Nino Konis Santana National Park and Atauro Island in particular. In this regard, Atauro and Com, both located on the northeastern coast of the mainland, have developed a positive reputation for ecotourism. Other activities with significant ecotourism potential include whale watching and observing other marine mega fauna in the country's eastern coastal area and Nino Konis Santana National Park in particular (Edyvane et al. 2009).

In general, coastal and marine biodiversity and interactions with marine wildlife offer the most significant potential for ecotourism development. Community-based ecotourism likewise has significant potential for development, as it would allow cultural tourism to be combined with nature-based tourism (Edyvane et al. 2009). However, if improperly managed, tourism could worsen food insecurity in Timor-Leste's coastal environments. At the same time, the scale of the country's food insecurity highlights the necessity of developing tourism to create jobs and bring in foreign-exchange earnings. Successful development of Timor-Leste's tourism sector will depend on the sector adopting best management practices, particularly during its formative stage. Guidelines for developing this sector may thus be helpful in this regard (UniQuest 2009).

Currently, Timor-Leste's tourism infrastructure, including its quality of tourist accommodation and services, are limited and generally of poor quality. However, sites on both the northern and southern coasts have significant potential for development of ecological and cultural tourism. In general, tourists tend to favor the northern coast as access to tourism-related sites there is easier. In addition, the southern coast has a greater abundance of saltwater crocodiles.

With regard to the potential for cultural tourism, several sites of cultural and historical significance could complement those of recognized natural beauty in the formulation of ecotourism packages (Edyvane et al. 2009). Thus far, Timor-Leste's cultural ecotourism packages have relied heavily on religious and historical themes. Historical sites associated with Portuguese colonization, the Indonesian occupation, and the struggle for independence from it by the Frente Revolucionária de Timor-Leste Independente hold significant potential in this regard (Edyvane et al. 2009).

Minerals, Oil, and Gas

Timor-Leste has significant oil and gas deposits, which currently account for the bulk of the country's revenue and foreign-exchange earnings. However, these resources are finite, and are projected to decline rapidly beginning in 2020. Further, the government's injection of oil and gas revenues into the economy currently targets growth in consumption rather than stimulation

of productive activity, as significant improvement in the economy's production capacity is limited in the medium term.

Transport and Shipping

Timor-Leste's port in Dili is the country's major—and only international—port of entry. Located near the center of town, Dili port has a wharf length of 300 m, and can concurrently accommodate two large vessels with a draft of up to 7 meters (m) (World Bank 2011). Roll-on, roll-off facilities are available for front-loading vessels.

The United Nations Peacekeeping Force improved Dili port by extending its wharf. Funding for this initiative included \$5.7 million from the Government of Japan, and \$1.3 million from the World Bank under its Emergency Infrastructure Rehabilitation Project (World Bank 2011).

A fuel terminal located at the western end of Dili port complements its wharf facilities. The Indonesian State Oil Company or Perusahaan Pertambangan Minyak dan Gas Bumi Negara (PERTAMINA) currently operates this facility. Small wharfs or jetties are located at Caravela, Com, Hera, and Tibar, as well as the island of Atauro and the enclave of Oecusse. The latter two facilities provide the only access to these localities from other parts of Timor-Leste (World Bank 2011).

Traditional Knowledge Management

Timor-Leste's Constitution recognizes traditional natural resource management practices such as *tara bandu* (seasonal prohibitions against marine resource extraction), which are part of the *adat* (traditional) system of local beliefs. Both the Coral Triangle Support Partnership (CTSP) and the FAO-sponsored Regional Fisheries Livelihoods Programme for South and Southeast Asia have integrated traditional knowledge into resource management. The CTSP program has provided some guidance to fisheries managers on how to capture local knowledge and make the best of it in data-deficient environments. Pinto (2011) is one of the few published works that provides guidelines on helping fisheries managers understand the nuances of such contexts.⁸

Gender Issues

The sole report addressing fisheries and gender in Timor-Leste is De Carvalho et al. (2007). Much as with elsewhere in the region, men dominate Timor-Leste's fisheries sector. However, unlike other locales, men rather women run most of the fish markets in Timor-Leste. While Timor-Leste women play a role in postharvest fisheries activities, such as drying and salting, given the limited amount of training available, their role in fisheries-related activities is often confined to intertidal fishing. In this regard, the Japan International Cooperation Agency (JICA) has provided training and has facilitated establishment of women's cooperatives. However,

⁸ <http://unesdoc.unesco.org/images/0021/002145/214540tet.pdf>

the coverage of this training was limited to a small group in various districts. Expansion of this program would increase the availability of training provided to women who are interested in greater involvement in the fisheries sector.

Payment for Ecosystem Services

The Coral Triangle Initiative was the first program to introduce the concept of payment for ecosystem services in Timor-Leste. While no projects targeting implementation of payment-for-ecosystem-services schemes are ongoing in Timor-Leste, introduction of this concept has alerted the government to the availability of various innovative approaches to generating incentives for sustainable management of Timor-Leste's coastal and marine resources by the general population.

Threats and Vulnerabilities

Most of the population of Indonesian origin that inhabits Timor-Leste's transmigration zones originated in Bali, Java, and Sulawesi, as the population density of all of these jurisdictions is extreme. Indeed, during the Indonesian administration, transmigration was a formal part of the official Indonesian government's "go east" policy. These transmigrants introduced new fishing practices and uses of Timor-Leste's natural resources.

Fisher communities in Com, Hera, and Tibar, all of which are near to the country's major fishing ports, link the introduction of destructive fishing practices (e.g., blasting reefs with dynamite, cyanide fishing, and the use of compressors for harvesting trochus and sea cucumber) with the arrival of some transmigrants, particularly those from Celebes. These unsustainable fish-harvesting practices have left Timor-Leste's coastal and marine environments in a vulnerable state. While anecdotal evidence suggests some improvement in the reef environments that endured such abuse, more than a decade will be required for the reefs to recover from the damage caused by dynamiting the reefs on Timor-Leste's northern coast.

