Analyses of the Current Situation and Potential for Aquaculture Development in Timor-Leste

National Directorate of Fisheries and Aquaculture
Ministry of Agriculture and Fisheries
Timor-Leste
2012
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<th>Acronym</th>
<th>Definition</th>
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<tbody>
<tr>
<td>ALGIS</td>
<td>Agriculture and Land-use Geographic Information System</td>
</tr>
<tr>
<td>FAO</td>
<td>Food and Agriculture Organization</td>
</tr>
<tr>
<td>GIS</td>
<td>Geographical Information system</td>
</tr>
<tr>
<td>GoTL</td>
<td>Government of Timor-Leste</td>
</tr>
<tr>
<td>HRD</td>
<td>Human Resource Development</td>
</tr>
<tr>
<td>I/NGOs</td>
<td>International/National Non-governmental Organizations</td>
</tr>
<tr>
<td>IAA</td>
<td>Integrated agriculture-aquaculture</td>
</tr>
<tr>
<td>MAF</td>
<td>Ministry of Agriculture and Fisheries</td>
</tr>
<tr>
<td>MoE</td>
<td>Ministry of Environment</td>
</tr>
<tr>
<td>MoED</td>
<td>Ministry of Economy and Development</td>
</tr>
<tr>
<td>MoH</td>
<td>Ministry of Health</td>
</tr>
<tr>
<td>MTCI</td>
<td>Ministry of Tourism, Commerce and Industry</td>
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<tr>
<td>NDFA</td>
<td>National Directorate of Fisheries and Aquaculture</td>
</tr>
<tr>
<td>RFLP</td>
<td>Regional Fisheries Livelihoods Programme</td>
</tr>
<tr>
<td>SDP</td>
<td>Strategic Development Plan</td>
</tr>
<tr>
<td>SME</td>
<td>Small and medium sized enterprise</td>
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EXECUTIVE SUMMARY

Combating poverty and malnutrition has always been the topmost priority agenda of the Government of Timor-Leste (GoTL) since its independence in 2002. It is apparent that widespread poverty and malnutrition continue to remain major impediments to recovery and potential growth of the country.

There is strong need for improving access to animal protein sources to address the problem of chronic malnutrition in Timor-Leste. Aquaculture development has been identified by the GoTL as a means of improving the food and nutrition security situation of inland communities. Coastal aquaculture is also considered as having potential to provide opportunities to raise income among coastal communities. There is increasing appreciation that fish can play an important role in supplying essential fats for brain development and cognitive ability in the foetus, and for the young child up to 24 months of age.

Development of a national strategy to provide practical guidance for socially and environmentally responsible aquaculture has been one of the priorities of the National Directorate of Fisheries and Aquaculture (NDFA). A framework for the preparation of the National Aquaculture Strategy was outlined in 2010, which highlighted various issues related to aquaculture development in the country. It was emphasized that the Strategy should follow a holistic approach, and aim at producing lasting impacts on the livelihoods of a large number of resource-poor communities.

In 2011, a study was carried out, particularly to provide background information and analysis for the preparation of the National Aquaculture Development Strategy. The study analyzed the current situation and potential for aquaculture development in Timor-Leste, encompassing agro-ecological, social, economic and institutional aspects. The study methodology included a review of available secondary information from GOs/NGOs/donor funded development projects; visits to potential aquaculture development sites in selected districts; and consultation with stakeholders (including government, farmers, development partners, I/NGOs, and private sectors) at national and local levels.

Analysis of the current aquaculture situation revealed that:

- Low input–low output freshwater pond aquaculture systems currently in practice in Timor-Leste are unlikely to become a viable option to improve the livelihoods of resource-poor farming households.
- However, there is potential for improving the performance of the current ‘extensive’ fish culture systems to ‘semi-intensive’ level in a balanced and sustainable way to ensure optimal levels of productivity and efficiency from aquaculture.
- Expansion and intensification of freshwater aquaculture is largely constrained by the unavailability of production inputs, viable technologies, and inadequate human resources within the NDFA.
- Rehabilitation of existing brackishwater aquaculture ponds would be essential to restart shrimp and milkfish culture.
- Seaweed farming was introduced after the independence of the country – essentially all seaweed produced is exported to overseas markets.
Nevertheless, aquaculture development in Timor-Leste is believed to have significant potential for improving the livelihoods of small-scale farming households and resource-poor communities. The government has also recognized this and has clearly emphasized the need for aquaculture development in its Strategic Development Plan (2011-2030):

- Suitable agro-ecologies for freshwater aquaculture development in Timor-Leste were identified through GIS modelling. Analysis provided the basis for zoning aquaculture development pockets based on a combination of bio-physical, social and economic factors.

- There is high potential for freshwater aquaculture development in Timor-Leste, but the total area suitable for its development varies according to the resource base and socio-economic context across districts.

- Brackish water aquaculture could be developed through rehabilitation of existing milkfish and shrimp ponds (22 ha), which could be developed in the short term. There is potential for the expansion of shrimp and milkfish farming in the medium and long term, but care would have to be taken to ensure that expansion did not negatively impact on coastal mangrove areas.

- Viability of seaweed farming could be increased through improvements in post-harvest handling, drying and packaging systems. Value addition would increase market prices, thereby making the enterprise more viable.

- Sustainable aquaculture technologies, adequate human resources, input supply systems, provision of markets, infrastructure and a conducive policy environment are vital to harnessing aquaculture development potential, thereby contributing towards alleviating the chronic food and nutrition insecurity in Timor-Leste. Moreover strong coordination among GOs, I/NGOs, the private sector, and communities would be essential to translate the potential into reality.

Overall, this analysis provided background for the preparation of the Timor-Leste Aquaculture Development Strategy which was presented to a national workshop of key stakeholders for their feedback on 16 February 2012.
1. **Background**

Timor-Leste’s people are chronically food insecure. The nutritional status of children and adults in the country remains well below acceptable world standards. Timor-Leste has one of the world’s highest rates of maternal, newborn, infant and child mortality and under-nutrition. In recent years, the Government of Timor-Leste (GoTL) has strongly emphasized the need for diversification of livelihoods for the improvement of food and nutrition security in the country. A joint program on promoting food and nutrition security through building synergies among the UN agencies and their support to the government was launched in 2009\(^1\) in order to effectively address the problem of widespread poverty and hunger. In 2010, the Comoro Declaration against hunger and malnutrition (Comoro Declaration, 2010) was made, which reiterated the need for a nationwide coordinated action plan and international efforts to realize ‘food and nutrition security’ as a fundamental right of every person.

Timor-Leste recently launched the Strategic Development Plan (SDP) (2011-2030)\(^2\). The SDP provides a vision and actions that will guide the country’s pathways to development until 2030. It envisages the need for the development of a thriving agricultural sector to reduce poverty, provide food and nutrition security, and to promote economic growth of the nation as a whole. The need for the expansion and intensification of crop and livestock production systems, as well as the development of sustainable fisheries and aquaculture sector is emphasized in the SDP. The SDP (2011-2030) is an integrated package of strategic policies to be implemented in three stages — short term (first five years), medium term (five to 10 years) and long term (10 - 20 years) as follows:

- **STAGE 1**: Short term (2011-2015): Human resource development; strategic industries; and, infrastructure;
- **STAGE 2**: Medium term (2016-2020): Infrastructure; strengthening human resources; and, market formation; and,
- **STAGE 3**: Long term (2021-2030): Eradication of extreme poverty; strong private sector; and diversified non-oil economy.

Aquaculture in Timor-Leste has the potential to contribute to reducing chronic food insecurity and nutrition problems, and to generate income. A draft *Policy and Strategy for Fisheries Development in Timor-Leste* (dated 2007) nominates the development of a viable aquaculture industry in the country as a policy priority, but it lacks a practical prioritized implementation strategy. The current legislation accommodates aquaculture in a limited way, and is mainly concerned with subsidies and fish licensing.

The National Directorate of Fisheries and Aquaculture (NDFA) under the Ministry of Agriculture and Fisheries (MAF) is responsible for the development and management of the aquaculture sector. Existing fisheries legislation emphasizes marine capture fisheries, with inadequate attention to aquaculture. Developing policy for aquaculture is a priority of the NDFA. There are presently no established procedures for licensing, site selection or zoning – all of which are necessary to develop an industry that integrates inland as well as coastal aquaculture development initiatives. A draft policy for aquaculture has been prepared, but it has limited ‘ownership’ by the GoTL, and the government lacks a practical implementation plan.

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\(^1\) Joint Program: Promoting Sustainable Food and Nutrition Security in Timor-Leste (2009), Ministry of Economic Development, Timor-Leste

The need for the development of a national strategy to provide practical guidance for a socially and environmentally responsible aquaculture sector was agreed during a WorldFish mission to Timor-Leste in 2009 (see 2009 WFC mission report to the Coral Triangle Support Partnership [CTSP]). The mission recommended investment in a range of areas, including pilot sites (see 2009 WFC mission report to CTSP). Meetings with the NDFA, the Regional Fisheries Livelihoods Programme (RFLP) funded by Spain and executed by FAO, CTSP and other key stakeholders during another WorldFish mission in November 2010 (see 2010 WFC mission report to CTSP) reiterated the need to prioritize the National Aquaculture Strategy. A framework for its preparation was also outlined during these meetings. It was agreed that the Strategy must encompass both marine and freshwater components in a coherent policy framework. All the stakeholders recognized that an aquaculture strategy anchored in the principles of combating widespread poverty and malnutrition and effective ecosystem management would provide a framework for future responsible development of the sector.

In view of the challenges of managing a co-funded project, senior scientists from WorldFish travelled to Dili in March 2011 and a consensus was reached among NDFA, WorldFish and the funding partners (RFLP and CTSP) to ensure an integrated approach.

Subsequent visits were made to Timor-Leste by the WorldFish team between April and August 2011. Field visits and consultations with national and local level stakeholders were carried out jointly by the NDFA and the WorldFish team.

This document provides an analysis of the current situation and potential for aquaculture development in Timor-Leste, and is the basis for preparation of the aquaculture strategy, which is presented as a separate document. The analysis was prepared by the NDFA with support of WorldFish, and funded by the RFLP and CTSP.

2. The Context

2.1 Widespread poverty and food insecurity

Rural livelihoods systems in Timor-Leste, one of the poorest countries in Asia, are largely dependent on crop farming and livestock raising, essentially of subsistence or semi-subsistence nature. The country has been facing chronic food insecurity, which is attributed to low crop yields, lack of income-generating activities, limited purchasing power, drought and lack of infrastructure. Nearly half of its total population is living in extreme poverty. Around half the children across the country do not have a nutritionally balanced diet. The World Food Program (2010)\(^3\)\(^4\) estimates the proportion of underweight and stunted (too short for their age) children under five in the country to be 45% and 54%, respectively. A Timor-Leste demographic and health survey (2009-10)\(^5\) revealed that over half the children were stunted in 10 of the Timor-Leste’s 13 districts. Bobonaro, Oecussi, Ermera, Manufahi, Covalima and Ainero are the districts where an estimated two-thirds to nearly three quarters of children under five are stunted. Likewise, one-third of women (between 15-49 years) are estimated to be thin with a body mass index (BMI) <18.5%. In general, districts with a high rate of stunting among children under five also have a high proportion of undernourished women.

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\(^{3}\) In: http://www.wfp.org/countries/timor-leste


Around three quarters of the population in Timor-Leste is living in rural areas. Whilst the government has set a US $0.88 income per caput per day as the national poverty line, progress towards meeting MDG targets has been rather slow. Despite continued efforts on the part of the government and its development partners in improving livelihoods, increased incidences of poverty have been reported in recent years. The proportion of the population living below the extreme poverty line (USD 0.88 per caput per day) in the country was estimated to have increased to 50% in 2007 from 36% in 2001. 

Improving food and nutrition security of the population across the country is the primary concern. In order to address the widespread problem of poverty, the government has in recent years put emphasis on diversification and intensification of agricultural production.

### 2.2 The Challenge: combating poverty and malnutrition

Combating poverty and malnutrition has always been the topmost priority agenda of the GoTL since its independence in 2002. It is apparent that widespread poverty and malnutrition are still major impediments to recovery and the potential growth of the country.

Demand for food in Timor-Leste has greatly exceeded local supply in recent years. The country relies heavily on imported food grains as well as on processed food items to bridge the widening gap between demand and supply. Timor-Leste imported 25,892 t of rice between January and June 2011, which is estimated to be over half the national demand for the six months (see Food and Nutrition Security Task Force Report, 2011). In the same period, the country imported an estimated 1,825 t and 2,667 t of chicken and beef, respectively. Whilst there is heavy dependence on imported food, the high rate of inflation on major food items in the global market poses a new challenge to Timor-Leste. The food price index rose 15% between April 2010 and April 2011. The GoTL has been providing subsidies on major food grains as one of its strategies for combating food insecurity. Nevertheless, overreliance on the major staple food grains (rice and maize) by the government and development partners as well as poor knowledge of the households on nutritionally balanced diet have been major challenges to improving food and nutrition security situation in Timor-Leste. Whilst rice is considered as the major staple food grain, only a quarter of the total households farm rice.

The current population size of Timor-Leste is only 1.07 million. Nevertheless, the annual population growth rate in Timor-Leste is estimated at 3.2% and if this trend continues, the population will double by 2030. Food supply, and public goods and facilities would need to double just to maintain the current standard of living. Thus, it is vital to take into consideration population growth for the success of programs aimed at improving the food and nutrition security situation in Timor-Leste in the future.

Despite continued efforts, limited progress towards meeting MDG targets has been achieved due primarily to the adoption of a sectoral approach to addressing the chronic hunger and malnutrition situation. A holistic approach to agriculture development is crucial for realizing sustainable improvement in food and nutrition security in Timor-Leste. Rather than focusing on conventional farming practice for cereals, emphasis should be given to diversification of livelihoods options through harnessing ‘niche’ based agriculture development potential.
SDP (2011-2030) envisions that the country will develop its agriculture sector not only to meet the domestic demand but also to generate revenue from the export of surplus. Nevertheless, the GoTL is well aware of the challenges that lie ahead to translate its ambitious targets into reality. In recent years, the strong need for a coordinated action plan and international efforts has been emphasized to effectively combat hunger and malnutrition. The Timor-Leste joint program on MDG-F (2009); Comoro declaration against famine and malnutrition (2010); Food and nutrition security task force report (2011) are some of the examples of such endeavors.

2.3 Dietary systems and role of animal protein sources in the Timorese diet

Traditionally, carbohydrate-based foods (maize, rice, cassava, taro, sweet potato, beans and vegetables) are the major source of calories in the Timorese diet. Animal protein sources such as meat and fish are consumed only on special occasions, as these are not only expensive but are also in limited supply in rural areas. Though an island nation, the lack of an ice production and distribution network means little marine fish reaches inland areas. With a large majority of population in Timor-Leste lacking a nutritionally balanced diet, it has one of the world’s highest rates of maternal, newborn, infant and child mortality and under-nutrition.

A study conducted by the Spanish funded, FAO executed and NDFA implemented Regional Fisheries Livelihoods Programme (RFLP) in 2011 assessed the role of fish and animal source protein in the Timorese diet. The study included a survey of a total of 820 randomly selected households across five districts, namely Baucau, Dili, Bobonaro, Covalima and Oecussi. The study confirmed the minimal role of animal source food in the diet of surveyed households (Tables 1, 2)\(^\text{10}\). Annual per capita consumption of fish was estimated at 6.1 kg, which is only about a third of average consumption of Asian countries. A strong variation in annual per capita fish consumption was noted across the districts (from 1.8 kg in Bobonaro to 8.6 kg in Oecussi). Bobonaro and Covalima districts had the most deprived communities with very low access to animal source protein. Naturally, fish consumption was high among coastal communities. Table 2 shows that inland districts consumed approximately one quarter the amount of fish protein of coastal districts. While on average fish was a more important animal protein source than meat, this varied by district. In Baucau, Bobonaro and Oecussi per capita consumption of meat was higher than fish.

<table>
<thead>
<tr>
<th>District</th>
<th>Consumption (kg/capita/year)</th>
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<tbody>
<tr>
<td></td>
<td>Fish</td>
</tr>
<tr>
<td>Baucau</td>
<td>5.5</td>
</tr>
<tr>
<td>Dili</td>
<td>7.5</td>
</tr>
<tr>
<td>Bobonaro</td>
<td>1.8</td>
</tr>
<tr>
<td>Covalima</td>
<td>5.1</td>
</tr>
<tr>
<td>Oecussi</td>
<td>8.6</td>
</tr>
<tr>
<td><strong>Mean</strong></td>
<td><strong>6.1</strong></td>
</tr>
</tbody>
</table>

\(^{10}\) Source: FAO/RFLP Timor-Leste (2011),
\(^{11}\) Source: FAO/RFLP Timor-Leste (2011),
The results of the recent RFLP study confirm that per capita consumption of animal protein in Timor-Leste was significantly lower than the Asian region. Annual per capita consumption of fish in the country at an estimated 6.1 kg is also substantially lower than the global (17.3 kg/capita/year), least developed countries (9.8 kg/capita/year), and low-income food-deficit countries (8.8 kg/capita/year) averages. Similarly, average per capita meat consumption was estimated at merely around 1/8th of the global average. The global and developing countries averages are estimated at 41.9 kg and 32 kg, respectively.

The potential role of animal protein sources and fish in particular to address the special challenges of micro-nutrient and vitamin deficiencies in Timor-Leste, a country with one of the highest levels of child malnutrition in the world, deserves special attention. Hence, there is strong need for improving access to animal protein sources to address the problem of chronic malnutrition in Timor-Leste. Fish can play an important role in supplying essential fats for brain development and cognitive ability in the foetus and the young child up to 24 months of age.

### 2.4 Supplementary feeding program for children and vulnerable groups

In recent years, the Department of Nutrition of the Ministry of Health (MoH) — with the support of World Food Program (WFP) — has launched a supplementary feeding program for underweight children, pregnant women, and lactating mothers. Under this program, ‘Timor Vita’, a food supplement, is provided to this needy group. It is formulated using cereals, legumes, minerals and vitamin supplements (Table 3). Timor Vita is distributed monthly (6 kg/person) and should be consumed at a rate of 200–300 g/person/day. Although it is perceived to be rich in protein and nutrients, its major role is to improve daily calorie intake by women and children suffering from malnutrition. ‘Soya Corn Blend’ is also being distributed as another food supplement in Timor-Leste by the MoH/WFP.

### Table 3: Composition of Timor Vita

<table>
<thead>
<tr>
<th>Ingredients</th>
<th>Percentage</th>
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<tbody>
<tr>
<td>1 Corn (maize)</td>
<td>64.2</td>
</tr>
<tr>
<td>2 Soybean</td>
<td>23.0</td>
</tr>
<tr>
<td>3 Sugar</td>
<td>9.0</td>
</tr>
<tr>
<td>4 Soybean oil</td>
<td>2.0</td>
</tr>
<tr>
<td>5 Vitamin/Mineral</td>
<td>1.8</td>
</tr>
</tbody>
</table>

The Ministry of Education, with the support of the WFP, has been running a School Meals Program. Under this program, the ministry provides rice, whereas WFP subsidizes beans, salt

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12 Source: FAO/RFLP Timor-Leste (2011)
15Source: Ministry of Health, Department of Nutrition, Timor-Leste (2011)
and oil for school lunches. Schools receive a subsidy on ingredients at the rate of 75 g rice, beans and cooking oil 20 g each, and 10 g salt per student per day. A large number of households in Timor-Leste suffer food insecurity and it is not uncommon to send children to schools in the morning without a meal. The School Meals Program was initiated not only to increase enrolment and attendance of children at the school, but also to improve their ability to focus on learning. ‘A child with a full stomach is better able to concentrate in class’ is the rationale behind subsidizing school meals. Presently, all school children across Timor-Leste are provided with a morning meal before starting their classes (Personal Communication: Ms. Dirce Maria, Director, Department of Nutrition, MoH, GoTL).

