SRI LANKA CONNECTING REGIONAL ECONOMIES (USAID/CORE)

Assessment of Aquaculture and Inland Fisheries in Eastern Sri Lanka

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Assessment of Aquaculture and Inland Fisheries in Eastern Sri Lanka

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Acronyms

ADB	-	Asian Development Bank
A'NG	-	Aqua 'N Green
BAP	-	Best Agriculture practices
ARDQIP	-	Aquatic Resource Development and Quality Improvement Project
CBO	-	Community Based Organization
CFC	-	Ceylon Fisheries Corporation
CGE	-	Ceylon Grain Elevators
CORE	-	Connecting Regional Economies
EU	-	European Union
FAO	-	Food and Agriculture Organization
FCS	-	Fisheries Cooperative Society
GAA	-	Global Aquaculture Alliance
GDP	-	Gross Domestic Product
GoSL	-	Government of Sri Lanka
IUCN	-	International Union for Conservation of Nature
LKR	-	(Sri Lankan) Rupees
NAQDA	-	National Aquaculture Development Authority
NARA	-	National Aquatic Resources Research and Development Agency
NGO	-	Non-Governmental Organization
PL	-	Post Larvae
PCR	-	Polymerase chain reaction
SRC	-	Semi Refined Carrageenan
USAID	-	U.S. Agency for International Development
WWF	-	World Wildlife Fund

Executive Summary

This report is an assessment of the aquaculture and inland fisheries sectors with the potential for generating new income sources and employment opportunities in the Eastern Province of Sri Lanka. The fisheries sector plays a key role in Sri Lanka's social and economic life. From an economic viewpoint, there is significant scope to increase the level of contribution from the sector through increased output, exploiting the potential for value addition and exports. Fish products are an important source of animal protein for the population, and the sector contributes around 2% to GDP. Fish production in Sri Lanka totaled 319,000MT in 2008 of which 275,000MT (86%) came from commercial fishing in marine waters and 44,500MT (14%) came from inland and aquaculture fisheries. More than 90% by weight of these fish were sold (or consumed) within the country. In addition, Sri Lanka imported over 18,000MT of canned fish worth USD 16 million and USD 100 million worth of dried fish.

The fisheries sector of Sri Lanka consists of three main subsectors, namely coastal; offshore and deep sea; and inland and aquaculture. These three subsectors employ around 200,000 active fishers and another 100,000 in support services. The USAID/CORE program completed a study on the coastal, offshore, and deep sea fisheries sub sectors titled “Fisheries Sector Assessment in Sri Lanka” in mid 2009. This report looks at existing inland fisheries and aquaculture sub sector practices in the Eastern Province as well as discusses various alternative aquaculture activities that can generate increased incomes and employment.

Some aquaculture products (pond raised fish and shrimp) are selling successfully in the local market in Sri Lanka, and form a part of the fish supply chain competing both with marine-caught fish and imported fish. In the right locations, aquaculture can also be an employment opportunity for persons without land or displaced by conflict. In Sri Lanka, aquaculture development complements capture fisheries in that the facilities built and operated to support the marine fisheries sector (ice, cold storage, and refrigerated transport) can also be used to process and market tilapia, shrimp, sea bass, or other fish cultured in ponds, cages and pens.

Food and Agriculture Organization (FAO) estimates total worldwide fish imports to have exceeded USD 100 billion in 2008, for the first time in history. The value of fish exports is estimated slightly lower. About half of world fish exports originate in developing countries, while 80% of world imports go to the developed part of the world. Net exports from developing countries reached USD 25.4 billion in 2008, thus emphasizing that fishery products are an important source of foreign exchange earnings for developing countries. FAO estimates that production of fish products (excluding seaweed and marine mammals) reached 141.6 million tons in 2008, a slight increase (0.9%) over 2007. While capture fisheries were more or less stable at 90 million tons, aquaculture grew by 2.5% to 51.6 million tons. Aquaculture production contributes 45% of total fish as food supply. Various studies show that the global collapse of the world’s major marine fisheries by the middle of this century. Over the past 50 years, there has been a 90% reduction of the ocean’s large predatory fish, including sharks, swordfish, and tuna. Consequently, there is significant potential in the growth in imported farm-raised seafood coupled to meet the decline in global fish stocks.

Successful aquaculture on a commercial scale starts with meeting the physical requirements for the production, processing, and storage of aquatic animals and plants. In practical terms, “meeting” these requirements means finding a location to operate that meets all the basic requirements at a competitive cost. The elementary requirements are suitable water (freshwater, marine or brackish), land, feed supplies for the fish or shrimp, replacement stock (fish fry/fingerlings or post larvae for

stocking ponds, cages and pens) and support and logistical facilities for processing, transport, and storage.