Further, the Indonesian government's attempt to get local Timorese communities to shift from subsistence practices into a market economy generated clashes between the manner in which traditional belief systems valued natural resources, and the predominantly economic valuation of natural resources that the Indonesian government attempted to impose on local populations (Monk et al. 1997). Moreover, this incursion led to a cessation of traditional natural resource management practices as dictated by customary law that emphasized sustainability. This in turn created a natural resource management gap that accentuated exploitation and misuse of Timor-Leste's natural resources, mangrove forests, and coral reefs in particular.

The current lack of ecological data regarding Timor-Leste's marine and coastal ecosystems makes development of the country's coastal areas particularly challenging. Lack of understanding and consequent underestimation of the value of the country's coastal ecosystems, as well as short-term thinking on the part of decision makers and lack of accountability on the part of developers both aggravate the potential for destruction of these ecosystems.

Illegal fishing due to low levels of enforcement by Timorese authorities constitutes a major threat to sustaining the productivity of Timor-Leste's fisheries stocks. Reportedly, it has meant a loss to the Timorese economy of some \$40 million by 2009 (www.oreporter.com 2009).

Most illegal fishing appears to occur in the eastern part of Timor-Leste's southern coast, with substantial numbers of boats being reported to local authorities by artisanal fishers there.

Previous surveys of Timor-Leste's fisheries using pelagic longlines and drift gill nets indicate that pelagic fish are mainly distributed along coastal areas in the northern reaches of the Timor Sea, 25–30 kilometers offshore (TDCA 2004). The fact that such boats are now increasingly fishing closer to shore may indicate depletion of fish stocks further from the coast.

Current Issues for Marine Resource Management

Several major issues confront management of Timor-Leste's marine and coastal resources. First, rapid population growth has greatly increased pressure on these resources because of the need to improve household nutrition and incomes. Second, population pressure has likewise caused agriculture to increasingly shift on to steep and marginally productive lands. This negatively impacts the marine environment through increased sedimentation rates, particularly in the wake of flash flooding. Third, shortage of land suitable for agriculture and inadequate irrigation facilities are likely to cause deforestation to continue. Fourth, expansion of coastal populations inevitably places greater environmental pressure on the country's marine resources. Finally, the negative impacts of climate change likewise affect Timor-Leste's marine resources through erosion caused by storm surges and high waves (UniQuest 2009).

Population growth. Population growth is a major cause of increased vulnerability of Timor-Leste's marine and coastal resources. Current forecasts suggest that Timor-Leste's population will reach 2.5–3 million by 2050. Such an increase would greatly exacerbate the current food security and biodiversity conservation challenges the country faces. Due to the population's relatively high degree of dependence on the country's natural resource base, population growth appears to have a greater impact on it than does climate change. UniQuest (2009) forecasts of a 150% increase in the country's demand for fish by 2030 suggests that this demand alone could undermine the long-term sustainability of Timor-Leste's fisheries resources. Population growth may also expand the use of shifting (slash-and-burn) agricultural techniques, as well as the demand for farmland.

Excessive nutrients and other pollution. Population growth and inadequate infrastructure for supplying water and removing sewage in Timor-Leste's urban centers is forecast to increase the level of nutrients entering coastal environments through local drainage systems (UniQuest 2009). Overall, increasing urbanization will exacerbate current challenges to sustainable management of Timor-Leste's marine and coastal resources, including (i) water and air pollution, (ii) greater intensity of natural resource use in the areas surrounding urban centers, and (iii) loss of agricultural land and vegetative cover due to urban sprawl (UniQuest 2009).

Land degradation. There are four major causes of land degradation in Timor-Leste: (i) unsustainable agricultural practices, such as slash-and-burn agriculture and cultivation of steep, marginally productive uplands, (ii) illegal logging of native wood species, (iii) extraction of fuelwood, and (iv) fire. All four cause increase run-off and sediment deposits in coastal environments, particularly during the heavy rain and flash flooding that occurs in nearly all of the country's districts. Further, the longer-term impacts include soil erosion and landslides in the uplands, as well as disastrous floods in lowland areas (UniQuest 2009).

Farming of sugar cane, one of Timor-Leste's most important crops, particularly threatens the country's coastal systems, as sugar cane is planted primarily on steep hillsides. Clearing of forestland for sugarcane planting in turn causes erosion, landslides, flashfloods, and siltation. As fertilizer use in Timor-Leste is limited, soil erosion is particularly damaging over the long term, as it results in loss of nutrient-rich top soil.

Overfishing. Demand for fish by coastal populations is a primary cause of overfishing. Curtailing overfishing presents a significant challenge for the government, given its weak enforcement capacity, and in some cases, a complete lack of appropriate fishing regulations. For example, there are no limits on either the fishing gear that may be used, or the size or volume of fish that may be taken.

Existing surveys of fish stocks in the Nusa Tenggara and Moluccas regions have confirmed overexploitation there (Monk et al. 1997). However, few studies exist that can substantiate this claim for Timor-Leste. One of the first surveys conducted after independence reported evidence of overfishing and detailed its impact on fish assemblages in Timor-Leste (Deutsch 2003). This study reported lower fish family richness than previously, as well as fewer snapper and parrotfish at sites in Dili as compared to elsewhere. Such results suggest that the negative impact of the current fishing effort on fish abundance is greatest in the fishing grounds in and around Dili.