The Supplementary Feeding Program is believed to be playing a crucial role in effectively responding to the problem of chronic food insecurity in the short run. However, in the long term, diversification of livelihoods through harnessing agro-ecological ‘niche’ based potential is vital for producing lasting impact on the food and nutrition security situation in Timor-Leste.

2.5 Increasing access to animal source foods: potential role of fish

The need for increasing access to animal protein sources is considered vital to the improvement of the nutritional status for the large segment of the population in Timor-Leste that has a nutritionally imbalanced diet16. Regional variations in the incidence of poverty and malnutrition are also evident in the country. In particular, the central and western provinces are more prone to poverty. Around 2/3 to 3/4 of the children under five in Manufahi, Aileu, Ermera, Bobonaro, Covalima and Oecussi districts are estimated to be suffering from chronic malnutrition17.

Meats are expensive and in limited supply in rural areas, as cattle and pigs are slaughtered only on special occasions. Cattle and pigs are therefore unlikely to offer the potential to substantially increase daily animal protein consumption. There is however increasing appreciation of the role of fish in a nutritionally balanced diet (particularly vitamins, minerals and micro-nutrients). Clearly, the food and nutrition security situation in Timor-Leste can be improved through harnessing the development potential of the fisheries and aquaculture sector. Timor-Leste has over 700 km of coastline, and has a tremendous opportunity to develop its coastal fisheries and possibly aquaculture as well. Although coastal fishery resources may be able to meet the animal protein source demand of the coastal communities to a large extent, the interior population is presently deprived of access to these resources. The RFLP is currently seeking donor funding for a national ice production and distribution system which would if funded would supply fish to inland districts and take agricultural products from inland districts to coastal markets. Nevertheless, some inland areas are endowed with freshwater resources with the potential for fish production for nutrition and income. In some cases, the addition of a small pond to a rural household farming system would also improve resilience to seasonal droughts. Whilst there have been some attempts in the past to develop freshwater aquaculture, and currently several NGOs are making or considering investments in this sector, these initiatives to date have proved difficult to sustain, particularly during the previous period of political conflict.

16 http://www.tl.undp.org/
Aquaculture development has been identified by the GoTL as a means of improving food and nutrition security situation of inland communities. Coastal aquaculture is also considered to offer potential income raising opportunities for coastal communities. The SDP (2011-2030)\textsuperscript{18} highlights the need for the development of aquaculture (freshwater and coastal) for improving domestic animal protein consumption as well for generating revenues from the export of fish and fisheries products. The plan emphasizes that at least three types of aquaculture systems will be introduced to coastal communities by 2020. Likewise, freshwater aquaculture will be promoted in areas endowed with fresh water resources (for example: Ermera, Aileu, Liquica, Ainoro, Manufahi and Viqueque districts).

2.6 Role of GOs and NGOs in aquaculture development

2.6.1 Government Organizations

Fisheries and aquaculture development is one of the priorities of the Ministry of Agriculture and Fisheries (MAF), under which the National Directorate of Fisheries and Aquaculture (NDFA) was established in 2007. The NDFA is responsible for devising and executing policies and regulations pertaining to fisheries and aquaculture development in Timor-Leste.

There was some attempt to develop aquaculture during the Indonesian regime (between 1975 – 1999). Brackish water aquaculture (particularly black tiger shrimp \textit{(Penaeus monodon)} and milkfish \textit{(Chanos chanos)} was promoted in coastal areas of some districts including Liquica and Manatuto. Freshwater aquaculture, particularly common carp \textit{(Cyprinus carpio)}, was promoted in Ermera, Aileu, Manufahi and Viqueque districts, where freshwater fish hatcheries were established. Aquaculture activities virtually collapsed during the conflict period.

In recent years, the NDFA has tried to revive aquaculture activities by restoring fish hatcheries and aquaculture extension services. Its hatcheries have begun operating at very low capacity mainly constrained by the lack of human resources and physical facilities. To date the NDFA has provided fingerlings free of charge to those households interested in fish culture. Development of brackish water aquaculture and mariculture is also a priority. Seaweed farming recently introduced by the NDFA around Atauro Island is now an income generating activity for a large number of coastal communities in the area. Likewise, the NDFA is trying to rehabilitate coastal aquaculture ponds in Liquica, Manatuto and elsewhere, and to engage farmer’s groups in brackish water aquaculture.

2.6.2 Non-governmental organizations

Although a large number of I/NGOs are focusing on improving the food and nutrition security situation in Timor-Leste, only a few of them have included aquaculture as one of the livelihoods development options. WorldVision successfully piloted freshwater pond aquaculture with a number of farmers in Aileu district. However, the WorldVision aquaculture support program was discontinued due to the lack of in-house technical expertise, and the unavailability of fingerlings and fish feed.

The Rural Development Program (RDP) under the support of European Commission (EC) has included aquaculture in its program in Manufahi district. The project has supported a number of farmers interested in pond aquaculture with subsidies for pond construction and fingerlings.

Mercy Corps, another NGO, has included aquaculture development as one of its activities. An I/NGO called Agricultural Cooperative Development International/Volunteers in Overseas Cooperative Assistance (ACDI/VOCA), in partnership with MAF and the Ministry of Tourism, Commerce and Industry (MTCI) has started mud crab and milkfish farming project in Timor-Leste. The project, aimed at increasing food security and income of coastal poor households, is going to be implemented in 20 coastal villages and women members of the communities will be encouraged to participate in the project. The mud crab and milkfish project aims to increase food security and to augment income.

A number of I/NGOs (for example CARE and Oxfam) have been supporting farmers to excavate ponds as on-farm reservoirs for irrigating vegetable and herbs. Stocking fish in these ponds can be an added advantage, and the farmers as well as I/NGOs are interested in increasing water productivity through multiple usage and system integration.

There is growing interest among I/NGOs to diversify their livelihoods support activities through the inclusion of an aquaculture component. However, such organizations are rather hesitant to focus on aquaculture mainly because of the lack of a clear national policy/strategy, viable production technologies and extension services needed for sustainable aquaculture development. The relatively long transformation process and heavy initial investment requirements for pond construction are some of the other reasons that constrain I/NGOs from including aquaculture components in their livelihoods support programs.

### 3. Rationale for the study

Social and economic policies for Timor-Leste in the initial years of its independence were focused on addressing immediate priority needs of the country:

- Combating poverty through addressing the immediate needs of the people;
- Consolidating security and stability; and,
- Providing a foundation for nationhood through building State institutions.

The GoTL adopted its first National Development Plan entitled ‘East Timor 2020 — Our Nation, Our Future’ in 2002, which laid the foundation for the launching of the SDP in 2011, which provides a vision and actions for Timor-Leste to guide the country’s pathways to development until 2030. Harmonization among all sectors/sub-sectors within the SDP is vital to ensure sustainable development.

In this connection, development of a national strategy to provide practical guidance for socially and environmentally responsible aquaculture has been identified as an NDFA priority. A framework for the preparation of the National Aquaculture Strategy was outlined in 2010, which highlighted various issues related to aquaculture development. It was emphasized that

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http://www.acdivoca.org/site/Lookup/EastTimor-MudCrabandMilkfishCultivation/$file/EastTimor-MudCrabandMilkfishCultivation.pdf

the Strategy should follow a holistic approach, and aim at producing lasting impacts on the livelihoods of a large number of resource-poor communities. This study was designed particularly to provide background information and analysis for the preparation of the Strategy. The study analyzed the current situation and potential for aquaculture development in Timor-Leste, encompassing agro-ecological, social, economic, and institutional aspects.

4. **Methodology**

4.1 **Data/information collection**

The data/information collection mainly included a review of available secondary information from GOs/NGOs/donor funded projects; visits to potential aquaculture development sites in selected districts; and consultation with stakeholders (including government, farmers, development partners, I/NGOs, and private sectors) at national and local levels.

4.1.1 **Review secondary data/information**

Secondary information was gathered from various sources. Policy documents, project reports and other available databases relevant to this study were collected from government ministries and departments, UN organizations and various I/NGOs active in Timor-Leste. The data/information gathered was helpful in analyzing the chronic poverty and malnutrition situation in Timor-Leste. These were also useful in assessing the current situation and the future potential for aquaculture development in the country. A number of policy documents including the SDP provided a framework for devising the National Aquaculture Strategy.

4.1.2 **Field visits and consultation with local stakeholders**

The study team visited a total of eight districts and carried out consultations with local stakeholders at a number of sites (Table 4). The field visits also focused on observation of the NDFA hatcheries, aquaculture activities of farmers, and potential sites for aquaculture development. The selection of sites for field visits and scheduling consultation meetings with local stakeholders were jointly carried out by the NDFA and WorldFish team. The major considerations made included:

- A balance between districts that have potential for developing inland freshwater and coastal aquaculture; and,
- Inclusion of districts that have been identified as having potential for aquaculture development by the NDFA.
Table 4: Districts visited by NDFA/WorldFish team

<table>
<thead>
<tr>
<th>Region</th>
<th>Districts</th>
<th>Key activities</th>
</tr>
</thead>
</table>
| East   | Baucau    | - Focus group discussion (FGD) with freshwater fish farmers Ossoala village, Vemasse sub district  
       |           | - Key Informant Interview (KII) with Fisheries officer, Baucau  
       |           | - visit NDFA hatchery in Viqueque  
       |           | - KII with NDFA Hatchery Manager, Viqueque  
       |           | - KII with fish farmer in Ossu sub-district  
       | Viqueque | - FGD with freshwater fish farmers in Aaimouli village, Laclobar sub district  
       |           | - Discussion with seaweed farmers group in Behada village, Lacloc sub-district  
       |           | - KII with fisheries officer, Manatuto  
       | Manatuto | - KII with WorldVision supported freshwater fish farmer  
       |           | - KII with World Vision staff at Aileu site  
       |           | - KII with pioneer fish farmer in Lahat village  
       |           | - KII with Director, District Agriculture office  
       | Aileu    | - FGDs with fish farmers in Letefoho village, Same sub-district  
       |           | - KII with hatchery manager, NDFA fish hatchery, Same  
       | Manufahi | - KII with District Fisheries officer  
       |           | - Observation of potential brackishwater aquaculture sites  
| West   | Liquica   | - FGDs with freshwater fish farmers in Raifun village, Maliana  
       |           | - FGD fish farmers in Leohito village, Balibo sub-district  
       |           | - KII with Agriculture officers in Maliana  
|       | Bobonaro  | - KII with NDFA fish Hatchery Manager, in Maliana  

In addition to the above, the study also covered another two sites adjacent to Dili, namely (i) Atauro Island for Seaweed value chain analysis and (ii) Ermera district, which the NDFA believes has high potential for freshwater aquaculture development.

4.1.3 Consultation with District aquaculture officers

A one-day meeting with district aquaculture officers was organized in Dili on 2 May 2011. A total of nine officers (including hatchery managers) participated in the meeting. The NDFA National Director and Chief of the Aquaculture Division also attended throughout.

The meeting started with welcome remarks from key NDFA officials, who highlighted the need for the development of a National Aquaculture Strategy for Timor-Leste and also emphasized the key role of district officers in facilitating the field work. The project work plan and tentative schedule of the field work was presented during the meeting.

All the participants from the districts presented a general overview of the fisheries and aquaculture situation in their respective districts, largely focusing on on-going activities. They were also asked to provide feedback on the proposed work plan. All of them appreciated the
need for the development of a National Aquaculture Strategy and provided initial feedback on the key points that should be included in the strategy.

### 4.1.4 Consultations with GOs (Government Ministries/Departments) and I/NGOs

Consultation meetings with government departments involved in natural resource allocation, particularly of freshwater and coastal land/water were carried out during July–August. These meetings focused on issues related to resource allocation and their use for aquaculture and other purposes; policy gaps; strategies for improving food and nutrition security; and challenges to and opportunities for aquaculture development. Key ministries/departments consulted were:

1. **MAF:**
   a. National Directorate of Irrigation
   b. National Directorate of Agriculture and Horticulture
   c. National Directorate of Policy and Planning (including the Agriculture and Land-use Geographic Information System (ALGIS))
2. Ministry of Health /Department of Nutrition
3. Ministry of Economic and Development
4. Ministry Education – National Directorate of School Meal Program
5. Ministry Tourism, Commerce and Industry (MTCI)
6. Ministry of Economic and Development - Institute of Microfinance

A number of key staff members representing various departments under MAF were consulted to identify agro-ecological and socio-economic factors that influence aquaculture development (‘niches’) in Timor-Leste.
Selected I/NGOs, development partners as well as private sectors active in the country were also consulted. Discussion with I/NGOs largely centered around their livelihoods support activities, and the potential for inclusion of an aquaculture component was explored with those promoting farming-based programs. The major organizations consulted were:

- WorldVision
- CARE International
- UNICEF
- UN-Women
- Timor-Global Co. Ltd.

4.2 Identification of agro-ecological ‘niches’ for freshwater aquaculture

Geographical Information Systems (GIS) were used to identify agro-ecological ‘niches’ for aquaculture development. The GIS modelling of this study covered all districts in Timor-Leste, excluding the islands of Atauro and Jaco. The former has been designated for the development of only seaweed cultivation, whereas the latter is an uninhabited island. The GIS analysis focused on identifying:

- Geographical areas with high potential for promoting freshwater aquaculture; and,
- Determinants of bio-physical and socio-economic factors for aquaculture development.

A simplified GIS modelling methodological framework developed by Kam et al. (2008) was used for delineating recommendation domains to assess and map suitability for freshwater aquaculture. Figure 1 shows the main steps for mapping aquaculture potential. The methodology principally applied multi-criteria evaluation (MCE) combining the multiple factors (or criteria) influencing the suitability of freshwater aquaculture using the mathematical technique of weighted linear combination (WLC).

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22 Kam SP, Barth H, Pemsl DE, Kriesemer SK, Teoh SJ and Bose ML. 2008. Recommendation Domains for Pond Aquaculture. WorldFish Center Studies and Reviews 1848. The WorldFish Center, Penang, Malaysia. 40pp. with DVD-ROM.
4.3 Analysis and report preparation

Data/information collected was analyzed by the study team. Preliminary findings and a framework for the project report was presented to a meeting at the MAF on 10 September 2011. The MAF Director General, the NDFA Director and a number of senior MAF officials attended the meeting. The meeting provided the study team with input for refining the framework and coverage of the report.

This project report has been prepared, in line with the agreed work plan. It covers:

- Analysis of the current situation and potential for aquaculture development in Timor-Leste;
- National Aquaculture Strategy; and,
- A follow up implementation plan for piloting of aquaculture interventions.

Finalization of the National Aquaculture Strategy will be done after its presentation to stakeholders meeting in Dili on 16 February 2012.

5. An overview of Marine and Freshwater fisheries production in Timor-Leste

The fisheries sector in Timor-Leste is characterized by artisanal fishing operations in coastal areas largely dominated by small-scale fishers. Freshwater fisheries are also practiced in rivers and lakes in inland areas but no data/information are available on the estimated volume of fish catches. Discussion with community people in Baucau, Ermera, Aileu and Manufahi districts
suggest that a small number of households in areas with access to freshwater fisheries resources practice fishing only occasionally and catches are virtually all used for household consumption.

Marine fishery catches account for over 95.0% of total fish production in Timor-Leste according to official statistics, with aquaculture contributing less than 5.0%. There are some coastal fisheries activities in all but two inland districts, namely Ermera and Aileu. In 2009, the total marine fisheries production was estimated at 3,207 t which was slightly higher than the total fisheries catches estimate for 2007 (Table 5).

There is a strong variation in total fisheries production across districts. Dili alone accounts for around a third of total fisheries production, while Liquica, Oecussi, Bobonaro, Covalima and Manufahi have relatively high marine fisheries production compared to other districts.

Table 5: Total fisheries production (t) in Timor-Leste

<table>
<thead>
<tr>
<th>District</th>
<th>Fisheries production (t)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>2007</td>
</tr>
<tr>
<td>Ainaro</td>
<td>9.0</td>
</tr>
<tr>
<td>Oecussi</td>
<td>207.9</td>
</tr>
<tr>
<td>Baucau</td>
<td>76.5</td>
</tr>
<tr>
<td>Bobonaro</td>
<td>331.2</td>
</tr>
<tr>
<td>Covalima</td>
<td>154.8</td>
</tr>
<tr>
<td>Dili</td>
<td>1035</td>
</tr>
<tr>
<td>Liquica</td>
<td>498.6</td>
</tr>
<tr>
<td>Lautem</td>
<td>111.6</td>
</tr>
<tr>
<td>Manufahi</td>
<td>153.9</td>
</tr>
<tr>
<td>Manututo</td>
<td>229.5</td>
</tr>
<tr>
<td>Viquique</td>
<td>103.5</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td>2,911.5</td>
</tr>
</tbody>
</table>

Although the numbers of fishers have increased over time, there has been no substantial increase in total fisheries production. Whilst the total population of Timor-Leste was estimated at 1.066 million in 2010,\textsuperscript{24} the per capita marine fisheries supply was estimated at only around 3.0 kg. Arguably, there is some potential for increasing production through the development of the marine capture fisheries industry. Although the GoTL plans to increase coastal and marine fishing activities in coming years\textsuperscript{25}, development of the aquaculture sector is vital to the increase in fish supply needed for the growing population of Timor-Leste.

6. Current aquaculture development situation in Timor-Leste: An analysis

This section examines the current aquaculture sector situation in Timor-Leste. The analysis encompasses freshwater and brackish water aquaculture as well as mariculture, and considers technical, social, economic and agro-ecological aspects, which are all components of the Ecosystems Approach to Aquaculture that FAO\textsuperscript{26} is promoting worldwide.

6.1 Freshwater aquaculture

Freshwater aquaculture was promoted in Timor-Leste to a limited extent during the Indonesian regime (1975 – 1999). Farmers were provided with subsidies for pond construction, fish seed and feed. Freshwater fish hatcheries were established in three locations, namely Ermera, Manufahi and Viqueque districts and broodstock (particularly common carp) were introduced from Indonesia. Whilst aquaculture practices (including other farming activities) virtually collapsed during the conflict, the MAF began activities to revive freshwater aquaculture after the independence of the country in 2002.

6.1.1 Major production area/agro-ecological pockets

Although the inland areas of Timor-Leste encompass rugged terrain, most districts have ecological pockets with freshwater resources and suitable land areas for aquaculture. Most of freshwater aquaculture is practiced in major rice producing districts (Table 6), mainly due to the easy accessibility of freshwater in rice-based farming systems.

There has been some effort to promote freshwater aquaculture in recent years and consequently the number of households practicing aquaculture has steadily increased. Whilst only 280 households were engaged in freshwater aquaculture in Timor-Leste in 2004, the number had increased to 1,280 in 2009 — a 4 fold increase in five years (Figure 2)\textsuperscript{27}.