Destructive fishing practices. Destructive fishing techniques, such as dynamite and cyanide fishing, are common throughout the Indonesian archipelago. However, in part because of the dominance of traditional fishing practices in Timor-Leste, these destructive fishing techniques were not as prevalent as in other parts of the Lesser Sunda Ecoregion. Nevertheless, Timor-Leste fishers have identified an increasing concentration of blast-fishing craters along the Laivai-to-Mehara transect. Local fishers tend to use destructive practices during the two lean seasons between harvests. These in particular include the use of derris root to stun fish, and crowbars, which are used to dislodge corals to create fish traps.

Climate change. Timor-Leste is drier today than it was 30 years ago. The country's sea surface temperatures have increased at a rate of 0.12°C per decade over the period 1981–2008 (Kirono 2010). A recent forecast by Kirono (2010) suggests (i) increasingly intense tropical cyclones, (ii) decreases in the rate of evaporation, (iii) increases in sea-surface temperatures (0.6°C–0.8°C by 2030), and (iv) increases in sea level (3.2–10 cm by 2020). While the annual number of extreme rainfall events is forecast to decrease, their intensity is forecast to increase. Ocean acidification is likewise forecast to increase over time. Given Timor-Leste's relatively large number of subsistence farmers and fishers who by nature are vulnerable to the negative impacts of climate change, the changes in weather patterns forecast for the country (prolonged drought, extended rains) suggest a further increase in this vulnerability.

Molyneux et al. (2012) presents quite detailed climate change forecasts for Timor-Leste for the entire 21st century, as well as their potential impacts on the country's level of food security. The authors forecast a rise in mean temperature of 1.25°C–1.75°C by 2040, and a rise of 2.25°C–2.75°C by 2080. By way of comparison, the average (1950–2000) mean annual temperature in Timor-Leste's coastal areas is 25°C–27°C, and 15°C–17.5°C in the higher elevations of the central mountain range. The climate change forecasts of Molyneux et al. (2012) indicate an increase in the frequency of days with extreme temperatures (days with maximum temperatures greater than 35°C on average), and the length of heat waves in the country's coastal areas. Similarly,

increased rainfall is forecast for Timor-Leste over the coming decades. Currently, rainfall varies from less than 800 millimeters (mm) in the country's coastal areas to 2,400–2,600 mm in the mountains. By 2050, rainfall levels are forecast to increase by 100–200 mm on the country's coastlines, and by more than 260 mm in the mountains.

Kirono (2010) also makes some climate change forecasts for Timor-Leste using the results of climate-change studies for Australia, Asia, and Indonesia as proxy variables. These include increased temperatures, increased rainfall levels, an increase in sea level, a decrease in the frequency of tropical cyclones and extreme rainfall events, but an increase in their intensity. Currently, the frequency of cyclones affecting Timor-Leste is relatively low at an average of 0.2 cyclones per year.

Climate change will most likely have a severely negative impact on the Timor-Leste economy, given its heavy reliance on agriculture and fisheries. For example, increased temperatures directly affect photosynthetic processes in plants. Temperatures exceeding 35°C negatively impact pollination and kernel set, and may even be lethal to the pollen viability of corn, which would result in poor yields (Herrero and Johnson 1980, Dupuis and Dumas 1990). Pollination of rice, another major crop in Timor-Leste, has also been shown to be sensitive to increased temperatures (above 34°C). Increased climate variability will most likely have a particularly adverse impact on the livelihoods of farmers, who for the most part practice rain-fed agriculture, as irrigation facilities in Timor-Leste are limited.

The results of a series of participatory research activities carried out under the Australian Aid-funded Community-Based Climate Change Adaptation Programme in Timor-Leste has confirmed that increases in rainfall levels, temperatures, and climate variability, and climate change in general will negatively impact both biodiversity and the livelihoods of the population. For example, some respondents confirmed that they could no longer rely on their traditional calendar for determining appropriate times to plant and harvest crops.

Threatened species. Harvest and trade in threatened species remains rampant in Timor-Leste. For example, sea turtles and their eggs, shark fins, shells, and corals are openly sold in the country's supermarkets (Edyvane et al. 2009).

With the exception of birds, Timor-Leste's fauna (Table 4) is characterized by low levels of overall species richness, but relatively high levels of endemism (Monk et al. 1997). Of the 168 resident bird species, 32 are endemic to the Lesser Sundas, and 8 are endemic to the island. At least two mammals (the Timor shrew and Timor rat, of 35 native species) and one reptile (of 40 species) are endemic. According to the International Union for the Conservation of Nature (IUCN), three tree species, four birds, three mammals, and one butterfly are considered threatened with extinction (Table 5).

The reconstruction of Timor-Leste fisheries by Barbosa and Booth (2009) indicated that further fisheries potential was low and that overfishing was already evident in areas suitable for fishing. The Regional Fisheries Livelihoods Programme for South and Southeast Asia in Timor-Leste made many recommendations for development of the fisheries sector, focusing on the small-scale sector (Alonso et al. 2012). Bearing in mind the low potential, these include focusing on developing market chains and raising the consumption of aquatic products; maintaining the present ice distribution system; recognizing local traditional systems of resource management;

establishing programs on sustainable development of the sector, renovation of the fishing fleet, and accident-at-sea recovery; capacity building, including women; and maintaining the national fisheries statistical system and other roles for the NDFA.

Emerging Issues Facing Timor-Leste's Use of Marine Resources

The emerging issues relate mainly to marine aquaculture (discussed in the section on aquaculture) and climate change impacts (discussed in the section on current issues for marine resource management). Another such issue facing some Coral Triangle countries is harmful algal blooms. However, there are no reports of such blooms in Timor-Leste.