\textsuperscript{24} National Statistics Directorate, Ministry of Finance (2010). Population and Housing Census 2010- Preliminary Results.
\textsuperscript{26} http://www.fao.org/docrep/013/i1750e/i1750e.pdf
\textsuperscript{27} Source: NDFA, 2010
Freshwater aquaculture is practiced as a part-time farming activity in Timor-Leste. Fish farming households are distributed across the country and are recorded in all 13 districts. However, a large concentration was noted in Ermera (350 households), Baucau (210 households) and Bobonaro (150 households), accounting for over half of the country’s total number of freshwater fish farmers. Access to hatcheries and a favorable resource base are likely reasons for this.

Table 6: Number of freshwater aquaculture farmers and estimated fish production (t) by district

<table>
<thead>
<tr>
<th>District</th>
<th>Total area under aquaculture (ha)</th>
<th>Number of fish farmers</th>
<th>Fish production (t)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Aileu</td>
<td>4.0</td>
<td>80</td>
<td>8.0</td>
</tr>
<tr>
<td>Ainaro</td>
<td>4.0</td>
<td>75</td>
<td>5.0</td>
</tr>
<tr>
<td>Baucau</td>
<td>3.0</td>
<td>210</td>
<td>2.0</td>
</tr>
<tr>
<td>Bobonaro</td>
<td>4.0</td>
<td>150</td>
<td>2.5</td>
</tr>
<tr>
<td>Covalima</td>
<td>1.5</td>
<td>35</td>
<td>1.5</td>
</tr>
<tr>
<td>Dili</td>
<td>0.5</td>
<td>35</td>
<td>0.8</td>
</tr>
<tr>
<td>Ermera</td>
<td>7.0</td>
<td>350</td>
<td>10.0</td>
</tr>
<tr>
<td>Lautem</td>
<td>6.0</td>
<td>40</td>
<td>7.0</td>
</tr>
<tr>
<td>Liquica</td>
<td>0.5</td>
<td>50</td>
<td>0.8</td>
</tr>
<tr>
<td>Manatuto</td>
<td>2.0</td>
<td>45</td>
<td>1.5</td>
</tr>
<tr>
<td>Manufahi</td>
<td>4.0</td>
<td>70</td>
<td>3.0</td>
</tr>
<tr>
<td>Oecussi</td>
<td>1.5</td>
<td>60</td>
<td>1.5</td>
</tr>
<tr>
<td>Viqueque</td>
<td>3.0</td>
<td>80</td>
<td>2.0</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>41.0</strong></td>
<td><strong>1,280</strong></td>
<td><strong>45.6</strong></td>
</tr>
</tbody>
</table>

Although there has been a steady increase in the number of freshwater fish farmers over time, only an estimated 41 ha of water area are under freshwater fish culture at this time. Ermera, Baucau and Bobonaro districts have the most fish farmers with 350, 210 and 150 respectively, while Ermera and Lautem alone (7 and 6 ha, respectively) accounted for around one-third of the total fish culture area. Aileu, Ainaro, Bobonaro and Manufahi districts each had an estimated 4 ha of fish culture ponds.

Consultation with local stakeholders indicated that the estimated area (ha) and fish production (t) from freshwater aquaculture is likely to be higher than that presented in Table 6. In Bobonaro alone, nearly 500 fish ponds were estimated. However, the lack of up-to-date statistics makes it difficult to make a more precise estimation.

Freshwater aquaculture is largely dominated by two species, namely common carp and Nile tilapia. A small number of farmers were also stocking Mozambique tilapia (Oreochromis mossambicus) and a few other indigenous species (for example, Ikan Mazalaya (Cyprinus carpio var. flavipinnis). Whilst common carp was first introduced, Nile tilapia (Oreochromis niloticus) was only recently introduced. To date the majority of farmers are culturing common carp. However, there is growing interest in Nile tilapia.

6.1.2 Fish Seed

There are four freshwater hatcheries currently in operation in Timor-Leste. However, all of them are operating at very low capacity due essentially to the shortage of appropriately trained staff and inadequate physical facilities.

Three fish hatcheries were established in the early 1980s during the Indonesian regime but they virtually collapsed during the time of conflict in 1999. Although hatchery operation was restarted after independence in 2002, their activities were limited to the production and distribution of fingerlings to a small number of farmers interested in stocking fish. Whilst the country has an estimated 41 ha under freshwater aquaculture, the total number of fingerlings produced from all four hatcheries was estimated at only around 50,000 annually – which is

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29 Source: Bobonaro District Agriculture Office
barely sufficient for stocking of 4 ha of pond area (Table 7). Assuming a stocking density of 3 fingerlings per m$^2$, over 1.2 million fingerlings would be required to stock 41 ha of ponds.

### Table 7: Physical facilities and fingerlings production capacity of NDFA hatcheries

#### (a) Hatchery facilities:

<table>
<thead>
<tr>
<th>Hatchery</th>
<th>Established (Year)</th>
<th>Brood Ponds (n)</th>
<th>Breeding tanks (n)</th>
<th>Office building (Y/N)</th>
<th>Human resource (n)</th>
<th>Other facilities</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ermera</td>
<td>1984</td>
<td>13</td>
<td>-</td>
<td>Y</td>
<td>1</td>
<td>Scoop nets</td>
</tr>
<tr>
<td>Manufahi</td>
<td>1983</td>
<td>24</td>
<td>8</td>
<td>Y</td>
<td>3</td>
<td>Scoop nets, oxygen cylinder, a motorcycle</td>
</tr>
<tr>
<td>Viqueque</td>
<td>1993</td>
<td>15</td>
<td>-</td>
<td>Y</td>
<td>2</td>
<td>Scoop nets</td>
</tr>
<tr>
<td>Bobonaro</td>
<td>2004</td>
<td>6</td>
<td>3</td>
<td>Y</td>
<td>1</td>
<td>Scoop nets</td>
</tr>
</tbody>
</table>

#### (b) Broodstock and fingerling production:

<table>
<thead>
<tr>
<th>District (Location)</th>
<th>Common carp</th>
<th>Nile tilapia</th>
<th>Red tilapia</th>
<th>TOTAL</th>
<th>Fingerling production (n) (annually)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ermera (Gleno)</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>10,000</td>
</tr>
<tr>
<td>Manufahi (Same)</td>
<td>125</td>
<td>50</td>
<td>70</td>
<td>245</td>
<td>25,000</td>
</tr>
<tr>
<td>Viqueque (Loi Huno)</td>
<td>90</td>
<td>250</td>
<td>-</td>
<td>340</td>
<td>8,000</td>
</tr>
<tr>
<td>Bobonaro (Maliana)</td>
<td>-</td>
<td>400</td>
<td>-</td>
<td>400</td>
<td>11,000</td>
</tr>
</tbody>
</table>

An assessment of the current situation of NDFA hatcheries was made based on the discussion with the hatchery managers and other staff, and on visual observation. The main findings were as follows:

30 Source: KII: NDFA Hatchery Managers
- Freshwater was abundantly available in all the hatcheries (either from nearby natural springs or from irrigation systems).
- Brood ponds were in relatively good conditions in all the hatcheries.
- Manufahi Hatchery has some basic tools and equipment like nets and oxygen cylinders. However, the other three lack these basic facilities.
- Brood fish were poorly managed in all the hatcheries, which was associated with inadequate human as well as financial resources available for feeding and management.
- Introduction of quality brood stock and appropriate staff training particularly hands-on training on breeding, nursing and broodstock management is vital to the production of quality fingerlings by these hatcheries.
- Essentially, all the hatcheries lacked staff specialized in hatchery technologies. Most of the staff (including managers) were high school graduates with only limited training experience in fish seed production.
- All the hatcheries were operating at very low capacity. However, the managers were confident that there is potential for increasing fingerling production by at least 10 fold even with only the existing facilities. With only limited improvement in hatchery facilities, these hatcheries altogether have potential to produce over 4 million fingerlings annually.

6.1.3 Aquaculture technology

Freshwater pond aquaculture in Timor-Leste is characterized by ‘low-input and low-output’ systems. Whilst there are no specific recommendations available on proven aquaculture technologies that are suitable for the local context, the performance of aquaculture varies greatly due to the wide range of variations in stocking, feeding and management practices. The extension services provided by NDFA officers are limited to distributing fingerlings based on their availability from the hatcheries and demand of farmers; providing small quantities of subsidized pellet feeds to selected farmers; and offering some technical advice of stocking, feeding and pond management. Pellet feeds are imported from Indonesia.

Most farmers visited during the survey were feeding fish with only rice bran and kitchen wastes. Some households were also applying cassava leaves, coconut by-products and wild cassava roots. Nonetheless, the amount and frequency of application of these inputs largely varied with their availability in the households. Pellet feeds were used when supplied free of charge by the NDFA or I/NGOs, but not otherwise.

Discussions with farmer groups revealed that in some locations, aquaculture was introduced during the Indonesian regime, while in others, it was a relatively new farming activity introduced after independence (Table 8). Nevertheless, artisanal aquaculture was in practice regardless of the location and the experience of the communities, reflecting that farmers lack access to promising aquaculture technologies that are suitable for their resource base context.

The livelihoods of the majority of the households in the communities visited were predominately based on production of paddy, upland crops (coffee, corn, cassava) and livestock raising. However, Laclobar sub-district, Manatuto was predominately mountain upland without suitable area for paddy production. Areas with longer experience in aquaculture were also endowed with paddy lands with rich soils and abundant water resources, indicating their high suitability for aquaculture development.
Table 8: Characteristics of freshwater pond aquaculture by location\textsuperscript{31}

<table>
<thead>
<tr>
<th>Location</th>
<th>Number of fish farmers in the village</th>
<th>Aquaculture experience (years)</th>
<th>Average pond size (m\textsuperscript{2})</th>
<th>Cultured species</th>
<th>Production (kg/pond)</th>
<th>Productivity (t/ha)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ossoala/Vemasse/Baucauc</td>
<td>24 (2 groups)</td>
<td>&lt;10</td>
<td>200-600</td>
<td>Common carp</td>
<td>25-50</td>
<td>0.8-1.2</td>
</tr>
<tr>
<td>Aimauali/Laclobar/Manatuto</td>
<td>12 (2 groups)</td>
<td>&lt;5</td>
<td>40-100</td>
<td>Common carp</td>
<td>2-10</td>
<td>0.5-1.0</td>
</tr>
<tr>
<td>Sukulari/Aileu/Aileu</td>
<td>&lt;20</td>
<td>&gt;20</td>
<td>100-300</td>
<td>Common carp</td>
<td>5-30</td>
<td>0.5-1.0</td>
</tr>
<tr>
<td>Lahat/Aileu/Aileu</td>
<td>~25</td>
<td>&gt;20</td>
<td>100-300</td>
<td>Common carp, Tilapia</td>
<td>5-50</td>
<td>0.5-1.7</td>
</tr>
<tr>
<td>Letefoho/Same/Manufahi</td>
<td>~50</td>
<td>&gt;20</td>
<td>80-500</td>
<td>Common carp, tilapia</td>
<td>10-60</td>
<td>1.2-1.3</td>
</tr>
<tr>
<td>Raifun/Maliana/Bobonaro</td>
<td>26</td>
<td>&lt;5</td>
<td>40 – 100</td>
<td>Tilapia</td>
<td>6 - 15</td>
<td>1.5</td>
</tr>
<tr>
<td>Leohito/Balibo/Bobonaro</td>
<td>34</td>
<td>&gt;20</td>
<td>100 -500</td>
<td>Common carp</td>
<td>10 -50</td>
<td>1.5</td>
</tr>
</tbody>
</table>

6.1.4 Viability of freshwater aquaculture

Although aquaculture productivity was estimated to be low in all the locations, many farmers have been managing to augment their household income by selling some cultured fish. Demand in all local areas was high, as fresh fish fetches up to US$ 10 per fish (weighing around one kg) – a price that is not affordable for poor households. However, the high fish price is due mainly to the very low cultured production and supply at present, and prices are likely to decrease with increased fish production in the future.

Nevertheless, the economic viability of freshwater aquaculture systems currently being practiced is still low because of low productivity and low financial returns. Improving from the present ‘extensive’ aquaculture systems to ‘semi-intensive’ culture systems is a balanced approach that would ensure optimal returns. Devising low-cost feeding technologies with effective utilization of locally available resources is vital to increase the efficiency of homestead aquaculture systems aimed at improving food and nutrition security, and augmenting household income.

6.2 Brackish water aquaculture

Shrimp and milkfish farming was initiated in some coastal areas of Timor-Leste during the Indonesian regime. However, like other farming activities, it was discontinued during the conflict. In recent years, there have been some attempts to rehabilitate existing brackishwater aquaculture ponds in order to revive shrimp and milkfish farming. Oecussi, Covalima, Liquica and Manatuto are the major districts where brackish water aquaculture was promoted in the past.

\textsuperscript{31} Source: FGDs/KII with local communities
Currently, a small number of farmers, particularly in Oecussi, Covalima and Liquica, are engaged in brackish water aquaculture. In 2010, around 60 households from these districts were engaged in shrimp and/or milkfish culture. All brackishwater ponds are operated in an extensive manner, resulting in low productivity. The emphasis of the government is on improving the performance of existing brackishwater farming systems rather than expanding the total production area. The area under these systems was estimated at a mere 6 ha in 2010, and this has remained unchanged since 2007.

In 2011, NDFA and ACDI/VOCA launched a collaborative project on mud crab and milkfish culture. The project plans to promote mud crab and milkfish aquaculture in 20 northern coastal villages. Milkfish culture is aimed at improving access to high protein diet of the resource-poor coastal communities, while mud crab is for income generation through its sale in urban centers like Dili. Mud crab and milk fish nurseries will be established at local level and resource-poor households, particularly their women members, will be encouraged to participate in the project. The project will run for a three-year period. The project expects that the aquaculture intervention made will be sustained beyond the project period because there is high demand for milk fish and mud crab in local and Dili markets, respectively. There may however be issues of seed supply sustainability for both mud crab and milkfish and feed supply for mud crabs.

6.3 Mariculture

6.3.1 Seaweed

Mariculture in Timor-Leste, essentially the farming of seaweed (*Eucheuma cottonii*), was started in 2003-2004. In the beginning, a small number of farmers (20 farmers in 2004) participated in pilot trials. However, with its success, the number grew steadily and reached 1,282 in 2009. The geographical focus has mainly been on Atauro – a small island situated to the north of Dili with a population of about 10,000. There are two seaweed producers’ cooperatives, namely Cottonii and BEATA, on Atauro Island. The large majority of the farmers are members of one of the two cooperatives (Table 9).

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32 Andrew, N., S.P. Kam, and M. Phillips. 2010. Fisheries dependence in Timor Leste. The WorldFish Center, Penang Malaysia
33 http://www.acdivoca.org/site/ID/easttimorMudCrabandMilkfishCultivation
There has been a rapid increase in the number of members in the existing seaweed cooperatives (Cottonii and BEATA) in recent years. Seaweed farming is also expanding to other districts, for example, Liquica and Manatuto (Table 9).

**Table 9: Seaweed farmers’ groups and cooperatives in Timor-Leste**

<table>
<thead>
<tr>
<th>Location/Cooperative</th>
<th>Number of groups</th>
<th>Number of members</th>
</tr>
</thead>
<tbody>
<tr>
<td>Dili – Atauro (Cottonii cooperative)</td>
<td>366</td>
<td>1,830</td>
</tr>
<tr>
<td>Dili – Atauro (BEATA Cooperative)</td>
<td>276</td>
<td>1,380</td>
</tr>
<tr>
<td>Dili – Dolok Oan</td>
<td>1</td>
<td>10</td>
</tr>
<tr>
<td>Liquica</td>
<td>2</td>
<td>45</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>645</strong></td>
<td><strong>3,265</strong></td>
</tr>
</tbody>
</table>

Unlike freshwater aquaculture, seaweed is produced mainly for export and only a small proportion is used for domestic consumption. In 2009, the total revenue generated was estimated at US$ 19,130. However, in 2011, there was a sharp decline in seaweed production due to ice disease outbreak. Consequently, the revenue declined in 2011.

Companies based in Dili serve as brokers for seaweed marketing. They negotiate the price with producers’ cooperatives and inform overseas companies to come and collect the produce, which occurs at 3-6-month intervals. It was noted that the role of producers in setting the price of their produce was minimal.

Nevertheless, seaweed culture has been one of the major income-generating activities in the areas where seaweed farming is located. Growing concerns over marketing issues could be addressed by empowering farmers’ groups and cooperatives to explore markets themselves and to negotiate directly with the importers.

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34 Source: NDFA, Timor-Leste (2011)
35 Source: NDFA, 2010
A value chain analysis of seaweed production systems was also conducted. The study confirmed the role of seaweed farming in the diversification of the livelihoods of coastal communities (see full report in Appendix 1). It has provided an income-generating opportunity for such communities, which have few alternative livelihoods opportunities. The average household income from seaweed farming was estimated at USD 60 -70 per production cycle (45 days) and farmers produce 6 cycles of seaweed per year, giving an annual average household income from seaweed estimated to be around USD 360 – 420. The study also outlined some key issues related to seaweed production and marketing (Box 1), and suggested possible intervention areas to increase its economic viability and sustainability in Timor-Leste.

Box 1:

Technical, socio-economic and environmental issues in seaweed farming in Timor-Leste

Technical
Dissemination of knowledge, extension services, and capacity to follow international developments will always be a problem for such a small country with low seaweed production levels. The upside is the close proximity to Indonesia, the world’s largest producer and Timor-Leste should aim at building a friendly commercial relationship with its neighbour. Culture systems, culture periods and sites should be used and selected that minimise the risk of ice ice disease.

Again because of its small size and low production volume Timor-Leste size production will never be recognised as one of the region’s leading seaweed volume producers and it may miss out on the opportunity to attract foreign investment. Presenting itself collectively under the one seaweed association will help Timor-Leste to establish greater market presence.

Social
The social obstacle that the Timor-Leste seaweed industry may face as it develops is conflict between shared users of coastal sea water areas. To overcome this situation the government needs to set out appropriate zones dedicated to seaweed production and to create a shared resource policy, where all producers are aware of their rights and responsibilities.

Economic
The economic performance is probably the greatest obstacle after disease prevention to seaweed culture expansion in Timor-Leste. This can be mitigated by approaching the market collectively through a national seaweed association and thereby creating a sense of volume. Timor-Leste will always struggle in the region as it can only ever be a small producer, but collectively through the association, prices can be set with export markets (premium markets). This will allow the exporter(s) of Timor-Leste to have greater bargaining power, as they negotiate price collectively (with the association setting a minimum export price).

Environmental
The greatest obstacle is to overcome the ice ice disease outbreak and to ensure preventative measures are implemented going forward. An alert systems need to be put in place and nurseries producing different strains need to be set up, to avoid a repetition of current conditions.
6.3.2 Other potential species

There is considerable interest of NDFA in developing mariculture of high value fish species. Although the environment in and around Nino Konis Santana (NKS) Marine Park also appears to be suitable for farming of other species, such as sea cucumbers, groupers, lobsters, clams, ornamentals and possibly sponges, judicious consideration of technical, social, economic and environmental aspects is vital before their introduction. A more detailed feasibility study is required, investigating issues related to the sustainability of seed inputs and the development of hatchery systems, carrying capacity, remoteness and market access arrangements.