Table 4 Timor-Leste Fauna

Taxon	Number of Species	Number of Threatened Species
Vertebrates		
Amphibians	10	—
Freshwater fish	48	1
Marine fish	264	6
Freshwater and marine fish	22	—
Terrestrial birds	151	4
Marine birds	16	—
Terrestrial and marine birds	91	3
Terrestrial mammals	69	2
Marine mammals	28	3
Freshwater reptiles	3	—
Terrestrial reptiles	47	—
Marine reptiles	13	6
Invertebrates		
Freshwater mollusks	2	—
Marine mollusks	278	2
Marine crustaceans	39	—
Coelenterates	2	—
Hexacorals	12	—
Insects	488	—
Plants		
Terrestrial	807	4
Marine	28	—
Freshwater	30	—
Total	2,448	31

— = not applicable.

Source: ASEAN Center for Biodiversity.

Table 5 Endangered Animals and Plants of Timor-Leste

Common Name	Scientific Name	IUCN Status	Threatening Process
Trees			
Sandalwood	<i>Santalum album</i>	VU	Habitat loss, fires, agriculture, extraction
Borneo teak	<i>Intsia bijuga</i>	VU	Habitat loss, selective logging
Burmese rosewood	<i>Pterocarpus indicus</i>	VU	Habitat loss, agriculture, selective logging
	<i>Mangifera timorensis</i>	EN	
Birds			
Timor green pigeon	<i>Treron psittaceus</i>	EN	Habitat loss, agriculture, hunting
Timor imperial pigeon	<i>Ducula cineracea</i>	EN	Habitat loss, agriculture, hunting
Wetar ground dove	<i>Gallicolumba hoedtil</i>	EN	Habitat loss, agriculture, hunting
Yellow crested cockatoo	<i>Cacatua sulphurea</i>	EN	Habitat loss, harvest for pet trade, agriculture
Mammals			
Thin shrew	<i>Crocidura tenuis</i>	VU	Habitat loss, degradation, restricted range
Western naked-backed bat	<i>Dobsonia peronei</i>	VU	Habitat loss, extraction, restricted range
Mentawai palm civet	<i>Paradoxurus hermaphroditus</i>	VU	
Long-tailed macaque	<i>Macaca fascicularis</i>	LR/nt, CITES	
Northern common cuscus	<i>Phalanger orientalis</i>	CITES	
Timor leaf-nosed bat	<i>Hipposideros crumeniferus</i>	DD	
Greater long-eared bat	<i>Nyctophilus timoriensis</i>	VU	
Philippine horseshoe bat	<i>Rhinolophus philippinensis</i>	LR/nt	
Papuan pipistrelle bat	<i>Pipistrellus papuanus</i>	LR/nt	
Schreibers bent-winged bat	<i>Miniopterus schreibersii</i>	LR/nt	
Timor monitor lizard	<i>Varanus timorensis</i>	CITES	
Estuarine crocodile	<i>Crocodylus porosus</i>	CITES	
Timor python	<i>Python timorensis</i>	CITES	
Snake neck turtle	<i>Chelodina mccordi</i>	CR	
Southeast Asian box turtle	<i>Cuora amboinensis</i>	VU	
Insects			
Timor yellow tiger	<i>Parantia timorica</i>	EN	Severely fragmented population with ongoing decline

continued on next page

Table 5 *continued*

Common Name	Scientific Name	IUCN Status	Threatening Process
Marine Species			
Green turtle	<i>Chelonia mydas</i>	EN, CITES	
Hawksbill turtle	<i>Eretmochelys imbricata</i>	CR	
Leatherback turtle	<i>Dermochelys coriacea</i>	CR	
Loggerhead turtle	<i>Caretta caretta</i>	EN	
Olive ridley turtle	<i>Lepidochelys olivacea</i>	EN, CITES	
Dugong	<i>Dugong dugon</i>	VU	
Sperm whale	<i>Physeter catodon</i>	VU	
Killer whale	<i>Orcinus orca</i>	LR/ed, CITES	
Spinner dolphin	<i>Stenella longirostris</i>	LR/ed, CITES	
Bottlenose dolphin	<i>Tursiops truncatus</i>	DD	
Basking shark	<i>Rhincodon typus</i>	VU	
Southern giant clam	<i>Tridacna derasa</i>	VU	
Giant clam	<i>Tridacna gigas</i>	VU	
Small giant clam	<i>Tridacna maxima</i>	LR/ed	
Fluted giant clam	<i>Tridacna squamosa</i>	LR/ed	
Bear paw clam	<i>Hippopus hippopus</i>	LR/ed	
China clam	<i>Hippopus porcellanus</i>	LR/ed	
Giant coconut crab	<i>Birgula latro</i>	DD	

CITES = Convention on International Trade in Endangered Species of Wild Fauna and Flora; CR = critically endangered; DD = data deficient; EN = endangered; IUCN = International Union for the Conservation of Nature; LR = lower risk (nt = near threatened, ed = conservation dependent); VU = vulnerable.

Source: Foreign Assistance Act (FAA) 118/119 Report; Sandlund, et al. 2001. Assessing Environmental Needs and Priorities in East Timor. Final Report. NINANIKU, United Nations Development Programme (UNDP), Dili. Norwegian Institute for Nature Research. Trondheim.

National Plan of Action Initiatives and Future Plans

Timor-Leste is currently undertaking actions to achieve the regional goals of the Coral Triangle Initiative (CTI). These actions, which together comprise the country's National Plan of Action (NPOA), are consistent with the principles and guidelines of the regional CTI.

As with other CTI member states, Timor-Leste's NPOA includes five overall goals, and the strategies, targets, and initiatives it has formulated for achieving them. Each goal corresponds to a particular set of issues that relate to the marine resource:

- Goal 1: Designation and effective management of priority seascapes
- Goal 2: Application of an ecosystem approach to management of fisheries and other marine resources
- Goal 3: Establishment and effective management of marine protected areas
- Goal 4: Application of climate change adaptation measures
- Goal 5: Improvement of the status of threatened species

The priority seascapes identified under Goal 1 comprise large-scale geographies that have been prioritized for both investment and action. Under these investments and actions, best practices are to be applied and their use expanded. Goal 2 specifies that the ecosystem approach to fisheries and marine resource management is to be fully applied under Timor-Leste's NPOA. Similarly, the effective management of marine protected areas included under Goal 3 is to include community-based resource utilization and management.