Nevertheless, the following considerations should be made while selecting a mariculture species in Timor-Leste:

- Simple technology – easy to breed/propagate, nurse and culture;
- Low production costs (for feed, seed and management); and,
- Species having potential for addressing the problem of food and nutrition insecurity either directly (by increased access of local population to animal protein sources) or indirectly (by generating income via sales which can be used to buy food).

Sea cucumbers are among a few species which offer excellent potential for developing environmentally benign and economically viable production systems in Timor-Leste. For centuries, they have been a high-value commodity throughout the Asia/Pacific region. They are collected by hand in intertidal areas (called gleaning) or by diving in deeper waters. The consumption of sea cucumbers is widely held in China and neighbouring countries as having beneficial medicinal and health effects. They fetch very high prices when processing quality is high, and this has lead to over-exploitation throughout the tropical distribution of this high-value species. As a result, wild supplies are now extremely low, and there is a considerable unmet market demand for high quality processed sea cucumbers. They are typically dried and sold via traders to markets in Singapore, Hong Kong, China or Korea. As a dried product, there are benefits in terms of their ability to be stored, and held until bulk quantities can be transported. Dried sea cucumber is therefore less reliant on efficient transport infrastructure than most other high-value seafood commodities.

While temperate sea cucumber species are cultured in vast numbers in central and northern China, the high demand for tropical species remains unmet. On-going research (since the 1990s) to culture tropical species (notably the sandfish, *Holothuria scabra*) as an alternative source of income has recently provided dividends, with some success in both pond-based grow-out systems and sea ranching. Commercial hatcheries are now in operation in a number of countries, and small-scale production is underway in Vietnam and the Maldives. Active research programs in the Philippines, Vietnam and Papua New Guinea are working on refining and simplifying hatchery techniques and improving survival rates of ranched animals.

Sea ranching of sea cucumbers may be a viable option in some areas of Timor-Leste however this would require sea area zonation, seabed access use rights allocation and the establishment of community management systems to ranch them. There is high potential for integrated seaweed and sea cucumber culture, and this might be a particularly worthwhile pathway for development. Culture in pens, or even in open lease areas, below seaweed lines will provide economies of scale in terms of labor costs and security requirements, which are the major cost items for sea ranching operations. Ultimately, the success of such ventures depends on a combination of availability of appropriate legal framework and government policies for sea

Andrew, N., S. P. Kam, and M. Phillips. 2010. Fisheries dependence in Timor Leste. The WorldFish Center, Penang Malaysia
area zonation and access use rights, habitat, management and rights frameworks, legislation and security systems to provide protection to operators, and the availability of infrastructure and hatchery production capacity. Current research efforts to simplify technology, such as the substitution of live algae feeds with processed algal pastes, will improve options for hatchery development in remote areas. Diverse nursery methods currently being tested in the Philippines will maximize the benefits that flow to communities by allowing their early engagement in the production process, thereby minimizing the seed costs.

7. **Aquaculture development: Opportunities and issues**

7.1 **Agro-ecological ‘niches’**

7.1.1 **Freshwater aquaculture**

7.1.1.1 **Determinants for freshwater aquaculture development:**

The GIS modelling process commenced with identifying bio-physical and socio-economic factors that influence the potential of a freshwater aquaculture technology being considered for promotion. A stakeholder consultation meeting was organized at the Agriculture and Land-use Geographic Information System (ALGIS) Unit office, under the National Directorate of Policy Formulation and Planning directly under the Minister for MAF, Dili on August 2011, involving key officials from the NDFA. The participants suggested that the study focus on freshwater aquaculture production mainly for home consumption, with the surplus for the sale to local consumers in order to improve local food security. The local experts provided useful insight into the major determinants for freshwater aquaculture development. Each of the determinants identified were then also given ratings based on its relative importance (Figure 3).

The indicator used for modelling also depended on spatial data availability and their scale. Although soil conditions, water quality and risk of flood damage were also identified as factors influencing aquaculture development, these were not included in modelling because of data unavailability.

![Figure 3](image-url): Biophysical and socio-economic determinants for freshwater aquaculture development in Timor-Leste.
All the indicator maps representing each determinant factor were standardized into a continuous scale of suitability from 0 (the least suitable) to 255 (the most suitable). This soft or “fuzzy” concept (0-255 scale) gives all locations a value representing its degree of suitability, instead of a hard Boolean definition for any particular location as being absolutely suitable or not for a given criteria condition.

Whilst a number of factors were identified, these were grouped logically into a series of sub-models representing key aspects of their influence on aquaculture potential. The output suitability maps of the sub-models were then combined in the main model to produce the overall suitability map.

While constructing sub-models and the overall model, factors considered more important were given relatively higher weighting. The factor weights were given by local experts during the stakeholder consultation sessions in such a way that they summed to 100%, indicating their relative importance.

Indicator maps for all the factors and the construction of the sub- and main model are shown and explained in Appendix 2: Technical notes on GIS modelling.

As mentioned above, the maps developed from the sub-models were mathematically combined using the weights provided by local experts (Figure 3), and an overall suitability map for freshwater aquaculture was produced (Figure 4). The resulting maps were rated into a continuous scale of suitability ratings from 0 (the least suitable represented by the lightest tone) to 255 (the most suitable represented by the darkest tone). For an easier interpretation, the 0-255 continuous suitability rating system was reclassified into four levels as most suitable, suitable, moderately suitable and least suitable. This final suitability map provides a broad picture of the potential areas for freshwater aquaculture development, with dark green indicating the most suitable, whereas dark brown indicates the least suitable.

![Figure 4](image-url): Combining sub-models using weights assigned by local experts to produce a final model for evaluating overall aquaculture suitability.
7.1.1.2 Estimated area suitable for freshwater aquaculture

The final four suitability classes of map were used (Figure 4) to generate statistics on estimated area (in km$^2$) for all districts (Figure 5), which fall under each suitability class namely, most suitable, suitable, moderately suitable, and least suitable. Bobonaro, Ermera and Baucau were found to be the most favourable, where the estimated area under the ‘highly suitable’ category in these districts was notably larger than other districts totalling almost 800 km$^2$. These districts were rated ‘highly suitable’, suggesting their relatively easy access to the NDFA hatcheries, i.e., Maliana in Bobonaro and Gleno in Ermera, and the presence of a large number of aquaculture farmers.

Locations having favourable bio-physical conditions were given the highest weighting (45%), followed by good access to input supply and proportion of farmers with aquaculture experience (35%), and accessibility to market (20%). The least suitable locations were largely distributed in the districts with an unfavourable resource base, and poor access to market and input supplies.

In many districts, highly suitable area was limited to certain sub-district(s) or villages by virtue of a wide range of diversity in resource-base and socio-economic contexts even within the same district. For example, highly suitable areas in Manufahi were limited to a few villages in the same sub-district, due to the favourable resource base and easy access to a fish hatchery and market.

![Figure 5: Estimated areas (km$^2$) under four suitability classes by district.](image)
The suitability maps provide an overview of spatial distribution for aquaculture planning and management. Nevertheless, it is equally important to know the constraints faced in low potential areas to understand whether appropriate interventions could be made to overcome them. Figure 6 illustrates the use of drill-down query function to identify which of the specific constraints was encountered at a particular less-suitable location.

Figure 6: Querying the resultant maps show factors limiting potential at each specific location.

The work indicates potential advantages of using GIS to provide guidelines for policy makers, aquaculture planners and extension workers to make strategies for harnessing aquaculture development potential in Timor-Leste, and to identify interventions that are suitable to promote freshwater aquaculture.

7.1.1.3 Harnessing freshwater fish production potential

As discussed in the preceding section, ‘suitability analysis for freshwater aquaculture development was largely based on: (i) existing number of fish farmers and population concentration; (ii) resource-base characteristics (for example, accessibility to rivers/streams and terrain), and (iii) easy accessibility to market. Arguably, total area estimated as ‘highly suitable’ is likely to be overestimated since rivers/streams included seasonal as well as perennial rivers/streams due to unavailability of disaggregated data. Therefore, it will be unrealistic to aim at harnessing the full potential presented in Figure 5. Nevertheless, realization of only up to 5.0% potential would result in a substantial increase in the total fish supply in the country (Table 10). In recent years, the annual total fish supply from fisheries and aquaculture sectors was estimated to be only about 3,300 t (Tables 5 and 6). However, freshwater aquaculture alone could supply over 14,000 t annually, with its expansion to around 4,800 ha (5.0% of the ‘highly suitable’ category) and the introduction of low-cost technologies based on locally available feed. Annual per capita consumption of fish and aquatic products
could then be increased to around 15 kg, which is notably higher than the present per capita consumption (6.1 kg)\(^{37}\) (Table 10).

### Table 10: Freshwater aquaculture development potential of Timor-Leste

<table>
<thead>
<tr>
<th>District</th>
<th>Total area (ha)</th>
<th>Total production (t)</th>
<th>10 percent area (ha)</th>
<th>10 percent production (t)</th>
<th>5 percent area (ha)</th>
<th>5 percent production (t)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Aileu</td>
<td>1,100.0</td>
<td>3,300.0</td>
<td>110.0</td>
<td>330.0</td>
<td>55.0</td>
<td>165.0</td>
</tr>
<tr>
<td>Ainaro</td>
<td>810.0</td>
<td>2,430.0</td>
<td>81.0</td>
<td>243.0</td>
<td>40.5</td>
<td>121.5</td>
</tr>
<tr>
<td>Baucau</td>
<td>20,190.0</td>
<td>60,570.0</td>
<td>2,019.0</td>
<td>6,057.0</td>
<td>1,009.5</td>
<td>3,028.5</td>
</tr>
<tr>
<td>Bobonaro</td>
<td>31,300.0</td>
<td>93,900.0</td>
<td>3,130.0</td>
<td>9,390.0</td>
<td>1,565.0</td>
<td>4,695.0</td>
</tr>
<tr>
<td>Covalima</td>
<td>300.0</td>
<td>900.0</td>
<td>30.0</td>
<td>90.0</td>
<td>15.0</td>
<td>45.0</td>
</tr>
<tr>
<td>Dili</td>
<td>470.0</td>
<td>1,410.0</td>
<td>47.0</td>
<td>141.0</td>
<td>23.5</td>
<td>70.5</td>
</tr>
<tr>
<td>Ermera</td>
<td>27,890.0</td>
<td>83,670.0</td>
<td>2,789.0</td>
<td>8,367.0</td>
<td>1,394.5</td>
<td>4,183.5</td>
</tr>
<tr>
<td>Lautem</td>
<td>920.0</td>
<td>2,760.0</td>
<td>92.0</td>
<td>276.0</td>
<td>46.0</td>
<td>138.0</td>
</tr>
<tr>
<td>Liquica</td>
<td>1,070.0</td>
<td>3,210.0</td>
<td>107.0</td>
<td>321.0</td>
<td>53.5</td>
<td>160.5</td>
</tr>
<tr>
<td>Manatuto</td>
<td>530.0</td>
<td>1,590.0</td>
<td>53.0</td>
<td>159.0</td>
<td>26.5</td>
<td>79.5</td>
</tr>
<tr>
<td>Manufahi</td>
<td>2,420.0</td>
<td>7,260.0</td>
<td>242.0</td>
<td>726.0</td>
<td>121.0</td>
<td>363.0</td>
</tr>
<tr>
<td>Oecussi</td>
<td>3,460.0</td>
<td>10,380.0</td>
<td>346.0</td>
<td>1,038.0</td>
<td>173.0</td>
<td>519.0</td>
</tr>
<tr>
<td>Viqueque</td>
<td>5,960.0</td>
<td>17,880.0</td>
<td>596.0</td>
<td>1,788.0</td>
<td>298.0</td>
<td>894.0</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>96,420.0</strong></td>
<td><strong>28,9260.0</strong></td>
<td><strong>9,642.0</strong></td>
<td><strong>28,926.0</strong></td>
<td><strong>4,821.0</strong></td>
<td><strong>14,463.0</strong></td>
</tr>
</tbody>
</table>

#### 7.1.2 Brackish water aquaculture

Brackish water aquaculture was introduced in a number of coastal sites during the Indonesian regime. The species cultured primarily included milkfish and tiger shrimp. While considerable success was achieved in culturing shrimp and milkfish, brackish water aquaculture systems virtually collapsed during the conflict.

Development of brackishwater aquaculture, particularly where shrimp and milkfish culture was practiced in the past, is also one of the priorities of the NDFA. Nevertheless, the policy is not to construct new ponds in the immediate future, but rather to rehabilitate existing ones and to improve their productivity. Because there are no brackish water hatcheries in Timor-Leste, shrimp or milkfish farming will depend largely on fry or fingerlings collected from natural water bodies or imported. Expansion of area with heavy reliance on fry or fingerlings collected from wild source is not benign to the natural environment. Also, it is unlikely to be a viable practice due essentially to high labor requirement to collect fish seed from wild sources. Hence, NDFA’s present policy to limit brackish water aquaculture development to existing ponds is a safer option for the short to medium term. Keeping this in mind, the potential area presently available for brackishwater aquaculture development across locations is limited as shown in Table 11.

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\(^{37}\) Source: Fish and animal protein consumption and availability in Timor-Leste (2011), FAO/RFLP, Timor-Leste
Table 11: Area (ha) covered by brackish water aquaculture ponds

<table>
<thead>
<tr>
<th>District</th>
<th>Location</th>
<th>Area (ha)</th>
<th>Remarks</th>
</tr>
</thead>
<tbody>
<tr>
<td>Dili</td>
<td>Tibar</td>
<td>4</td>
<td>Repaired</td>
</tr>
<tr>
<td>Liquica</td>
<td>Loes</td>
<td>4</td>
<td>Repaired</td>
</tr>
<tr>
<td>Manatuto</td>
<td></td>
<td>10</td>
<td>Needs repairing</td>
</tr>
<tr>
<td>Covalima</td>
<td>Suai</td>
<td>1</td>
<td>Needs repairing</td>
</tr>
<tr>
<td>Oecussi</td>
<td>Sakato</td>
<td>4</td>
<td>In operation</td>
</tr>
</tbody>
</table>

**Total** 23

Judicious considerations are essential for sustainable brackish water aquaculture development. Development of milkfish or shrimp production systems at the expense of mangroves is detrimental to coastal ecosystems. Likewise, attention should be given to proper management of effluents from fish ponds to ensure that aquaculture activities are not polluting coastal aquatic systems.

GIS modelling is helpful to map potential areas for brackishwater aquaculture development. In this study, this modelling was not performed due to the lack of a database and sufficient information to determine influencing factors and allocating weighting to each of the factors. The potential area for brackish water aquaculture development will also depend on the environmental policy of the GoTL, and zonation and access use rights legislation and policies. It is clearly stated in the constitution (Section 139(3)) that ‘the exploitation of natural resources shall preserve the ecological balance and prevent destruction of ecosystem’. Consultation with the Ministry of Environment revealed that drafting of a series of environmental policies/laws—with the assistance from various development partners—was underway in 2011. They are as follows:

- General environmental law;
- Bio-diversity law; and,
- Climate change adaptation plan.

The above policies/laws, upon their launching, will provide clear guidelines for GIS modelling of potential areas for the expansion of brackish water aquaculture to new areas. Hence, it would be relevant to carry out such a modelling in the coming years once the new environmental policies/laws are in place. Meanwhile, the focus is on improving/rehabilitating existing sites, which could produce over 44 t of fish/shrimp with modest inputs.

### 7.1.3 Mariculture

#### 7.1.3.1 Seaweed

Although Timor-Leste has a favourable resource-base for seaweed farming, its expansion can be argued only provided that there is increase in demand in the export market. Nevertheless, there is some scope for increasing viability through social and economic interventions. Improvement in post-harvest handling, especially through value addition in production, drying and packaging systems, would fetch higher price, thereby making the enterprise more viable.

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Likewise, strengthening of seaweed farming groups/cooperatives would enable the primary producers to explore markets by themselves, and to increase their bargaining power.

A careful evaluation of suitable farming methods and areas is critical if environmental and socio-economic sustainability of seaweed farming are to be maintained. Advanced farming schemes require high investments, reducing their economic profitability. Therefore, the acceptance of such methods among producers and communities should be enhanced by parallel development of post-harvest processing and marketing, which would yield an overall higher net profit from their farms. It was hypothesized that seaweed farming can create a stewardship over marine shallow water resources. Its usefulness as a tool to stop over-fishing and the destructive fishing practices is however doubtful, and over-harvesting of marine resources often prevails. However, in contrast to artisanal fisheries, seaweed farming can help in building a better general environmental awareness.

The whole production cycle, pests and diseases depends on and is influenced by environmental conditions. Very simple monitoring of such parameters as salinity and nutrient levels can contribute significantly to a better understanding of the marine environment. Government agencies, therefore, should not only promote seaweed farming, but also combine this effort with programmes to build general awareness and social cohesion and empowerment (i.e., set up an association).

While increasing production presents a relatively straightforward challenge, attention should also be turned towards creating further value through localized processing. Drying, crushing and grinding the product in small factories operated by community people would create further employment, allowing them to produce a more valuable semi-refined product.

Government intervention through the setting up an association could help improve techniques, thereby increasing productivity. The association could also help in securing investment for processing, opening new accesses to markets, creating market awareness, and establishing a market information system, which can provide crop forecasts and detailed price information.

At the producer level, becoming a stakeholder in the association will allow for lessons learnt to be shared among other producers, learn about improvements and techniques, generate a feeling of transparency and trust, and most importantly, create a stable platform for forward development.

7.1.3.2 Sea cucumbers

Sea ranching of sea cucumbers may be a viable option in some areas of Timor-Leste. There is high potential for integrated culture of seaweeds and sea cucumbers, and it might be a particularly worthwhile pathway for development. Culture in pens, or even in open leases, below seaweed lines will provide economies of scale in terms of labour and security requirements, which are the two biggest ranching operations costs. Ultimately, success of such ventures depends on a combination of various factors, which include appropriate enabling government policies, habitat, management and zoning and access rights frameworks, legislation, and security systems to provide protection to operators, infrastructure, and hatchery capacity.

Research efforts to develop simplified hatchery technology elsewhere (such as the substitution of live algae feeds with processed algal pastes) will provide viable options for hatchery
development in more remote areas. Diverse nursery methods being tried out at present in the Philippines will maximize the benefits that flow to communities by allowing their early engagement in the production process, thereby minimizing the cost of seed. There is potential to transfer some of these technologies to Timor-Leste from countries like the Philippines, Indonesia and Vietnam through RFLP output 6 on Regional Sharing of Knowledge. Lessons learned from the Philippines and elsewhere suggest that development of sea cucumber farming can be an alternative livelihood option for some coastal communities. Nevertheless, devising promising recommendations through pilot trials with due consideration of technical (hatchery technology), social, economic and environmental aspects is essential prior to its promotion in Timor-Leste.

7.1.3.3 Other species

There are few other high-value species possessing mariculture potential (for example, grouper, seabass, and lobsters). However, mariculture of such species in Timor-Leste in the short or medium term cannot be argued due essentially to:

- High investment requirement for infrastructure development;
- Low potential for addressing widespread poverty and malnutrition by promoting high-value fish farming;
- Heavy reliance on capture fisheries for seed and feed (trash fish) – which is not benign to environment;
- Low domestic demand for high-value fish (as these are not affordable for the majority people); and
- Poorly developed post-harvest handling/processing systems.