Timor-Leste's CTI National Coordinating Committee (NCC) endorsed the NPOA in April 2010. The NPOA is consistent with other national programs relating to marine resources such as Timor-Leste's National Biodiversity Action Plan, its National Adaptation Plan of Action, and Program of Works on Protected Areas. To date, Timor-Leste has initiated programs for fulfilling all five goals. Since its establishment in 2009, the NCC has led implementation of national initiatives such as community-based fisheries management schemes in priority areas. These initiatives include strategies for diversifying household incomes in fishery-dependent areas.

Timor-Leste has made progress in fulfilling the five goals under its NPOA:

Goal 1: Designation and Effective Management of Priority Seascapes

All donor-assisted programs relating to priority seascapes (e.g., those funded with Coral Triangle Support Partnership [CTSP] and National Oceanic and Atmospheric Administration [NOAA] assistance), such as training on marine surveys, will be incorporated into national programs that focus on habitat enhancement and biodiversity conservation (e.g., the National Biodiversity Action Plan).

Goal 2: Application of an Ecosystem Approach to Management of Fisheries and Other Marine Resources

The government is undertaking a series of capacity-building initiatives for ensuring adoption of the ecosystem approach to fisheries management (EAFM). The Training Course on the Ecosystem Approach to Managing Coastal and Marine Resources, conducted in Timor-Leste in June 2011, explained the EAFM tools and techniques available to managers of fisheries, marine resources, and coastal areas. The integrated coastal management (ICM) component of the training helped participants to better understand the ICM framework and the processes it supports, as well as how it can be used to promote sustainable output from the fisheries resource. The fisheries management component explained the principles and framework of the EAFM to participants. Identification of activities for initiating ICM programs, and prioritizing immediate actions relating to management of the fisheries subsector concluded the course.

This course also served as a venue for forging new partnerships and strengthening collaboration between the CTSP, the Ministry of Agriculture and Fisheries (MAF), NOAA, PEMSEA, academic institutions, district offices, national agencies, and staff from ongoing programs and projects that address marine and coastal management concerns in Timor-Leste. Capacity-building and technical requirements were likewise identified, and plans for follow-on training agreed.

In collaboration with the CTSP, the government also developed knowledge products for use in its capacity-building initiative such as fisheries logbooks, sample licensing procedures, monitoring protocols, lessons on spawning aggregation, and information on size at sexual maturity, and the life cycles of key fish species. A fisheries legal framework was also presented, and a national aquaculture strategy developed.

With support from the Asian Development Bank (ADB), the government is strengthening the NDFA's capacity in formulating a legal reform program for ICM and EAFM. Similarly, the Timor-Leste Lawyers' Association is currently training environmental law students and practitioners to improve their contribution to the formulation of ICM legal frameworks, policy, and legislation as these relates to management of Timor-Leste's natural resource base.

Goal 3: Establishment and Effective Management of Marine Protected Areas

Initiatives relating to Goal 3 mainly relate to establishment of the Coral Triangle Marine Protected Area System.

In 2007, Timor-Leste formally declared its first national park, Nino Konis Santana National Park. Following the park's establishment, it was incorporated into Timor-Leste's national protected area network. IUCN has declared Nino Konis Santana Park a Management Category V Protected Landscape/Seascape, in that the park maintains tradition and culture in a way that protects the environment and provides sustainable livelihoods for local communities.

With support from BirdLife International and the Department of Environment and Climate Change of the New South Wales (Australia) State Government, Timor-Leste adopted a collaborative approach to managing Nino Konis Santana Park that includes joint management with members of local communities and civil society organizations. Outreach and community engagement training events were conducted at the park in 2010 for staff of the national and district government, and members of local communities. The purpose of these training events was to formulate action plans that identified field activities for fostering park conservation efforts. Similarly, with CTSP assistance, joint management of the park was further strengthened by the formulation of a capacity development strategy for the park's joint managers.

In 2012, an extensive marine survey of the park's northern coast was performed. This survey discovered new marine species, and relatively high concentrations of marine biodiversity. The results of this survey have been used to inform further zoning and management planning for Nino Konis Santana National Park.

In addition, a number of current initiatives will result in designation of other MPAs in Timor-Leste. For example, the NPOA now identifies both Batugade Subdistrict and Atauro Island as marine protected area (MPA) sites to be declared in the future.

The NCC and the MAF are working with ADB to establish the country's first community-managed MPAs. With support from locally-based nongovernment organizations (NGOs), MPA establishment committees comprising community leaders, fishers, local government officials, and resort owners have been formed. These committees will ultimately establish MPAs at both these new sites. In May 2013, training in MPA establishment and management was provided to NGOs, staff members of MAF and the Department of Environment, as well as MPA focal points for Nino Konis Santana National Park. Follow-on field-based training was provided in Cebu, Philippines, which is home to some of the longest-existing community-managed MPAs in the Coral Triangle. These trainees also received open-water diving certification training in Dili, which is essential for monitoring MPAs. Members of the establishment committees are conducting village awareness programs to inform other stakeholders that new MPAs will be established.

Once appropriate biological surveys, geographic information system mapping, and ground truthing have been completed, the MPA establishment committees will proceed to demarcate the sites, prepare management plans, and seek formal designation of the sites as Timor-Leste's first community-managed MPAs. With assistance from ADB, the NCC will document the MPA

establishment process. This documentation will form the basis of national guidelines for establishing MPAs. Future activities in this regard include formulation of a model MPA network, identification of priorities relating to conservation, and pilot testing of sustainable financing for MPAs.