In the long run, development of mariculture based on high-value species will depend on the availability of viable production technologies that are benign to the environment, domestic demand and export potential, infrastructure facilities and access to services.

7.2 Infrastructure development

7.2.1 Road networks

Fish is a highly perishable commodity. Therefore, smooth delivery of inputs (seed and feed) and transportation of the products to the local as well as distant markets is very important. Currently, 90% of national and district roads are in a poor condition, requiring urgent repair or rebuilding. The GoTL has adequately recognized that this is a major constraint to industrial and agricultural development in the country. Nevertheless, the SDP (2011-2030)\textsuperscript{39} envisions that by 2030, an extensive network of quality and well-maintained roads will connect communities, promote development (agriculture, industry and tourism), and provide access to markets. Construction, rehabilitation and upgrading of the present road network has been prioritized as follows:

• By 2015:
  o Rehabilitation/upgrading of major national/regional roads will be completed.
  o A few major roads (Dili-Manatuto-Baucau and Manatuto-Natarbora) will have been upgraded to international standards.

• By 2020:
  o All national/regional roads will have been upgraded to international standards.

• By 2030:
  o National ring road will have been completed.
  o New bridges will have been constructed to provide all weather access to all district routes.

With this improvement of road network in the future, aquaculture development in Timor-Leste is likely to take place at a steady pace, given that technical, social and economic considerations are adequately taken into account.

7.2.2 Electricity

The SDP (2011–2030) considers access to electricity as a basic right and a foundation for national development. It aims at ensuring reliable access to electricity for all people by 2015. Development of the aquaculture sector to SMEs level will be easier with the improved access to electricity supply across country.

7.2.3 Irrigation

In recent years, a number of irrigation systems have been rehabilitated in Timor-Leste. Consequently, the total irrigated area countrywide reached 50,000 ha in 2011. The Department of Irrigation under the MAF plans to continue expanding irrigated area through rehabilitation of existing irrigation systems and the development of new ones. By 2020, over 70,000 ha of agricultural land will be irrigated. Reliable access to water resources is vital to the development of sustainable pond aquaculture. The introduction of aquaculture in rice-based farming systems will also help in diversifying livelihoods opportunities. Improved access to irrigation will not only increase crop productivity, but will also provide new opportunities for the diversification of livelihoods through the introduction of aquaculture to traditional crop-livestock-based farming systems.

7.3 Sustainable Aquaculture Technology Development

Low input–low output freshwater pond aquaculture systems currently in practice in Timor-Leste are not likely to become a viable option to improve the livelihoods of resource-poor farming households. However, there is potential for improving the performance of the current ‘extensive’ fish culture systems to ‘semi-intensive’ level using a balanced approach to ensure optimal levels of productivity and efficiency from aquaculture in a sustainable way. Devising
low-cost technologies with effective utilization of locally available resources is vital to increasing the efficiency of homestead aquaculture systems aimed at improving food and nutrition security and augmenting household income. Testing and devising of a promising technological package for wider recommendation domains could be done through on-farm trials managed by small-scale fish farmers themselves.

The agro-ecological focus of aquaculture intervention should be in ‘high potential areas’, as scope for scaling up and replicating the technology in wider recommendation domains is higher in such areas. Once proven viable, many small-holder farmers can gradually start expanding their fish production systems towards SME level, provided they are not constrained by the resource base and market access.

As elsewhere, farmers’ participatory on-farm trails are the best way of testing and validating pond aquaculture technologies (freshwater and brackish) in Timor-Leste. Such trials will also help in expediting the dissemination of proven technologies to wider recommendation domains, as many households in the community will already be aware of the technology during the trial period itself. Key areas of interventions for the validation of technology through on-farm trials are:

- Fry/fingerling nursing systems to reduce loss of stocked fingerlings due to predation from wild fish, snakes, birds and other aquatic animals;
- On-farm preparation of feed using different combinations of locally available resources;
- Use of crop by-products (coconut by-products, rice bran, cassava and other root crops, and corn) based on their availability in the community;
- Low-cost green water technology (pond fertilization to increase in-situ fish food production (plankton) in the pond, particularly for tilapia farming;
- Polyculture systems, and multiple stocking and multiple harvesting systems;
- Integrated agriculture-aquaculture (IAA) with emphasis on on-farm nutrient recycling;
- Rice-fish culture (fingerling nursing and grow-out culture);
- Water quality management in ponds; and,
- Harvesting and post harvest handling of fish.

### 7.4 Inputs

#### 7.4.1 Seed

Ensuring easy access to quality fish seed is crucial to the expansion of aquaculture. Whilst the NDFA has four freshwater fish hatcheries with modest facilities, the potential for improvement of seed production capacity of these hatcheries is highly dependent upon rehabilitation of their facilities and appropriate applied training for NDFA hatchery staff. With upgrading of the hatcheries and staff capacity, the demand for fish seed is likely to be met by these hatcheries in the short and medium term. However, in the long run, existing hatcheries alone are unlikely to meet the expected growing fingerling demand. If freshwater aquaculture was expanded to 4,800 ha (i.e., 5.0 % of total potential area), annual demand for fish seed will be over 150 million. Whilst the NDFA hatcheries have the potential for meeting around 40% of total fish seed demand upon improvement of their physical facilities and technical capacity of hatchery...
staff, the remaining 60% should be supplied through private sector hatcheries, indicating a strong need for private sector investment in fish hatcheries. The development of small-scale fish hatcheries and nurseries at the community level would be necessary to ensure easy access to fish seed supply at the local level. Low investment technologies exist for common carp and tilapia breeding and nursing systems, which are appropriate for decentralized seed production by local entrepreneurial farmers.

Undoubtedly, the NDFA fish hatcheries need to focus their activities beyond just seed production and distribution. In the long run, they should serve as a reliable source of quality fish brood stock for private hatcheries. Yet, in the short and medium term, improving fingerling production capacity, and acquiring and maintaining fish brood stock of improved strains is crucial.

7.4.2 Feed

Timor-Leste has imported limited quantities of pelleted fish feed from neighbouring countries, mainly Indonesia, in recent years. The NDFA has been providing subsidized pelleted feeds to a small number of farmers. Likewise, I/NGOs promoting aquaculture have also been subsidizing pelleted fish feeds. However, the promotion of small-scale aquaculture systems reliant on commercial pelleted feeds is unlikely to be viable because of the high feed production cost. The GoTL is promoting fish farming in the country primarily to improve household food and nutrition security. Therefore, the introduction of low-cost technologies is inevitable to both increase fish production, while at the same time reducing production costs. There is potential for the development of low-cost feeds prepared utilizing locally available resources. Formulation of feeds utilizing crop by-products (rice bran, cassava leaves and roots, grasses, corn, coconut by products, etc.) can be promoted as a low cost feeding system. Likewise, ‘green water technology’ - fertilization of ponds with organic and chemical fertilizers to promote phyto- and zooplankton populations is also likely to be a viable option for culturing tilapia.

The types of ingredients and their proportions for on-farm fish feed preparation will vary with differences in locally available resources. In the longer term the production of fish feed pellets within the country may be an option for intensification of fish production systems.

7.5 Markets

7.5.1 Fish and other aquatic products

Markets for agricultural products are poorly developed in Timor-Leste. Farmers often sell fish to their neighbours due to their limited local supply and high demand. Marine fish is sold at prices ranging from USD 5 to 15 per kg (depending on the type and size of fish) in coastal areas and are normally sold by the roadside either directly by the fisher or by a middle-trader. In inland areas, vendors carry small volumes of marine fish and go around from one community to another by motorcycle. However, they do so only irregularly.

It is imperative to link fish farmers with markets as their production increases. Developing clusters of farmers concentrated in a given geographical location and organizing them in groups or cooperatives, which has already proven to be successful in promoting aquaculture in small-scale farming systems elsewhere, is likely to become effective in Timor-Leste as well. This
would not only make it easier to acquire seed and other inputs, but also help in marketing the product to local and more distant markets.

The Ministry of Economy and Development (MoED)\(^{40}\) has been supporting the development of local markets at district and sub-district levels. Weekly markets are common in villages/sub-districts. However, at the district level, markets operate daily. A large number of shade structures for local markets have recently been constructed at convenient locations across the country. Community people sell their products (food grain, vegetables, livestock and chickens) and purchase household merchandise in such markets. Unlike other commodities, fish is a highly perishable item, requiring careful post-harvest handling. Provision of basic facilities (for example, potable water for ice production and cleaning, and ice and ice boxes) would help in developing fresh fish markets locally.

There is currently no commercial large-scale production of ice in Timor-Leste and most ice used to ice fish is produced in household fridges. The Ministry of Tourism, Commerce and Industry (MTCI) has two large scale (20 tons per day) ice machines available which have remained in containers since purchase, which require commissioning. The RFLP and the MAF offered to support bringing these machines into operation, but the MTCI failed to take up the offer. Following the successful piloting by RFLP in two districts of a small-scale ice production and distribution system, the RFLP is now seeking donor funding for a nationwide ice production and distribution system. There is clear potential for developing fish marketing systems at the local level in joint collaboration between the MAF, the MoED and the MTCI.

7.5.2 Seaweed

External trade promotion in Timor-Leste is under the domain of the Ministry of Tourism, Commerce, and Industry (MTCI). The ministry has been facilitating the export of coffee internationally\(^\text{41}\). Likewise, the ministry has been exploring export potential of a number of agricultural products. China alone has shown interest in importing over 400 types of products from Timor-Leste with a zero tariff. The MTCI also facilitates quality improvement of export commodities. Establishing a national coffee board is already underway. MTCI officials confirmed that there is potential for forming a seaweed board, 5 or more private sector companies are interested. China could be a potential buyer for marine aquaculture products like seaweed. There is also potential for exporting dried sea cucumbers to China if its farming is developed in Timor-Leste in the future. In the short term, coordination between the MTCI, the NDFA, and seaweed producers and exporters will help to improve seaweed quality and access to new export markets.

7.6 Human Resource Development

Aquaculture development in Timor-Leste is largely constrained by the limited NDFA staff capacity and number (Table 12). Currently the NDFA has a total of 113 staff including 22 staff under its Aquaculture division. I/NGOs similarly have too few trained aquaculture specialists. Therefore, increasing the number of appropriately trained aquaculture staff in the country is essential.

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\(^{40}\) Personal Communication: MoED

\(^{41}\) Personal communication: Mr Ossorio Correa, MTCA
Strengthening the capacity of NDFA staff is equally important, as most of them have insufficient relevant training to perform their assigned responsibilities. The RFLP has supported the development of a human resource development plan for the NDFA of the MAF, through supporting international consultancy input from TRAGSA. The HRD plan should be available in Q1 of 2012. The SDP (2011-2030) has prioritized the development of national training systems in all major occupations. The government emphasizes the need for a broad range of public and private training providers throughout the country. In line with the SDP, the NDFA also needs to develop its own training program on aquaculture in order to increase the capacity of its officials. Such programs should focus on skills development in the short term. The role of the ‘Planning, Human Resource, and Administration’ unit under the Director General, MAF is critical to the development of an effective training system for aquaculture.

Table 12: NDFA staff (n) by academic qualifications and location

<table>
<thead>
<tr>
<th>District</th>
<th>Secondary school</th>
<th>Diploma 1 (D1)</th>
<th>D2</th>
<th>D3 (equivalent to BSc)</th>
<th>Strata1/D4 (equivalent to BSc)</th>
<th>Strata2 (MSc)</th>
<th>Others (below secondary school)</th>
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<td>2</td>
</tr>
<tr>
<td><strong>Total</strong></td>
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<td><strong>1</strong></td>
<td><strong>3</strong></td>
<td><strong>8</strong></td>
<td><strong>31</strong></td>
<td><strong>2</strong></td>
<td><strong>10</strong></td>
<td><strong>113</strong></td>
</tr>
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</table>

The NDFA has very few staff with advanced degrees in aquaculture. There is a dire need for a strong team of appropriately trained experts for the planning and implementing of sustainable aquaculture development interventions that can produce lasting impact in Timor-Leste. In the short and medium term, qualified staff members should be encouraged to pursue advanced degrees in priority subject areas identified in the NDFA HRD plan.

7.7 Policy environment

The SDP (2011-2030) has clearly emphasized the need for adequately harnessing fisheries and aquaculture development potential of the country by 2030. The plan is to introduce at least three types of aquaculture activities (the types, however, are yet to be specified) to coastal communities by 2020. The SDP has also identified a number of districts endowed with abundant water supply and a favorable resource base as potential areas for aquaculture development.  

42 Source: NDFA (2012)
development (for example, Aileu, Ermera, Liquica and Ainaro districts). It is clearly mentioned in the SDP that districts/areas endowed with a favorable resource base will be encouraged to develop aquaculture. Overall, the SDP is conducive to aquaculture development in the country.

The GIS modelling of potential areas for freshwater aquaculture development carried out during this study supports the SDP well. The modelling, with due consideration of a number of bio-physical and socio-economic factors, has provided a clear basis for narrowing down aquaculture development focus to favorable agro-ecological pockets across country, which are in line with the SDP.

Essentially all ministries and departments consulted during this study confirmed the need for a coordinated approach to improving food and nutrition security in Timor-Leste. They appreciated the potential role of aquaculture development in addressing poverty and confirmed their willingness to support the NDFA’s aquaculture development endeavors. Potential areas for collaboration between the MAF, and other line ministries and departments, were discussed with all the stakeholders (Table 13).

**Table 13: Potential areas of collaboration between NDFA and GOs/NGO for aquaculture development**

<table>
<thead>
<tr>
<th>Ministry/Department/organization</th>
<th>Area(s) of collaboration</th>
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</table>
| Ministry of Economy and Development/ National Microfinance Institute | • Financial services to aquaculture development schemes:  
• SME loans: up to USD 5,000 (2 years);  
• Group loans for resource-poor fish farmers’ groups: up to USD 1,000 (6-9 months); and,  
• Loans for micro-enterprises (inputs and outputs marketing, etc): up to USD 2,000. |
| Ministry of Economy and Development | • Facilitate establishing market linkage with small-scale fish producers;  
• Development of fish markets in local areas; and,  
• Develop input markets (feed, seed, tools and equipment). |
| Ministry of Health (MoH)/Department of Nutrition | • Pilot testing - potential for inclusion of fish in supplementary feeding program; and,  
• Pilot testing - role of small-scale aquaculture in improving food and nutrition security of households. |
| Ministry of Trade, Commerce, and Industry | • Promotion of export market of seaweed and other aquatic products;  
• Support value addition of aquaculture and fisheries products to ensure premium price in export markets; and,  
• Industrial scale ice making machinery (20 ton capacity daily) available. |
| Ministry of Education | • Piloting – fish and fisheries products in school lunch program; and,  
• Piloting - aquaculture in school ponds (in favorable areas). |

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43 Source: consultation meetings with respective Ministries/Department/ NGOs/private sectors
<table>
<thead>
<tr>
<th>Ministry/Department/organization</th>
<th>Area(s) of collaboration</th>
</tr>
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</table>
| MAF/National Directorate of Policy and Planning | • GIS mapping of areas for aquaculture (freshwater/brackishwater/mariculture) and fisheries; and,  
• Validation and updating of agro-ecological suitability maps for aquaculture development. |
| MAF/Department of Irrigation | • Inclusion of aquaculture as one of potential enterprise requiring access to irrigation water. |
| MAF/National Directorate of Agriculture | • Prioritize integrated-agriculture-aquaculture systems promotion as a strategy for diversification of livelihoods. |
| I/NGOs: (CARE International, WorldVision, Oxfam, etc) | • Include aquaculture in livelihoods support programs. |
| Private sector: Timor Global Ltd. | • Pilot testing: fortification of Timor Vita by adding dried fish (in collaboration with MoH and MAF). |

8. **Potential role of aquaculture in improving livelihoods**

As elsewhere, aquaculture development in Timor-Leste is believed to have potential to play a significant role in improving the livelihoods of small-scale farming households and resource-poor communities. The government has already recognized this and has clearly emphasized the need for aquaculture development in its SDP (2011-2030). This section analyzes the potential role of aquaculture in improving and diversifying livelihoods in Timor-Leste.

8.1 **Household consumption: improving food and nutrition security**

The pivotal role of homestead pond aquaculture in improving food and nutrition security of the households has been well recognized in a number of countries in South and Southeast Asia. Fish consumption (quantity and frequency of eating aquatic products) is naturally high among fish farming households. In Timor-Leste meat is typically only available occasionally in rural areas and is also relatively expensive. When fish are cultured in farm ponds, fish are readily available and can be harvested at anytime for either consumption or sale for cash needs.

Timor-Leste has the potential to produce over 14,000 t of freshwater fish even if aquaculture is only developed with modest inputs in around 5.0% of the potential area (around 4,800 ha) classified as ‘most suitable’ for aquaculture. Assuming production from the capture fisheries sector also increases with improvement in fishing, post harvest handling and marketing systems, the total per capita supply could be increased to around 15 kg in the medium term (by 2020) – a figure which is close to the Asian region average. In the long run, the supply could be doubled through the intensification of production systems to semi-intensive level and the expansion of area to SMEs level.
8.2 Augmentation of family income

Aquaculture interventions aimed at only improving household food and nutrition security are unlikely to be viable in the long run, since farmers need to invest time and resources on inputs (seed and feed) and management. Therefore, emphasis should also be given to augment household income from the sale of surplus production. A small-scale farmer with a 200 m² pond could produce around 100 kg of fish annually (extrapolated yield of 5 t ha⁻¹). In general, small-scale fish farmers in many Asian countries typically sell 40–60% of the total fish produced from their farms. Income from the aquaculture sector contributes directly to combating poverty and can provide cash income in areas where few other cash income-generating opportunities may be available.

8.3 Supplementary feeding program (pregnant and lactating mothers, school children)

Marketing of fish was one of the issues raised by a number of stakeholders in Timor-Leste because of the low purchasing capacity of the large majority of the households across the country. This is likely to be true for many sub-subsistence households without alternative income-generating activities. Nevertheless, the SDP (2011-2030) envisions significant improvement in the livelihoods of a large number of resource-poor communities in the years to come. Consumption of fish and meat increases with increased household income. It can be safely argued that there will be a buoyant market in Timor-Leste for aquaculture products in the future.

In the short and medium term, there is the potential for including fish in the diet of pregnant and lactating mothers, and school children under the on-going GoTL supplementary feeding program. There is also scope for the fortification of the Timor Vita (supplementary food currently being promoted) by adding fish. Timor Global (a private company manufacturing Timor Vita) and the Department of Nutrition, MoH are keen to pilot the inclusion of fish in the supplementary feeding program through the fortification of Timor Vita by fish addition\(^{44}\). This will help provide fish in the diet of people in the areas with poor access to aquatic resources.

8.4 Empowerment of women and vulnerable groups (development of farmers’ institutions)

Development of fish farmers’ institutions by organizing them into production and marketing groups/clusters is crucial for viable small-scale aquaculture. Once organized into groups, farmers can respond collectively when selling their produce and buying inputs and services in bulk at discounted prices. This will reduce production costs on one hand, and on the other, increase their bargaining power.