A similar process is being followed for establishing other MPAs in Covalima and Viqueque districts.

Goal 4: Application of Climate Change Adaptation Measures

With CTSP assistance, Timor-Leste government officials and local residents received training on the Regional Early Action Plan for Climate Change Adaptation, and on development of the Local Early Action Plan Toolkit. This training taught government officials and residents of local communities in the area adjacent to Nino Konis Santana National Park how to incorporate climate-change considerations into community zoning and regulations. This training was then replicated in other areas.

Timor-Leste is one of a number of sites at which ADB and the WorldFish Center have developed a community-based, climate-change adaptation decision-making toolkit with funding from the Global Environment Facility. Working with fishers and farmers in Batugade and Atauro, a team of climate change and coastal livelihoods experts developed a process by which local communities could (i) assess their vulnerability to climate change, (ii) identify and analyze the climate-change adaptation options available to them, and (iii) plan the climate-change actions they will undertake. In addition to being a learning experience for the fishers and farmers who participated, this initiative validated their own personal observations regarding climate change. Outputs of the exercise included operational plans for adapting to climate change by members of participating communities.

The Government of Timor-Leste also participated in a study on climate-change impacts and adaptation strategies as these relate to coastal and marine resources in Coral Triangle countries. The government will use the recommendations formulated by this study to develop strategies for building the climate-change resilience of coastal communities and improving food security. These strategies will include implementation of environmentally sound aquaculture techniques.

The NCC is also formulating plans for a climate-change information center that will house data and information that will be used by Timor-Leste decision makers and development planners.

Goal 5: Improvement of the Status of Threatened Species

Timor-Leste has developed policies for addressing threatened species, and will in all likelihood ratify the Convention on Wetlands of International Importance (Ramsar Convention), as well as the Convention on International Trade in Endangered Species of Wild Fauna and Flora (CITES). Such ratification will support fulfillment of the Millennium Development Goal on protection of endangered species in Timor-Leste.

References

- Alongi, D. 2009. *The Energetics of Mangrove Forests*. Berlin: Springer Verlag.
- Alongi, D., A. Amaral, N. Carvalho, A. McWilliam, J. Rouwenhorst, F. Tirendi, L. Trott, and R.J. Wasson. 2009. *River Catchments and Marine Productivity in Timor-Leste: Caraulun and Laclo Catchment(s); South and North Coasts*. Arafura and Timor Sea Expert Forum (ATSEF) Project 6.
- Alonso, E., C. Wilson, P. Rodrigues, M. Pereira, and D. Griffiths. 2012. Policy and Practice. Recommendations for Sustainable Fisheries Development in Timor-Leste. Bangkok: *Regional Fisheries Livelihoods Programme for South and Southeast Asia Policy Paper TIM#2*.
- Audley-Charles, M.G. 2004. Ocean Trench Blocked and Obliterated by Banda Forearc Collision with Australian Proximal Continental Slope. *Tectonophysics* 389. pp. 65–79.
- Ayling, A.M. and A.L. Ayling. 2009. Preliminary biological resource survey of fringing reefs in the proposed East Timor Nino Konis Santana Marine Park. Draft report to the Northern Territory Department of Natural Resources, Environment, and the Arts. Darwin.
- Barbosa, M. and S. Booth. 2009. East Timor's Fisheries Catch Reconstruction (1950–2009): Fisheries Under Different Regimes. In *Fisheries catch reconstructions: Islands, Part I*, edited by D. Zeller and S. Harper. *Fisheries Centre Research Reports* 17 (5). Fisheries Centre, University of British Columbia. pp. 39–51.
- Baticados, D. 2005. *Socio-economic Issues in Fishing Communities and Socio-Economic Indicator to Monitor and Evaluate Sustainable Fisheries Development in East Timor*. Report to FAO.
- Boggs, G., K. Edyvane, N. de Carvalho, S. Penny, J. Rouwenhorst, P. Brocklehurst, I. Cowie, C. Barreto, A. Amaral, N. Smit, J. Monteiro, P. Pinto, R. Mau, J. Amaral, and L. Fernandes. 2009. *Marine and Coastal Habitat Mapping in Timor-Leste (North Coast) – Final Report*. Project 1 of the Timor-Leste Coastal-Marine Habitat Mapping, Tourism and Fisheries Development Project. Ministry of Agriculture and Fisheries, Government of Timor-Leste.
- Cinnati, R. 1987. *Arquitectura Timorense*. Lisboa: Instituto de Investigação Científica Tropical, Museu de Etnologia.
- Cook, D.C. 2000. *Mission Report: Rapid Appraisal of the Small-Scale Fisheries Sector of East Timor*. Rome: FAO.
- Da Silva, S. and T.F. Moniz. 2011. Climate, climate variability and change of Timor-Leste. Pacific Climate Change Program Update.
- De Carvalho, D., V. Da Silva Guterres, and A. Delimas. 2007. *Potensia Peska no Retrato Feto iha Aona Kosteira Parte Leste* [Fisheries Potential and a Portrait of Women in Coastal Areas in the Eastern Tip of Timor]. Dili: Haburas Foundation.