Such groups/clusters can be developed into full-fledged farmers’ cooperatives over time. Promotion of cooperatives is already a priority in the SDP (2011 - 2030), for it is recognized as an effective way to encourage private sector growth in rural areas. Requirements for the formation of a cooperative in Timor-Leste include a minimum of 15 members and US$ 1,000 capital. A large number of resource-poor and vulnerable households can be embraced by

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\(^{44}\) Personal communications: Ms Dirce Maria Soares (MoH) and Mr Bobby Lay Ni Sing (Timor Global (TL) LDA

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cooperatives owned and managed by the household themselves. A significant number of small-scale producer groups and cooperatives already exist and RFLP working in collaboration with the NDFA is in the process of facilitating the formation of a federation of producer groups.

Aquaculture development in Timor-Leste can also serve as an effective tool in empowering women and other vulnerable groups. Like home gardening, small-scale homestead pond aquaculture (from production to marketing) is also a women’s domain in many countries. Promotion of aquaculture with active involvement of women community members increases their access to, and control over resources. Moreover, organizing them into groups/cooperatives acts towards their empowerment and increases their decision-making power.

9. Follow up Implementation Plan: Piloting aquaculture development interventions

9.1 Freshwater Aquaculture

As elsewhere, farmers’ participatory on-farm trails (OFT) are the best way to test and validate pond aquaculture technology (both freshwater and brackish water) in Timor-Leste. Drawing recommendations based on on-farm trials will also help expedite dissemination of proven technologies to wider domains, as many households in the community will already be aware of the technology during the trial period. Key areas of interventions for pilot testing and validation will include:

- Fry/fingerling nursing systems to reduce loss of stocked fingerlings caused by predation from wild fish, snakes, birds, and other aquatic animals;
- On-farm preparation of feeds using different combinations of locally available resources:
  - Use of crop by products (coconut, rice bran, corn, cassava and other root crops, etc) based on their local availability in the community; and,
  - Low-cost green water technology (organic {and inorganic} pond fertilization to increase in-situ fish food production (plankton) in ponds, particularly for tilapia farming);
- Polyculture systems, and multiple stocking and multiple harvesting systems;
- Integrated-agriculture-aquaculture (IAA) with an emphasis on on-farm nutrient recycling;
- Rice-fish culture (fingerlings nursing and grow-out culture);
- Water quality management in ponds; and,
- Harvesting and post-harvest handling.

Agro-ecological focus will be in areas classified as ‘high potential’ through GIS analysis, because in such areas, the scope for scaling up and replication of the technology across wider areas is higher. The results of the on-farm-trials will help in devising and refining technical recommendations.

The framework for conducting participatory on-farm trials on freshwater aquaculture is outlined below:
i. **Selection of site and community**

One of the districts/sub-districts with high potential for freshwater aquaculture development (Ermera, Baucau, Aileu, Bobonaro, or Manufahi (Same sub-district)) will be selected. A team of researchers will visit the selected district and narrow down the potential piloting site by selecting 1-2 communities based on:

- Available resources (land and water) with potential for future expansion;
- Community need;
- Willingness of communities to participate in developing aquaculture; and,
- Accessibility of seed supply, extension services and markets.

ii. **Selection and recruitment of trial participant farmers**

The selection of households will be carried out through a meeting with prospective trial participants. The selection process will use the following criteria:

- Willingness to participate in trials on a voluntary basis;
- Possessing a pond or willing to excavate a new pond;
- Willing to follow the technical recommendations provided by the project team;
- Literacy and agreeing to maintain records of activities throughout the trial period, as requested by the project team;
- Willing to develop a group/cluster and share activities and experience with members through organizing meetings at regular intervals; and
- Encouraging women members to participate.

iii. **Training of participants**

Project participants will be provided with a series of practical training sessions after enrollment. The timing of training sessions will be appropriate to the different stages of the aquaculture cycle/season. Major topics to be covered will include:

- Groups dynamics — strengthening of group/community-based development interventions;
- Introduction to fish farming options (monoculture/polyculture; and rice-fish culture);
- Construction/preparation of facilities (ponds and rice fields);
- Pond preparation and water quality management;
- Acquiring, nursing and stocking of fingerlings;
- Potential problems (water quality and disease) and solutions;
- Fertilization, feed preparation and feeding;
- Disease prevention and treatment;
- Harvesting and marketing; and,
- Maintaining pond record book, and analyzing costs and benefits.

iv. **Technical recommendations**

Technical recommendation options for OFT of Tilapia monoculture, tilapia and carp polyculture, and rice-fish culture systems in Timor-Leste are presented in the Table 14. Participating farmers will be asked to choose a culture system(s) based on their resource-base and interest.
Table 14: Recommended culture systems

<table>
<thead>
<tr>
<th>Culture systems</th>
<th>Pond input</th>
<th>Stocking density (fish/m²)</th>
<th>Culture period (months)</th>
<th>Production (t/ha)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Tilapia</td>
<td>• 28 kg N and 7 kg P ha⁻¹ week⁻¹ (62 kg, 35 kg Urea and triple super phosphate (TSP), respectively)</td>
<td>3</td>
<td>5-6</td>
<td>4.0</td>
</tr>
<tr>
<td>Polyculture (Tilapia + carps)</td>
<td>• 28 kg N and 7 kg P ha⁻¹ week⁻¹ (62 kg, 35 kg Urea and TSP, respectively) until fish attain 100 g size (for 2-3 months period)</td>
<td>2-4</td>
<td>10-12</td>
<td>4-6</td>
</tr>
<tr>
<td></td>
<td>• Supplementary feed prepared based on locally available resources (rice bran cassava, and other crop by products)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Rice-fish culture</td>
<td>• Supplementary feed prepared based on locally available resources (rice bran cassava, and other crop by products)</td>
<td>0.5</td>
<td>2-3</td>
<td>0.5-1.5</td>
</tr>
</tbody>
</table>

v. Participatory analysis of the results of trials

NDFA staff will assist farmers to analyze the results of trials and to suggest adjustments in the recommendations based on their experiences. In particular, discussion will focus on assessing whether participating households are content with the fish productivity. In addition, they will also be asked to suggest ways to improve the productivity and viability of fish farming in the future.

vi. Developing recommendations for replication

Lessons learned from the on-farm trials will be documented in the form of scientific briefs. Also recommendations for wider dissemination of aquaculture technology will be devised based on results of the trials.

vii. Participating organizations and their roles

- NDFA – overall coordination, and implementing of project activities;
- The WorldFish Center: provide technical backstopping;
- Development partners: funding partners.

9.2 Mariculture

Although Timor-Leste has a favourable resource-base for seaweed farming, its expansion can only be argued if there is increased demand in the export market. Nevertheless, there is some scope for increasing the viability of current seaweed culture systems through interventions related to social and economic aspects. Improvement in post-harvest handling, especially through value addition in production, drying and packaging systems, would fetch a higher seaweed price, thereby making the enterprise more viable. Likewise, strengthening of seaweed farming groups/cooperatives would enable the primary producers to directly explore markets themselves, and increase their bargaining power.
The whole production cycle, and pest and disease incidence largely depend on and are influenced by environmental conditions. Very simple monitoring of such parameters as salinity and nutrient levels can contribute significantly to a better understanding of the marine environment and the likely impact on seaweed production. Government agencies, therefore, should not only promote seaweed farming, but also combine this effort with their other programmes to build general awareness (i.e., setting up a seaweed association).

While increasing production presents a relatively straightforward challenge, attention should also be turned towards creating further value through localized processing. Drying, crushing and grinding of the product in small factories operated by community people would create further employment, allowing them to produce a more valuable semi-refined product in country.

Interventions from GOs, I/NGOs and private sector through setting up an association could help improve techniques, thereby increasing productivity. The association could also assist in securing investment for processing, facilitating access to new markets, creating market awareness, and establishing a market information system, which can provide crop forecasts and detailed price information.

Pilot testing on improving seaweed farming will be conducted following a similar participatory process possibly with support from the RFLP Timor-Leste. The NDFA and seaweed cooperatives will play a key role in identifying problems and addressing them through simple interventions in production, processing and marketing. The framework for carrying out the pilot project will be as follows:

i. **Disease outbreak: causes and solutions**

Farmers on Atauro Island experienced substantial reduction in seaweed production during 2011 due to disease outbreak. A sudden change in water quality (particularly, salinity and/or water pollution) was the likely cause. Hence, identifying causes and finding solutions will be done through routine monitoring of water quality and performance of seaweed crops for 2–3 production cycles. Weekly monitoring of salinity and turbidity levels of water in seaweed culture sites will be done.

- Monitoring of variation in growth performance of seaweed simultaneously with water quality monitoring; and,
- Identifying possible precautionary measures to avoid seaweed farming when there are seasonal patterns that are likely to increase the occurrence of disease outbreak.

ii. **Planting and harvesting schedule**

A 45-day culture cycle is recommended for seaweed farming in Timor-Leste. However, many farmers do not follow this recommendation. Farmers will be advised to harvest their seaweed after culturing for the recommended number of days. This will ensure product uniformity at the time of harvest.

- Farmer groups will be encouraged to follow the same planting and harvesting dates as recommended by experts/seaweed cooperatives; and,
- Participatory analysis will be conducted to assess the relationship between productivity and the quality of seaweed produced following the same planting and harvesting schedule.
iii. **Enhancing quality through improving post-harvest handling and storage conditions**

Farmers will be given specific recommendations on drying, packaging and storing of seaweed before it is exported. These will be based on the quality requirements of overseas markets. The NDFA, cooperatives and the MTCI, supported by RFLP Timor-Leste will work jointly on the possibility of introducing grading systems depending on post-harvest handling and storage conditions. In addition they will also jointly explore seaweed markets where there is a demand for premium quality. Farmers will be advised that:

- Moisture content of dried seaweed must remain within the recommended range i.e. 35 - 40% moisture;
- Inert matter content must be within acceptable ranges, i.e. 1 - 3% for Chinese, Vietnamese or Indonesian markets; and,
- Dried seaweed must be stored properly as per recommended best practices (which will be devised through participatory processes)

iv. **Involving primary producers in value addition process**

An overview shows that the current seaweed value chain in Timor-Leste is very simple. The product only passes through two to three steps. Step 1: Producer; Step 2: Collector (at times can also be exporter); and Step 3: Exporter (mainly Indonesian buyers). Currently no additional value for seaweed is created within Timor-Leste, which is a missed opportunity. Creating further value by localized processing is likely to increase income and profitability of seaweed farming within Timor-Leste. Drying, crushing, grinding and packaging of the product in small community-operated factories would create further employment and allow the communities to produce a more valuable semi-refined product.

- Introduction of community/cooperative managed seaweed processing plant; and,
- Exploring new marketing opportunities for locally processed seaweed.

v. **Developing recommendations for wider dissemination**

Assisted by NDFA and RFLP Timor-Leste staff farmers will analyze the results of trials and suggest adjustments to the recommendations based on their trial experiences. Lessons learned from piloting will be documented in the form of scientific briefs. In addition, recommendations on seaweed production and processing for wider dissemination will be devised based on results of these pilot trials.

vi. **Participating organizations in Piloting and their roles**

a. NDFA – overall coordination, and implementation of project activities;
b. Seaweed cooperatives – play the lead role implementation and monitoring;
c. MTCI – help exploring new seaweed markets;
d. The WorldFish Center and RFLP: provide technical backstopping; and,
e. Development partners: funding sources.
APPENDICES
Appendix 1:
Value Chain Analyses of Seaweed farming

Timor-Leste Seaweed Value Chain

Report produced for the WorldFish Center

Andrew Bassford
9/23/2011

“Seaweed culture offers a potential livelihood option for the coastal communities of Timor-Leste. Coastal communities are normally subject to fishing seasonality and the uncontrollable conditions of the weather; seaweed culture allows coastal families the option of a stable and regular income.”
Background

Aquaculture development has been identified by the Government of Timor-Leste as a means of improving the food and nutrition security situation and augmenting household income of inland and coastal communities. A clear national strategy was deemed necessary for sustainable aquaculture development in Timor-Leste. The National Directorate of Fisheries and Aquaculture of the Ministry of Agriculture and Fisheries, Timor-Leste is being assisted by the Regional Fisheries Livelihoods Programme, the Coral Triangle Support Partnership and the WorldFish Center to devise a national aquaculture strategy and action plan for the development of sustainable aquaculture aimed at addressing the problem of poverty and hunger in the country.

Mariculture in Timor-Leste, essentially the farming of seaweed, was started in 2003-2004. In the beginning, a small number of farmers (20 farmers in 2004) participated in pilot trials. However, with the success of pilot testing, the number increased steadily and reached 1,282 in 2010. The geographical focus of seaweed farming has mainly been on Atauro Island – a small island situated north of Dili with a population of about 10,000. Unlike freshwater aquaculture, seaweed is produced mainly for export and only a small proportion is used for domestic consumption. In recent years, seaweed culture has been one of the major income generating activities in the area. The total revenue generated from seaweed in Timor-Leste was estimated at US$ 19,130\(^{45}\) in 2009.

\(^{45}\) Source: NDFA, 2010
Given the rather simple production technology, seaweed farming is expanding to other districts as well (mainly in Manatuto). However, a clear strategy for seaweed production, processing and marketing is vital to its growth and viability in Timor-Leste. This study was aimed at carrying out value chain analysis of seaweed farming in Timor-Leste encompassing problems, possible recommended solutions and next steps.

**Methodology**

The consultation period was five days (8th August – 12th August). On the 13th August the consultant stayed on Atauro Island to witness the local sale of fish and seaweed at the traditional Saturday market. Within the main component of the consultation period the consultant met with GOs, NGOs, cooperatives, MFIs and communities engaged in seaweed production and harvest. Unfortunately the consultant was unable to meet exporters during the mission, and so assumptions have been made on their behalf (three separate attempts were made to have interview exporters).

**Dili visitation**

During the period of the 8th – 10th August, interviews and discussions were conducted with Julio da Cruz, Chief of the Aquaculture Division, National Directorate of Fisheries and Aquaculture (NDFA) Timor-Leste. Mr. da Cruz became the main point of contact within the government ministries and helped navigate between the different organizations. Another important ministry which was visited was the Ministry of Tourism, Commerce and Industry (MTCI) Timor-Leste which gave an insight into future possibilities. The president of the Biata Cooperative (Timor-Leste largest seaweed cooperative) was visited and finally with reference to seaweed the Instituicao de Micro-Financas de Timor-Leste (IMFTL) which is currently the only MFI in the Timor-Leste was visited.

**Atauro Island Visitation**

During the 11th and the 12th five seaweed communities, namely (Akrema, Wuaruana, Beloi, Vila, Makili were visited and community interviews held. Only one side of the island was visited due to distance and limited time, but this side of the island is where the majority of the seaweed production occurs. In addition to meeting producers another important interview conducted was with the only capacity building NGO on the island, namely Belun. Although the field visitation was extremely short, which limited the ability to collect detailed social data, the consultant the economic cross checked comments given by community members to ensure no figures within this report were over inflated.

**Special Thanks**

Special thanks needs to be given to both the National Directorate of Fisheries and Aquaculture (NDFA) and the Spanish funded and Food and Agriculture Organization executed Regional Fisheries Livelihoods Programme (RFLP) for organizing the interviews and travel itinerary for the mission.

**Introduction**

Today virtually no marine resource remains unaffected and traditional use of marine ecosystems (i.e. artisanal fisheries) are affected by advances in acidification and globalisation. It was noted during the visitation that while some fishers venture further from the shore most stay and fish close to land (within the continental shelf area). Part of the reason for this is the variety of targeted species (dried
reef fish are the most common locally consumed aquatic product) and partly because most fishing vessels are only small canoes with out-riggers. The majority of Timor-Leste’s fishing activity occurs around Atauro Island and is considered very artisanal, with most fish sold at weekend markets (as seen in photo below). No commercial port currently exists and so there is virtually no semi or industrial fishing occurring. This leads to coastal communities being highly dependent on nearby local reefs and due to the small size of vessels, fishers are very prone to weather conditions.

Diagram 1: Dried fish sold at the local Saturday market on Atauro Island

Timor-Leste has approximately 700 km of coastline that could play host to a growing trend in this part of the world to develop seaweed culture. Seaweed culture was first tried in Timor-Leste in 1989 without success. More methodical seaweed culture was successfully piloted between 2002/03 and between 2004/07 and production increased and spread to other sites like Atauro Island. Seaweed production peaked in 2010 with a total exported volume of 72 tons (total 96.4 tons harvested). Since then ice disease has affected production and exported volume to date at the time of the mission in 2011 was approximately 33 tons.

The global demand for seaweed containing carrageenan exceeds supply and recently raw product price has risen in light of current demand imbalances. Indonesia beach prices in some areas for dried seaweed have reached US$1.30 compared to US$0.70 in Timor-Leste, this price difference can contributed to direct access to markets which producers in Indonesia have and the very low quality of seaweed production in Timor-Leste through poor handling. It should be noted that prices are expected to balance and stabilize again in the coming few years as production increases, especially in Indonesia which wants to produce 10 million tons of wet seaweed within three years. The global demand for carrageenan is increasing and the largest growth for demand is coming from Asia.

Seaweed culture is considered environmentally benign, is an appropriate way to alleviate poverty for coastal communities and is also commonly practised by the women. Fishing villages face many hardships including weather and monsoon affecting the number of days they can fish and recently over-fishing by foreign fleets. The culture of seaweed is widely seen as a valuable additional income source for poor coastal communities, especially as the need for initial investment and human resources is small compared to other forms of sea ranching / farming.

Alternative livelihoods approaches are crucial to implementing sustainable ecosystem management. However, the success of introduced alternative incomes depends on their acceptance in the community, on market access, and on market prices.

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46 USAID fact sheet (2011), Supporting the seaweed value chain in Gorontalo.
48 Alder et al. 1994, Kuhlmann 2002
Culture of seaweed in South-East Asia

Until the 1960s industry demand for seaweed was largely covered by wild stocks, and cold water species collected in North America and Europe dominated the cold water seaweed market. In South East Asia, Indonesia exported the largest quantities of red seaweeds, however, due to political unrest this supply to the world market collapsed. This and increasing production costs for cold water seaweeds in the 1960s encouraged cultivation trials for warm water species in the Philippines.49

Since the 1980s, there has been great effort in Indonesia to repeat the commercial success of seaweed farming in the Philippines. Starting in the province of Bali and on Lombok Island, commercial farming has since spread all over the archipelago.

A. Timor-Leste current supply

Timor-Leste is relatively a new player in the seaweed sector and comparable to its neighbour, Indonesia, is only a small-scale producer. Due to disease in 2011 the export value for seaweed production slumped resulting in production reaching only 50% of 2010 volumes exported at the time of the mission. Furthermore the communities interviewed had not tended their crops over the last few months because disease had become more acute.

In 2010 a total of 96.4 tonnes were harvested. Of that 24.4 tonnes was consumed locally in Timor-Leste. Seaweed is sold in local markets and is used in cooking. Although seaweed contributed to the diet of people for centuries; the efforts of the UN FAO have seen the successful revival of seaweed consumption on Atauro Island.

Diagram 2: Export tonnage of seaweed Timor-Leste: Source NDFA 2011

Atauro Island is the district producing the largest amount of seaweed, although there are opportunities for the mainland to match and surpass the production from Atauro. There are significant opportunities for Timor-Leste to scale up and expand its seaweed production. The consultant estimates, assuming culture within 50 m of the shore, that only 20% of the potential area usable for seaweed culture around the coastline of Atauro Island is currently cultivated. More advanced production techniques and moving further to sea would allow significant expansion of production volume and production area.