- Deutsch, C. 2003. Coral Reefs in East Timor: An Investigation of the Impacts of Fishing on Reef Fish Abundance. EM 531 Project Report, Unpublished.
- Drysdale, J. 2007. *Sustainable Development or Resource Cursed? An Exploration of Timor-Leste's Institutional Choices*. Fenner School of the Environment. Canberra, Australian National University. Doctor of Philosophy dissertation.
- Dupuis, I. and C. Dumas. 1990. Influence of Temperature Stress on In Vitro Fertilization and Heat Shock Protein Synthesis in Maize (*Zea mays* L.) Reproductive Tissues. *Plant Physiology* 94. pp. 665–667.
- Dutra, L.X.C. and M.B. Taboada. 2006. *Preliminary Survey of the Coral Reefs from Beloi (Atauro Island, Timor-Leste): Alternatives for Sustainable Use*. Dili: Ministry of Agriculture, Forestry and Fisheries, National Directorate of Fisheries and Aquaculture. 9p.
- Edyvane, K., A. McWilliam, J. Quinta, A. Turner, S. Penny, I. Teixeira, C. Pereira, Y. Tibirica, and A. Birtles. 2009. *Coastal and Marine Ecotourism Values, Issues and Opportunities on the North Coast of Timor-Leste*. Final Report. Ministry of Agriculture & Fisheries, National Directorate of Tourism, Government of Timor-Leste
- English, S., Wilkinson, C., and Baker, V. 1997. Survey Manual for Tropical Marine Resources, 2nd edition. Townsville: Australian Institute of Marine Science.
- FAO Emergency Office in Timor-Leste. 2011. *Timor-Leste and FAO Achievements and Success Stories*. Dili.
- Fedele, S. and P. Horjus. 2006. *Timor-Leste: Comprehensive Food Security and Vulnerability Analysis*. World Food Programme, Vulnerability Analysis and Mapping Branch.
- Food and Agriculture Organization of the United Nations (FAO). 2003. Status and Trends in Mangrove Area Extent Worldwide. *Forest Resources Assessment Working Paper* No. 63. Rome: Forest Resources Division.
- GERTIL. 2002. *Atlas de Timor-Leste*. Grupo de Estudos de Reconstrução de Timor-Leste (GERTIL). Lisboa: Lidel.
- Hamson, G. 2004. The Tectonic Evolution of East Timor and the Banda Arc. B.Sc.(Hons) Literature Review. University of Melbourne, Melbourne.
- Herrero, M.P. and R.R. Johnson. 1980. High Temperatures and Pollen Viability in Maize. *Crop Science*. 20. pp. 796–800.
- Hodgson G. 1999. A Global Assessment of Human Effects on Coral Reefs. *Marine Pollution Bulletin*. 38(5). pp 345–355.
- IRIN. 2012. <http://www.irinnews.org/Report/88648/TIMOR-LESTE-Coping-with-seasonal-food-shortages>.
- Jasarevic, T. 2002. Reviving fisheries in East Timor – Casting nets for development. UN Volunteers. <http://www.unv.org/en/what-we-do/countries/timor-leste/doc/reviving-fisheries-in-east.html> (Accessed 21 April 2012).
- Kailola, P.J. 1993. Tropical Snappers, *Pristipomoides* Species. In *Australian Fisheries Resources*, eds. P.J. Kailola, M.J. Williams, P.C. Stewart, R.E. Riechelt, A. McNee, and C. Grieve. Canberra: Bureau of Resource Sciences, Department of Primary Industries and Energy, and the Fisheries Research and Development Corporation.

- Keep, M., L. Barber, and D. Haig. 2009. Deformation of the Cablac Mountain Range, East Timor: An Overthrust Stack Derived from an Australian Continental Terrace. *Journal of Asian Earth Sciences*. 35. pp. 150–166.
- Kiriono, D. 2010. *Climate Change in Timor-Leste – A Brief Overview on Future Climate Projections*. Prepared for the Australian Department of Climate Change and Energy Efficiency.
- Kiswara, W. and L. Winardi. 1994. Upload Diversity and Distribution in the Gulf Kuta and Gerupuk Bay, South Lombok. *National Marine Technology Journal*. 3(1). pp. 23–36.
- Maralessy, C. 2012. Personal communication.
- McKinnon, A.D., J.H. Carleton, and S. Duggan. 2011. Determinants of Pelagic Metabolism in the Timor Sea during the Inter-Monsoon Period. *Marine and Freshwater Research* 62. pp. 130–140.
- McWilliam, A. 2002. Timorese Seascapes. *Asia Pacific Journal of Anthropology*. 3(2). pp. 6–32.
- Molyneux, N., G. Rangel da Cruz, R.L. Williams, R. Andersen, and N.C. Turner. 2012. Climate Change and Population Growth in Timor-Leste: Implications for Food Security. *Ambio*. DOI 10.1007/s13280-012-0287-0.
- Monk, K.A., Y. Fretes, and G. Reksodiharjo-Lilley. 1997. The Ecology of Nusa Tenggara. *The Ecology of Indonesia Series*, Volume 5. Hong Kong, China: Periplus Editions (HK) Ltd.
- National Directorate of Fisheries and Aquaculture and WorldFish Center. 2011. Timor-Leste National Aquaculture Strategy Development: Progress Report. Submitted to: FAO/RFLP (LOA/RAP/2010/88) CTSP (Agreement # CT09, Amendment #5, Activity No: C11-2.4-009).
- Nienhuis, P.H., Coosen, J., and W. Kiswara. 1989. Community Structure Biomass Distribution of Seagrass and Macrofauna in the Flores Sea, Indonesia. *Netherlands Journal of Sea Research*. 23(3). pp. 197–214.
- O'Connor, S. and P. Veth. 2005. Early Holocene Shell Fish Hooks from Lene Hara Cave, East Timor establish Complex Fishing Technology was in Use in Island South East Asia Five Thousand Years before Austronesian Settlement. *Antiquity* 79(304). pp. 249–256.
- Oliveira, N.V. 2008. Subsistence Archaeobotany: Food Production and the Agricultural Transition in East Timor. Australian National University, Canberra. Doctor of Philosophy dissertation. <http://palaeoworks.anu.edu.au/Nuno.html>
- oreporter.com. 1989. Timor-Leste sofre com pesca ilegal por parte de estrangeiros. <http://www.oreporter.com/Timor-Leste-sofre-com-pesca-ilegal-por-parte-de-estrangeiros,1450698970.htm>
- Pedi, D. 2007. *Community-based Ecotourism as a Pro-poor Development Option: A Case Study of Tua Ko'in Eco-village, Atauro Island, Timor-Leste*. School of Global Studies, Social Science and Planning, Melbourne. Royal Melbourne Institute of Technology University. Master of Social Science thesis.
- Pinto, R. 2011. Fish Poison Use in Nino Konis Santana National Park. Community Consultation Special Report. Unpublished Coral Triangle Support Partnership (CTSP) Technical Report.
- Pinto, R. and C. Da Cunha Barreto. Capacity Needs Assessment for the Department of Fisheries Resource Management and Research, National Directorate of Fisheries and Aquaculture, Ministry of Agriculture and Fisheries, Timor-Leste. Unpublished CTSP Report.