B. Production systems and management

The natural habitat of seaweed species is the reef environment, were they grow attached to hard substrates50. In very early farming trials, the seedlings were tied to stones and then “sown” at the farming site. This changed significantly later when it was discovered that the algae could thrive without attachment to hard substrate but rather tied onto ropes.

49 Delmendo et al. 1992, Trono 1999
50 Trono,1999
Today, practically all open water seaweed farms use lines as the growth “substrate”. In the Philippines, initially large-mesh fishing nets were fixed horizontally over the sea floor with poles. The algae seedlings were then tied to the knots of the mesh. This practice however was very labour intensive as the net could not be prepared on land and the seedlings had to be tied to it at the location. Furthermore, it was discovered that the spacing of the plants could be much closer than practiced then. From these findings, the “off-bottom method”, which is still in use today, evolved51.

The **off-bottom method** consists of relatively small (2.5 - 5m) individual plots. Head ropes are tightened between poles at a distance of around 40–50 cm above the sea floor. Between those headlines the culture ropes are spaced at approximately 20–25 cm. The average planting distance on these ropes is 20–25 cm. Between the individual plots, small paths are left open for maintenance and harvest of the algae. With this method very high farming intensity (in terms of seedlings per area unit) is achieved. The disadvantages of this system however are the relatively close distance to the sea bottom, making it possible for pests to reach the plants (i.e. by climbing up the poles or benthic structures below the culture site). Furthermore water depth at average low tide has to be less than 1.20 – 1.5 m so that harvest and maintenance can be done during this time without uneconomical SCUBA equipment. This restriction limits the area where seaweed can be cultured.

The **floating raft method** consists of frames approximately the same size as individual plots of the off-bottom method (2.5 – 5.0 m). In sheltered waters however, the rafts may be up to 10 m x 10 m. The frames are made of floating material, usually bamboo as it is sturdy, light and relatively cheap. Within the frames, the culture ropes with a seedling density similar to the of-bottom method are tightened. The rafts are held in place with ropes tied to large stones or anchors. The length of these ropes depends on the water depth, tidal amplitude and wave exposure. Due to the additional weight of the crop, the frames float just below the water surface during all tidal stages. With the growth of the plants (i.e. with increasing weight of the frames), additional floats may be necessary to prevent them from sinking. The algae receive maximum light, and turbulent water is much less a problem than with submerged methods52. Farming intensity per unit area is lower than with the off-bottom method, as the rafts cannot be spaced close together without restricting water movement with waves and currents. However, the farming area is not restricted to a particular water depth range, and the total area under farming can be much higher than using shallow-water methods. Pests are also excluded from the plots due to the distance from the sea bed. Reef-dwelling fishes feeding on the crop are also much less abundant in deeper water. Additionally, seasonal parameters (e.g. water temperature and salinity) are more stable off-shore and therefore seaweed growth with the floating raft method is better than with the off-bottom method53. The rafts can be towed on-shore to facilitate easy crop handling. The disadvantages of this method are that it requires a minimum water depth. If the water is too shallow, waves can smash the floats on the sea bottom and destroy them. Moreover the initial investment is much higher than for the off-bottom method, especially in areas where bamboo is not readily available.

The **floating long-line method** evolved parallel to the raft method in order to overcome the problems of the off-bottom technique. With this farming method seaweed is cultivated on long lines (up to 100 m = US$ 20 per length paid by farmer), which are kept in place with individual anchor ropes. The cultivation lines are kept close to the surface by floats, which can be commercially available Styrofoam buoys, or, much more commonly, re-used plastic water bottles. Seedling distance on the lines is similar to both methods mentioned above; however, individual ropes are spaced much further apart. Usually, a spacing of 1m is necessary between the ropes to prevent them from entangling.

51 Neish 2003
52 Zuberi 2001
53 Hurtado & Agbayani 2002
from becoming entangled. However, in calm waters, the cultivation lines can be spaced closer together, but seedling densities as high as with the off-bottom method cannot be achieved. The floating long-lines have no restrictions of minimum or maximum water depth or sea floor structure and can be used in most situations. In areas with very high wave action, the off-bottom method is preferred by farmers, though they admit that higher yields are possible when the plants are kept at a constant distance from the water surface. Initial investment is significantly lower than for the floating raft method without compromising its benefits. Cultivation lines can be prepared and the harvest can be handled conveniently on land, which adds to the popularity of the method. From this basic cultivation scheme local variations within the region have evolved as a response to differing environmental conditions and the availability of different construction materials. In very clear waters, cultivation lines of the floating raft as well as floating long-line method, might be installed hanging vertically from headlines with bottom weights effectively increasing the total length of cultured rope per plot and hence, harvest.

Timor-Leste production system

In Timor-Leste currently only the floating long-line method exists, although assumptions are made that due to the relatively short time seaweed culture has been introduced other methods have not been tried or tested. Both the floating long-line method and floating raft method would be appropriate and if a finance scheme could be initiated to support the initial investment then depending on the location, both methods could be promoted.

This would allow the geographical area for possible seaweed production to expand. Although the floating raft method would allow production to expand, a more detailed geographical survey would need to be conducted around potential areas for development to assess tidal, current and access availability. Secondly designated geographical areas should be assigned exclusively for the purpose of seaweed production, while at the same time not being set over reefs or fishing areas which would negatively impact on fishing activities.

Diagram 3: Timor-Leste production cycle

54 Mandagi & White 2005
The current floating line method seems to have a repetitive plot size of 50 m x 4 m, thus 4 lengths of 50 m lines. It was difficult to attain why this has become the common size for an individual plot even though questions were asked repeatedly during visits to producers. At current prices floating line producers must buy 200 m coils of rope at a cost US$20 per coil.

According to the producers they can harvest between 20 - 30 kg per line which averages out to be approximately 100 kg per 45 day cycle, giving a monetary return of US$ 75 per crop. One area which was unclear was the seaweed source. The community may manage areas of seaweed for re-stocking. This maybe one of the reasons why disease outbreaks have been occurring, but with such limited information and time at the location, this is merely an assumption.

C. Post Harvest processing/handling

Harvesting simply consists of detaching the stocks from the support line, and transporting them to the drying area. The drying area can be a community based central location shared by all the farmers.

Traditionally the harvested seaweed is cleaned, sorted, and freed of dirt and other seaweeds, before being sun-dried on clean drying platforms (usually made of bamboo slats). This method has been slightly modified recently to minimise the loss of materials and to facilitate improved drying. The platform is first lined with fine-mesh braided nylon net and the harvest is spread on top of it. The plants are regularly turned over to ensure complete sun-drying. The drying crop must be protected from rain: the crop is piled into a heap by pulling the lining net to one part of the platform which is then covered by a waterproof sheet. During hot, sunny weather, the harvest dries within two or three days. The final moisture content of the crop should not be more than be 40 per cent. The dried material is tightly packed in plastic sacks and stored in dry areas before shipment to collection centres.

There are two commercial carrageenan products - refined or 'traditionally extracted carrageenan' and ‘semi-refined carrageenan’ (SRC) or also known as 'Philippines Natural Grade Carrageenan' (PNG).

**Refined carrageenan** is processed by boiling the seaweed in alkali for several hours under oxygenated conditions. The dissolved carrageenan is leached into a solution and subjected to viscosity control, pumped and filtered, then coagulated in alcohol. The coagulate is dried and powdered.

**Semi refined carrageenan** is processed by soaking the freshly harvested or dried seaweeds in alkali at a moderate temperature (60 °C for *Eucheuma cottonii*). This process does not involve the dissolution and leaching of carrageenan into solution. The carrageenan remains intact and is protected by the inert cellulose matrix of the cell walls. From the alkali the seaweed is washed thoroughly with fresh water and again sun dried before milling the seaweed, making it easier to package, store and ship.
Market and trade for refined carrageenan

The local market for dried seaweed in the Philippines and Indonesia consists of farmers selling their produce through the main channels, which are local traders, farmers’ cooperatives and non-governmental organisations. The dried produce goes to large buying stations in the area commissioned by big processing companies. Independent traders may also sell their stocks directly to local exporters who sell them on to international processors. Timor-Leste is a smaller market and it is recommended that producers sell directly to a central collection centre managed by a central seaweed association.

These centres could be government supported and also facilitate a MFI, store with small equipment, a drying station with fresh water, small processor (eventually) and a research and training centre (a meeting point for the producers to share and learn, maybe even incorporate a hatchery to supply the community with seedlings). A seaweed association could help by managing the facility and ensuring transparency and equality of pricing and privileges. The consultant has concerns about the seaweed cooperatives interviewed during this mission; firstly the lack of commercial and business sense and secondly possible corruption and non-transparent trade relations. A body needs to oversee the association that does not have a direct commercial interest such as a bank, government office or MFI. As the association will be a public identity, records can be transparently be made available to stakeholders.

Two general forms of products are exported to the international market as well as dried seaweeds. These are (a) semi-refined carrageenan (SRC) or natural grade carrageenan (PNG) and (b) refined carrageenan or ‘traditionally extracted carrageenan’. Dried seaweeds for export must conform to the following manufacturer requirements:

- **Moisture**: 35-40%; and,
- **Contaminants**: 1-3% (China, Vietnam, and Indonesia markets).

According to the Seaweed Industry Association of the Philippines, three types of product are exported by the 22 industry players, namely, dried seaweed, semi-refined carrageenan and refined carrageenan. Eighteen of the exporters sold raw materials at an average price of US$0.55/kg in 2004, while thirteen of them exported semi refined carrageenan at an average price of US$3.95/kg and only five of them processed and exported refined carrageenan at an average price of US$8.68/kg.

It is being recommended in Indonesia by both the ministry and development organisations to focus on the semi refined carrageenan processing for adding extra value over refined carrageenan for the lower setup costs and creating localized processing units. From desk research for this report it is recommended that Timor-Leste follows Indonesia to create local value addition, and a balance between initial investments to return by encouraging semi refined carrageenan processing.

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57 AUSaid Focus (2004)
Timor-Leste has the problem of expensive shipping so it is important to minimize water content of the seaweed shipped, a balance needs to be found between the capital investment of plant and the rate of return by export sales. An alkali treated chip (ATC) processing plant needs about 10,000 tonnes per month to be economically sustainable. SEAPlant.NET organization is experimenting with the designing of a mini (micro) plant for production of the ATC chips, which would require only 100 tonnes of dry E. cottonii per month. According to SEAPlant.NET prices for ATC (semi refined carrageenan) were between US$3-US$4 in 2007, which equates to a large increase in profit margin over selling just dried non processed seaweed.

D. Regional demand/Supply and Markets

Seaweed is in very high demand in international markets, especially as a raw material for the production of food, pharmaceuticals and cosmetics. Seaweed is also good fertilizer and is currently under consideration as a potential source of bio-ethanol.

The world’s demand for carrageenan in 2006 reached 40,000 metric tons a year worth US$ 335 million, with 12,000 metric tons of alginates a year worth US$ 94 million and 10,000 metric tons of gelatine a year worth US$ 181 million.

Philippines

Seaweed farming is currently the largest and most productive form of livelihood among the coastal population of the Philippines. Data/information from the Seaweed Industry Association of the Philippines for 2004 indicated that more than 116,000 families consisting of more than 1 million individuals were farming more than 58 000 ha of seaweed. In 2000-2004, the average annual production of dried seaweeds in the Philippines was nearly 125,000 tonnes, with a value averaging about US$ 139 million. In the past years due to disease Philippine production has dropped, this drop has also helped escalate supply shortages and price spikes.

Indonesia

In 2009 Indonesia’s wet seaweed production reached 2,574,000 tons, which increased sharply from the 2005 level of only 910,636 tons. Indonesia’s total seaweed exports reached 102,416 tons, worth US$ 124.36 million in 2009, with destinations including Asia, Europe, America, Australia, and Africa. Indonesia is the world’s biggest dried seaweed exporter with its annual exports reaching 102,000 tons, or about 45 percent of the tropical world’s total exports of 290,000 tons. The total dried seaweed exports of tropical countries which is 290,000 tons accounted for 25 percent of the world’s total seaweed exports of 1.2 million tons.

World demand for seaweeds and seaweed products is projected to remain at 10% annual growth rate. In order to supply the high demand for dried seaweeds as raw materials for carrageenan production the industry is expanding the farming of seaweeds to new sites/areas. The development of the floating methods of farming presently applied to deeper areas has contributed significantly to the increase in farm areas and production.

Problems of growth – Indonesia becoming no.1 producer (lessons learnt)

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58 ACIAR/SFP (2006)
59 http://seaplant.net/bimpeaga/images/downloads/SPNF_HB2A_1108__V2_VC.pdf
60 http://www.thefishsite.com/articles/860/cultured-aquatic-species-eucheuma-seaweed
61 http://indonesia-oslo.no/indonesia-projected-to-become-global-seaweed-producer/
Indonesia’s *E. cottonii* quality has been decreasing in quality over time as shown by lower gel strength. It has been suggested that the cause of seaweed low gel strength is that the plants have been harvested when the plant tissue was immature. As the industry continues to grow in Indonesia, management systems need to be put in place to monitor quality and to ensure that seaweed is harvested only at full maturity to maximise export value.

In 2006 Indonesia became the world’s leading producer of *E. cottonii* with production contributing to exports in the order of 100,000 dry tons. Philippine production was estimated to be as low as about 50-60,000 dry tons (as mentioned earlier, with a drop in production due to disease) of raw *E. cottonii* produced in support of exports. The net US dollar values for 2006 exports were almost equal for Indonesia and the Philippines at close to US$ 60 million. The difference is that Philippine exports are almost entirely of carrageenan, while Indonesian exports were of almost entirely of raw dried seaweed. The increase in value over the last couple of years in Indonesia cannot be attributed to value adding at source, but is probably due to global price movement. However new government strategies in Indonesia are promoting seaweed processing.

Timor-Leste can take many lessons from Indonesian growing pains, developing both a central management system (association) to manage quality from the outset and also when economically feasible to introduce further processing to keep as much value localized for the benefits of its people. Unlike Indonesia with the world’s second largest coastline, Timor-Leste is smaller and more manageable which will allow for a more interactive relationship between different stakeholder groups to ensure transparency and success. Timor-Leste while also in its infancy of developing a seaweed industry must also look at alternative farming methods and assess what methods are most productive and suited to its specific environmental conditions.

**E. Socio-economic aspects of seaweed farming**

According to information gathered from community member interviews seaweed production can in some circumstances double family incomes, however the consultant was unable to find any official documentation to cross reference this statement at the time for the coastal communities of Timor-Leste. As already mentioned seaweed culture offers a low investment opportunity for coastal communities within the coastal region to develop a secondary income, offsetting seasonal and environmental conditions that hamper fishing communities.

There are two seasons in Timor-Leste fishing cycle, east season (June – August) and the west season the other months of the year. During the east season fishers on average can only fish 12 days a month and catches due to strong currents are extremely low. During the west season fishers fish nearly every day and land bigger catches. Women play a role in the fishing industry by smoking and selling the fish for local consumption. In the east season the average family income without seaweed is approximately US$1.50/day and with seaweed contributing approximately US$3.00/day. During the west season the average family income derived from fishing without seaweed is approximately US$7.00/day and respectively US$8.50 with seaweed contribution. All five communities visited on Atauro Island agreed that they had more than enough money when seaweed production was contributing to the family income. It was also observed that although most villages had access to clean water, none had toilets and only two communities had electricity (others used generators).
During the west season, with the seaweed contribution to the family income, most interviewed
admitted they could save a couple dollars a day for emergency and low season drops in income.
During the height of seaweed production (2009) most families could produce between 80 - 100 kg of
seaweed every 45 days which would generate an extra US$ 60 - 70 per cycle.

As there is no seaweed production women in the communities visited are currently seeking
alternative sources of income which includes hand-line fishing. However this is on an extremely
small scale as women do not venture far to sea.

Fresh fish is sold to Dili for US$ 1/kg, depending on size and species. Dried fish is sold for US$ 2.50/kg
at the local Saturday markets. The scope and availability of alternative markets is very limited for any
possible income development or entrepreneurial advancement as competition is fierce. Seaweed
offers the best opportunity for individuals and families to advance and to be rewarded for their hard
work.

While a market and value chain now exists for seaweed, the industry has been severely affected by
the recent disease outbreaks. Seaweed promotion by the government intervention to alleviate
poverty requires support to identify and develop markets, while minimising ice ice disease which has
not spread all across Atauro Island.

To further stimulate community and livelihoods development and to create further value for the
communities it is recommended to invest in processing. Processing offers the opportunity to gain
greater value from the seaweed produced which is currently only cleaned, dried, bagged and
exported.

**F. Timor-Leste foreign investment possibilities and finance services**

The Government of Timor-Leste is anxious to attract foreign direct investment in order to create jobs
and to stimulate growth in the economy. The Government of Timor-Leste intends to target its
investment efforts (oil and gas, coffee) but also expects to diversify wherever possible, especially in
the resources sectors, in order to create a more sustainable economy (focus on more than a couple
of commodities, and is open to explore other possibilities).
In 2005, a new autonomous investment and trade development organization (TITL) was created to be a one-stop centre for investors. Its main functions are to promote, coordinate, facilitate and monitor foreign investments and exports and to centralize the administrative procedures for foreign investment and authorizations. The External Investment Law of May 2005, which established the framework for investment incentives for foreign firms, allows a foreign natural person or corporate body, or a non-resident Timorese national, to invest in any sector of economic activity.

The Ministry of Tourism, Commerce and Industry (MTCI) is open to support setting up a seaweed association and to attract both trade and foreign investment opportunities. The main problem at the moment is the lack of capacity within the ministry and suggestions to move forward would be to seek expertise advice and use international interest to create an environment that welcomes industry growth. There are discussions for non-oil export products to obtain 0% tariff treatment which would also help to stimulate foreign interest. MTCI are discussing certificates of origin for certain agricultural products (i.e. coffee), to promote regional development and this could also benefit carrageenan promotion if all stakeholders manage to develop a high quality product.

This openness to attract foreign investment is interesting for possible future development of seaweed processing in Timor-Leste as it offers the possibility for Asian manufacturers to invest in establishing localized processing. It should be noted that caution needs to be appropriately applied to ensure as many benefits stay within the community and are not moved off-shore. Although current production volumes (current commercial ATC plant design, requires a minimum of 10,000 tonnes of seaweed per month to be commercially efficient, although research is being carried out by SEAPlant.NET to develop a cost effective micro plant that can be economically viable producing 100 tonnes per month) cannot be justified at current production levels. Secondly the minimum amount for any foreign investment has to be at least US$ 100,000. Despite this the possibility is still interesting for mid/long term development plans.

G. The role of cooperatives and co-management

Seaweed farming is a very common coastal activity in Indonesia/Philippines. Amongst other reasons, it has been promoted by country ministries and NGOs to reduce stress on other coastal resources (i.e. fish stocks). This makes seaweed farming a very popular activity and farming areas are spreading continuously. The need for management is most urgent in areas where intensive seaweed farming is present (i.e. Philippines disease outbreak good example) or in areas, where it contributes a high percentage to household income. There, a collapse of seaweed farming due to diseases or decreasing market demand/prices can have devastating consequences for local communities (as can be seen with current situation in Timor-Leste with disease outbreak as mentioned previously).