- Regional Physical Planning Program for Transmigration. 1989. *Regional Physical Planning Program for Indonesia, Review of Phase I Results: Java and Bali*. Jakarta, Indonesia: Directorate General of Settlement Preparation; Chatham, UK: Ministry of Transmigration Natural Resources Institute; London: Overseas Development Administration.
- Roelofs, A., R.G. Coles, and N. Smit. 2005. *A Survey of Intertidal Seagrass from Van Diemen Gulf to Castlereagh Bay, Northern Territory, and from Gove to Horn Island*. Report to the National Oceans Office. Tasmania, Australia.
- Sandlund, et al. 2001. Assessing Environmental Needs and Priorities in East Timor. Final Report. NINANIKU, United Nations Development Programme (UNDP), Dili. Norwegian Institute for Nature Research. Trondheim.
- Spriggs, M., S. O'Connor, and P. Veth. 2003. Vestiges of Early Pre-agricultural Economy in the Landscape of East Timor: Recent Research. In *Fishbones and Glittering Emblems: Proceedings from the EurASIEASigtuna Conference*, edited by A. Kallen and A. Karlstrom, pp. 49–58. Stockholm.
- TDCA. 2004. Final Report of Thailand and Timor-Leste Joint Survey on Fishery Research and Oceanographic Observations in the Exclusive Economic Zone of Timor-Leste.
- Timor-Leste Ministry of Finance. 2010. Census 2010. <http://www.mof.gov.tl/about-the-ministry/statistics-indicators/statistics-and-census/?lang=en>
- Timor-Leste Ministry of Finance, National Directorate for Statistic. 2001. Population and Housing Census. The Government of the Democratic Republic of Timor-Leste.
- Tomascik, T. 1993. Coral Reef Ecosystems. Environmental Management Guidelines. *EMDI (Environmental Management Development in Indonesia Project) Environmental Reports*, 35. Dalhousie University, School for Resource and Environment Studies. Halifax, Nova Scotia. 79 pp.
- Tomascik T., A.J. Mah, A. Nontji, and M. Kasim Moosa. 1997. *The Ecology of the Indonesian Seas, Part 1*. Hong Kong, China: Periplus Editions (HK) Ltd.
- UniQuest. 2010. RETA 6471: *Strengthening Coastal and Marine Resource Management in the Coral Triangle of the Pacific – Phase 1*. Prepared for the Asian Development Bank. <http://www2.adb.org/Documents/Reports/Consultant/REG/42073/42073-01-reg-tacr-02.pdf>.
- VAM. 2006. *Vulnerability Analysis and Mapping. Timor-Leste: Comprehensive Food Security and Vulnerability Analysis*. Rome: World Food Programme.
- Wagey, T. and Z. Arifin, eds. 2008. *Marine Biodiversity Review of the Arafura and Timor Sea*. Jakarta: Ministry of Marine Affairs and Fisheries.
- Wever, L. 2005. *Assessing Management Challenges and Options in the Coastal Zone of Timor-Leste*. Gold Coast, Queensland: Griffith Centre for Coastal Management.
- Wong, L.S. and L.M. Chou. 2004. Status of Coral Reefs on North-East Atauro Island, Timor-Leste, Based on Surveys Conducted in November 2004. *REST (Reef Ecological Study Team) Technical Report No. 7*, National University of Singapore: Marine Biology Laboratory, Department of Biological Sciences.
- World Bank. 2011. *Transport in Timor-Leste*. <http://go.worldbank.org/KVSPYH8GI0> (Accessed 21 April 2012).

State of the Coral Triangle: Timor Leste

One of a series of six reports on the status of marine resources in the western Pacific Ocean, the *State of the Coral Triangle: Timor-Leste* describes the biophysical characteristics of Timor-Leste's coastal and marine ecosystems, the manner in which they are being exploited, the framework in place that governs their use, the socioeconomic characteristics of the communities that use them, and the environmental threats posed by the manner in which they are being used. It explains the country's national plan of action to address these threats and improve marine resource management.

About the Asian Development Bank

ADB's vision is an Asia and Pacific region free of poverty. Its mission is to help its developing member countries reduce poverty and improve the quality of life of their people. Despite the region's many successes, it remains home to approximately two-thirds of the world's poor: 1.6 billion people who live on less than \$2 a day, with 733 million struggling on less than \$1.25 a day. ADB is committed to reducing poverty through inclusive economic growth, environmentally sustainable growth, and regional integration.

Based in Manila, ADB is owned by 67 members, including 48 from the region. Its main instruments for helping its developing member countries are policy dialogue, loans, equity investments, guarantees, grants, and technical assistance.

Asian Development Bank
6 ADB Avenue, Mandaluyong City
1550 Metro Manila, Philippines
www.adb.org



Printed on recycled paper

Printed in the Philippines