From the visitation and interviews in the field there seems to be currently two seaweed cooperatives and speaking to individual farmers and communities both cooperatives seem to offer very little in the way of services and transparency to its members. Government intervention is needed at this time to help structure the cooperatives correctly, while they are still in this early stage of development. One cooperative was offering a credit scheme, but the interest was not transparent and what could be determined via verbal discussions was that the interest rate was far higher than would be deemed as acceptable (20% flat interest plus monthly membership fee to participate, real value around 40% interest on a loan of US$ 100). The government should intervene at this stage and support forming a seaweed association which will incorporate MFIs (currently only one - BNCTL), exporters (currently only four), cooperatives and a representative from the producer communities. The role of the association would be to help set pricing paid to the producer, support with building a

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semi-intensive processing unit, monitoring global pricing, research to prevent disease, knowledge and information sharing, coastal area management, create a training and collection centre to help manage and improve quality and efficiency throughout the chain.

Interviews with producers found they were dissatisfied with the role of the government to date and as most producers are not actually harvesting due to disease and wanting the government to play a more active role in preventing further disease outbreaks and to set a transparent pricing structure. It was also mentioned that the government in their role also has to act more transparently (i.e. signs of favouring certain communities over others) and to have a fair system for distributing services and benefits. The communities expect the government to create a management policy to manage the potential growth to maximize producer profit, while mapping and controlling growth so it does not have any detrimental effect on the environment and coastal ecosystems.

H. Extension services

Currently very little in the way of extension services are offered by the government, and interviews with community members identified a sense of frustration. The community feels let down by the government and expects them to deal with the disease outbreak. The RFLP have been engaging in extension services and so has the NGO Belun.

During the interviews communities were asked if they would welcome extension services offered by the government and they all agreed it would be beneficial. The communities had a taste for seaweed cultivation, but just when they were starting to gain confidence, disease struck. Although they have experienced the financial benefits they would like greater education on how to prevent, disease and how to select quality seaweed seed.

When asked whether they understood about production management and post harvest handling to maximise quality, and what the market was looking for, most respondents were unsure.

Extension services are required to give guidance on how to maximise production and yields, how to prevent disease and to train seaweed farmers on improved practices for post harvest of seaweed in order to meet market needs for a quality product.

I. Environmental-impact

Highly productive farms are usually located in areas characterised by good water movement (current and/or moderate wave action); appropriate salinity levels and depth at low tide (in shallow farming areas); diverse flora and fauna; clear, fertile and unpolluted water; and appropriate substrate. Favourable ecological conditions are indicated by high production per unit.

Crowding or intensified farming in a limited area causes changes in the hydrology of the area. It has been shown that good water movement by current and/or moderate wave action is the primary factor that enhances the growth of the crop through the enhancement of nutrient absorption. Water movement also prevents rising seawater temperature and transports nutrients to the crop. When water movement is significantly reduced due to over-crowding, especially during the day at low tide, rises in seawater temperature will occur. Elevated seawater temperature during high irradiance causes adverse effects on the productivity of the crop (lowered growth rates), a precondition of the occurrence of two important farm problems, the occurrence of 'ice-ice disease' and epiphyte blooms. These conditions also exert a negative impact on associated flora and fauna.

In areas where favourable environmental conditions are maintained throughout the different cropping seasons, seaweeds show very high growth rates and form thick ground cover, which
attracts associated fauna (fish and invertebrates) and other seaweed species. During the cropping period seaweeds serve as a habitat and feeding ground for associated fauna as shown by the increase in their populations. The farm support system also provides additional substrate on which the associated seaweed species grow. Thus bio-diversity appears to be enhanced in seaweed farm areas. It is apparent, however, that changes in the level of bio-diversity are affected by the farming cycles, being comparatively lower during the start of cropping (planting) and harvest periods and high during the grow-out.

The farming of deeper areas using floating methods does not exert a negative impact on the coral communities below. A recent field study done in Lamitan, Basilan showed that the coral community at 5 - 10 m below the multiple floating units was observed to be robust and healthy. Hardwood and/or iron bars are used as anchors for the support lines.

**Value chain framework/system**

The current seaweed value chain in Timor-Leste is very simple. The product moves along only two to three steps. Step 1: Producer; Step 2: Collector (at times this person can also be the exporter) and Step 3: Exporter.

The problem with this current situation is the lack of transparency and the bargaining position of the producer. The producers interviewed stated that they never bothered to bargain or barter over the price, and preferred to believe that they were being paid a fair price and the same price as other producers. What the producers would like from the value chain is more transparency and understanding on how to improve and maximise the quality of their product which will empower them to demand a better price and create greater financial return.

When the idea of an association was suggested, partly subsidized by the government while the industry was growing, with the balance of funding coming from membership fees paid by all active stakeholders (producers, processors and exporters) the producers stated they would be happy to partake in such a scheme. The association would work for the benefits of all stakeholders and could create a point of contact, communication, transfer of knowledge and training. Most of the communities visited did not have access to internet, so the association could act as the conduit to delivering market developments and price movements to the greater benefit of seaweed stakeholders, thus creating a platform of trust and openness to share information and lessons learnt.

As the industry and region is so small and controllable it is not seen as being wise to have multiple value chain levels which reduces returns and margins, nor to have multiple single community cooperatives that struggle to bargain with exporters and lack the expertise of trade. A Timor-Leste Seaweed Association would be the best support service for both development and trade.

**Potential obstacles (technical, social, economic and environmental)**

**Technical**

Dissemination of knowledge, extension services, and capacity to follow international developments will always be a problem for such a small country with low production. The upside is the close proximity to Indonesia, the world’s largest producer and Timor-Leste should aim at building a friendly commercial relationship with its neighbour. Again due to the limited production volume from Timor-Leste it will never be recognised as one of the region’s leading producers in terms of volume and it may miss out on the opportunity to attract foreign investment. However by

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presenting itself collectively under the one association, it will help establish a greater market presence and make it logistically easier for exporters to deal with.

**Social**

The social obstacle that the Timor-Leste seaweed industry may face as it develops is conflict between shared uses of resource. To overcome this situation the government needs to set out appropriate zones dedicated to seaweed production and to create a shared resource policy, so that all producers are made aware of their rights and responsibilities.

**Economic**

After disease prevention, the economics of seaweed production in Timor-Leste are probably the greatest obstacle to further expansion. Again the suggestion to approach the market collectively will create a sense of volume. Timor-Leste will always struggle in the region as it can only ever be a small producer, but collectively through the association prices can be set with export markets (premium markets). This will allow the exporters of Timor-Leste to leverage greater bargaining power as they collectively negotiate price (association sets an minimum export price).

**Environmental**

The greatest obstacle is to overcome disease outbreaks and to insure preventative measures are implemented going forward. Alert systems need to be put in place and nurseries producing different strains need to be setup so that there is no repeat of current conditions.

**The potential of seaweed farming as an alternative income**

A careful evaluation of suitable farming methods and areas is required if environmental and socio-economic sustainability are to be maintained. Advanced farming schemes require higher investments for and running costs of the farms, reducing their economic profitability. Therefore, acceptance of such methods among producers and communities should be increased by a parallel development of post-harvest processing and marketing, thus yielding an overall higher net profit from their farms. It was hypothesized that seaweed farming can create a stewardship over marine shallow water resources. The usability of seaweed farming as a tool to stop over-fishing and the use of destructive fishing methods, however, is doubtful and over-harvesting of marine resources prevails. However, in contrast to artisanal fisheries, seaweed farming can help to building a better general environmental awareness.

The whole production cycle, pests and diseases depend on and are influenced by environmental conditions. Very simple monitoring of such parameters and their contribution to farming success can contribute significantly to a better understanding of, and identification with the marine environment. Government agencies therefore should not only promote seaweed farming, but also combine this effort with programmes to build general awareness (i.e. setup an association).

While increasing production presents a relatively straightforward challenge, attention should also be turned towards creating further value by localized processing. Drying, crushing and grinding the product in small community operated factories would create further employment and allow the communities to produce a more valuable semi-refined product and greater value addition within Timor-Leste, rather than Indonesia or elsewhere.

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65 Sievanen et al. 2005
Government intervention through the setting up of an association can help improve techniques, thus improving productivity. The association could also help with securing investment for processing, open access to new markets, create market awareness and setup a market information system which can provide crop forecasts and detailed price information.

At the producer level becoming a stakeholder in the association will allow for lessons learnt to be shared among other producers, learn about improvements and techniques, create a feeling of transparency and trust and most importantly create a stable platform to develop forward.

**Next steps - Plan of action for possible implementation**

The following are suggestions of the next steps that can be taken to develop the Timor-Leste seaweed industry further:

- Invest time into identifying and solving the disease outbreak. Invest in setting up small hatcheries or nurseries with co-supervision of the government/association. Seek external advice to improving seaweed strains and look at neighbouring countries for more robust strains that can be trialled within Timor-Leste. If one or two strains are identified, then a suggestion would be to harvest a mixed variety of strains in-case one is affected by disease again and producers do not lose their complete crop.

- Invest into an extension program teaching producers about better production procedures, market requirements and post harvest handling. The RFLP and WFC has the knowledge to be able to develop such a program for the government of Timor-Leste and local NGOs can be used to administer the training if desired. With extension training, producers will over time again gain confidence and an understanding of how best to maximize output potential.

- Setup an area or zone for possible seaweed production, research will need to be carried out into the most preferable areas by assessing coastal conditions. Make sure these areas do not clash with fishing sites to avoid conflict of resource. A shared resource policy can be produced that benefits both users.

- Setup an association with the different stakeholders to look at developing market connections, stabilizing pricing and communicating market trends and technological advances to its members.

- Work with local banks and MFIs on creating a lending scheme for the seaweed producers, cooperatives and association.

- Create collection centres that offer extension service, finance and a processing place for producers. Start with one on Atauro Island and as the industry grows replicate and expand. The collection centres should be overseen in the beginning by the association and the government to ensure transparency and to make sure the centres are offering services and value to the producers.
References


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Appendix 2:
Technical Notes on GIS Modelling of Potential Freshwater Aquaculture in Timor-Leste

The GIS modelling area includes all districts in Timor-Leste, excluding the islands of Atauro and Jaco. Atauro Island, a small island situated 25 km north of Dili, has been identified for the development of seaweed cultivation only. Jaco Island is an uninhabited island, located off the most eastern part of Lautem district.

Spatial modelling is highly dependent upon the availability of good GIS data. All the GIS data were integrated and the analysis was performed in a Universal Transverse Mercator coordinate system (UTM Zone 51 South) at a grid cells resolution of 90 meter.

Modelling was implemented at ALGIS, involving extensive input from key officers of the Timor-Leste National Directorate of Fisheries and Aquaculture (NDFA). The factors influencing the potential of freshwater aquaculture, input data sets, thresholds and weights assigned to run the model were discussed during consultation sessions at the ALGIS office during August 2011. The model results were also revised based on the inputs from NDFA experts.

Map Suitability Sub-models

There are several factors that influence the potential of freshwater pond aquaculture. For each factor, we needed to find a suitable proxy indicator to quantify and map it using the GIS. The data also need to be geographically comprehensive or could be mapped across the entire study area.

A minimum set of eleven factors with mapable data were selected for the GIS modelling. All the factors were grouped into three main sub-models representing key aspects of influence on aquaculture potential: i) biophysical, ii) inputs and experiences, and iii) market and accessibility.

Each indicator map needed to be rated in terms of suitability (or potential) for practicing freshwater aquaculture. A standard continuous rating scale of suitability from 0 (the least suitable) to 255 (the most suitable) was used.

For instance, it is widely known that flat or slightly sloping areas are most suitable for freshwater pond construction. But, what are the slopes considered as suitable? Thus, we need to consult experts to set the thresholds when rating suitability. The slopes below 8% are the most cost effective to construct ponds (the lowest slopes are the best), whereas any slope above 8% is considered unsuitable. The highest rating of 255 was assigned to locations (grid cells in the map) with a slope of 0%, then suitability decreases gradually as slope percent increases. Beyond 8%, all areas were considered not suitable (score 0 rating). This approach can be described by a mathematical function, decreasing Sigmoidal curve (or “S” shape), as indicated by the corresponding graph depicting the suitability rating-slope steepness (%) relationships in Figure A2.1.

One benefit of using 0-255 suitability rating scale is that it produces a continuous geographic map, which reflects relative suitability, instead of only absolute “yes or no” Boolean values. A continuous map offers more flexibility for evaluating any location of interests based on a range of relative suitable values as shown on the map.

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66 The UTM system divides the surface of Earth between 80°S and 84°N latitude into 60 zones, each 6° of longitude in width. Zone 1 covers longitude 180° to 174° W; zone numbering increases eastward to zone 60 that covers longitude 174 to 180 East. Timor-Leste is located at zone 51 South.
All relevant indicator maps with a standardized 0-255 scale range were then combined using Weighted Linear Combination (WLC) within each respective sub-model. With WLC, each standardized indicator is multiplied by its corresponding weight, then these are summed, and next the sum is divided by the number of indicators within the sub-model.

Again, consultation with local experts was required to rank each factor within the sub-model from the most important to least important. Thereafter weights were assigned to each factor to indicate the relative importance of each factor to influence potential suitability. The total weight for the full set of factors adds up to 100% in each case.

The following provides more details on the sub-models used.

**Bio-physical sub-model**

Bio-physical conditions represented a major determinant factor in determining where aquaculture has potential for development. The bio-physical factors analysed through the GIS were primarily water supply and topography.

**Water:** Water is essential for aquaculture. Water may come from water bodies such as streams, rivers, lakes, reservoirs and groundwater or also from precipitation and runoff. Many rivers in Timor-Leste are dry from May to October and do not hold water all year around. However, considering the limited resources and duration of this project, the best proxy that can be used to assess the water availability in the GIS modelling is perennial rivers/streams derived from the terrain data layer, without differentiating which rivers will dry up and those which have water year round. Thus, the results may be over-estimated. The proximity from the closest rivers/streams is taken into consideration under the topography (slope), assuming that to traverse 100 m on a steep slope takes more effort (i.e. cost) than on flat land. The suitability rating linearly decreases with increasing cost distance from rivers/streams.

**Irrigated rice field:** There is also potential for aquaculture if there are existing paddy fields. Irrigated rice fields have greater potential than rain-fed rice fields for the introduction of rice-fish culture. The water supply and infrastructure of irrigated rice fields are more reliable. However, rice-fish culture is yet to be promoted in Timor-Leste, this factor was considered least important than others.

**Natural lakes:** Freshwater lakes offer natural conditions for the development of aquaculture inside the lakes. All the natural lakes were considered equally suitable for freshwater aquaculture. As the priority for the development of aquaculture in lakes at this stage was minimal and the weightage given was relatively smaller than other factors.

**Terrain:** Slope steepness was used as a proxy for terrain. Slope was measured in percent by calculating from the Shuttle Radar Topographic Mission (SRTM) 90 m Digital Elevation data\(^{67}\). A slope of 45 degrees is 100 percent because the difference in vertical elevation is the same as the horizontal distance travelled. Slopes above 8 percent are considered unsuitable for the construction of ponds in Timor-Leste. The suitability rating is curvilinear and decreases gradually with increasing slope steepness.

Figure A2.1: Multi-criteria evaluation using weighted linear combination for biophysical sub-model.

**Inputs and Experiences sub-model**

**Number of fish farmers:** The number of fish farmers in each district was used as an indicator of whether there are existing experiences with aquaculture. The suitability rating is gradually increased with the increasing number of fish farmers. Ermera, Baucau and Bobonaro have the highest number of fish farmers with previous aquaculture experience, and therefore receive a higher weighting in terms of aquaculture experiences.

**Access to hatcheries:** There are five fish hatcheries in Timor-Leste, located at Same, Maliana, Gleno, Ossu and Oecussi. Proximity to a hatchery improves access to seed needed for stocking and reduces transportation stress. The proximity measure in the model factors in both distance travelled to a hatchery as well change in elevation.

**Access to different feeds:** Fish need proper feeding to grow well. Generally pelleted fish feeds are not widely available in Timor-Leste, therefore most fish will be fed on on-farm produced feeds using locally available inputs. Rice bran is the most commonly used on-farm ingredient in supplementary feeds for fish in Timor-Leste. The production per unit area from irrigated rice fields is generally higher than rain-fed rice fields, thus has been factored into the model as contributing more potential.
Figure A2.2: Multi-criteria evaluation using weighted linear combination for inputs and experiences sub-model.

**Market and Accessibility sub-model**

**Population densities:** Population data show the concentrations of people and potential markets for farmed fish and other aquatic products. The population data were based on the 2004 census, and the number of households was collected for each location of dwellings and recorded using GPS points. The point’s data was then summarized to Suco level. The suitability rating is based on assumption that Sucos (villages) with higher populations have greater demand for aquatic products and greater nutrition needs. The results are probably an under-estimate as the population has surely increased in the interim seven years.

**Access to market:** The capital towns of each district act as a potential market centre for the sale of fish. The access to market centre in the model was calculated based on the Euclidean distance\(^{68}\) from markets, also distance in terms of some measure of cost, hence the resulting values are known as “cost distance”. The cost indicates the relative difficulty of travel over different physical condition of roads and also takes into account that travel 100m over a steep slope takes more effort (“cost”) than on flat ground. The GIS modelling of this study focuses on aquaculture production mainly for home consumption, with the surplus for the sale to local consumers, assuming there are not much extra production delivers to market centre. Thus, the influencing weight of this factor is assigned much lower compared with others.

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\(^{68}\) In raster grid cells processing, the Euclidean distance is calculated from the center of the source cells (i.e. location of markets) to the centre of the surrounding cells by calculating the hypotenuse.
**Proximity to road:** The areas closer to roads are considered more accessible (or suitable) than those that are distant. The more accessible area will have easier access to pond inputs and markets for fish pond production. The proximity to road is the measure of “cost distance” from roads, applying the same concept used in generating the indicator map of access to market by calculating the Euclidean distance from roads instead of markets. The “cost” takes into considerations the relative difficulty of travel over different road types, like travel along four-wheel drive tracks will take more effort (i.e. cost) than one- and two-lane paved road. Besides, traverse across a steep slope also needs more effort.

**Coastal/Inland sucos:** The general lack of infrastructure means that inland communities have limited access to freshly caught fish. Thus, introducing pond aquaculture to inland Suco is desirable.

![Image of multi-criteria evaluation](image)

**Figure A2.3:** Multi-criteria evaluation using weighted linear combination for market and accessibility sub-model.

**Map overall suitability model**

The resulting maps from the sub-models are combined in another round of weighted linear combination to produce the final model or overall freshwater aquaculture suitability map. Each sub-model was multiplied by their respective weights given by experts and then summed using map algebra algorithms. The resulting map shows the suitability rating from 0 (the least suitable; lightest tone) to 255 (the most suitable; darkest tone). For convenient interpretation, the 0-255 continuous suitability rating system was reclassified into four discrete suitability rankings – most suitable, suitable, moderately suitable and least suitable as shown in Figure A.2.4.
The final map showing four discrete suitability classes was used to produce data on the estimated areas (in km$^2$) under each class for all districts (see Table A2.1).

Table A2.1: Estimated areas (km$^2$) under found suitability classes for all districts.
Appendix 3:

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RFLP/FAO also provided logistical assistance for field work and consultation meetings.

This analysis provided background for the preparation of the Timor-Leste Aquaculture Development Strategy, which was presented to a stakeholders’ consultation meeting in Dili on 16 February 2012.

The content of the strategy does not necessarily reflect the opinion of FAO, AECID, RFLP, WorldFish Center, CTSP or WWF.