The entire island of Sri Lanka has inland fresh water resources of approximately 261,941 ha and 120,000 ha of brackish water resources. These resources include a large number of water bodies including perennial reservoirs of various sizes, [large (>800 ha), medium (200-800 ha) and minor (<200 ha)], seasonal village tanks (1-25 ha) and estate tanks. The seasonal village tanks with almost 100,000 ha though significant, typically hold water for only 6-8 months of the year. The 100,000 ha of seasonal village tanks are made up of more than 834 tanks in the three districts of the Eastern Province. The three districts from the Eastern Province with an estimated 6,400 inland fishers accounted for 8,640MT (19%) of the national inland and aquaculture fish production.

Aquaculture products can be consumed or sold in the domestic market or sold into the export market. The best choice for a producer or firm depends on the market price and any added costs necessary to meet market requirements. Historically some percentage of Sri Lanka's farm-raised prawns and shrimp were exported, although the exact percentage for aquaculture is unknown because export data shows only aggregate figures combining aquaculture and wild capture. That data show that up to 40% of the combined catch was exported in 2000, but only 7.4% in 2008. The severe decline reflects both problems with disease, prolong conflict situation in the north and the east, and competition from other exporters. Export percentages for other species are thought to be very small if not zero. Sri Lanka has tremendous opportunity to consider the possibility of exporting some products at least to nearby Middle East countries for several reasons. There are a number of steps that will encourage an expansion in aquaculture production, and steps that can improve the incomes of farmers and fishers practicing aquaculture in post-conflict zones. The following are some of the opportunities in aquaculture and inland fisheries sector development in the Eastern Province:

- Pond culture of fish such as tilapia, milkfish, and carp species (in fresh water) has several advantages for new entrants into aquaculture. Although the market price of these species may be lower than that of shrimp, they are easier and less expensive to raise and less vulnerable to disease. Tilapia and milkfish can be raised in brackish or saline water which is more readily available in the Eastern Province than freshwater. Where freshwater is available efforts should be made to stock freshwater shrimp (*Macrobrachium rosenbergii*) in ponds with tilapia and carp. Fish raised in ponds should be targeted to local markets since these markets are willing to purchase fish fresh without ice or other forms of processing.

- Cage culture of marine fish such as sea bass is feasible at the present time in Batticaloa and Trincomalee districts. As this activity expands, efforts will be needed to source a local high protein feed that can be used to supplement and eventually replace the trash fish presently being fed to caged fish.

- Mud crabs (*Scylla serrata*) are interesting because a local capture fishery already exists. The crabs sell well in the local market and are also exported. Crabs are easier and less costly to transport.

- Seaweed farming has potential in the shallow marine lagoons near Batticaloa and Trincomalee. The advantages of seaweed culture include the low investment required to begin production and the labor intensive nature of this activity which can employ fishers and villagers.

- Ornamental fish and plants are a significant export item from Sri Lanka. In 2008 the export value of ornamental fish raised in Sri Lanka was USD 9 million. However, this figure has not

increased since 2000. Developing ornamental fish culture in the Eastern Province appears to be problematic in that all the fish produced have to be exported by air from the only international airport in Western Province within 24 hours after packing to ensure better survival. It is unlikely this can be achieved on a regular basis from the Eastern Province. There are plans to build a holding facility for the live fish near the airport but until then the transport time to the airport will discourage investment in this form of aquaculture.

- Shrimp farming is an existing activity in the Batticaloa district. In spite of disease problems and high feed costs that have greatly reduced volumes, shrimp farming for local and even export markets continues. To help keep this industry competitive the authors recommend that production should shift to a less intensive model. This means that less shrimp post larvae (PL) should be stocked per pond, less feed should be added and only specific pathogen free PLs should be used.

- High value temperate aquaculture species such as crayfish, salmon or sturgeon are not appropriate for the Eastern Province because water temperatures are too high and there is no cool period. The trout present in the highlands of Sri Lanka need to be replenished with eggs imported from colder countries.

The major conclusions of this assessment to explore the opportunities in the aquaculture and inland fisheries sector in the Eastern Province are the following:

- There are no major technical or natural obstacles to aquaculture producing fish, shrimp or seaweed in the Eastern Province of Sri Lanka.

- The high cost of fish and shrimp feed will be a constraint to the rapid expansion of caged fish culture and shrimp farming. However, this constraint would not prevent smaller scale growth in aquaculture. The constraint could be overcome or lessened by using fish offal and other wastes that will become more available when fish canning begins, or, if Sri Lankan farmers decide to grow feed grains in response to new local demand.

- The availability of suitable, affordable land and brackish water is a big advantage that will most likely outweigh other constraints to aquaculture development.

- Production of most common aquaculture fish species should be profitable even at local market prices. Existing aquaculture operations (mainly tilapia and carp) have demonstrated an ability to compete in local markets with marine-caught fish. New species for Sri Lanka such as mud crabs, brine shrimp and sea cucumbers are especially promising. Export of aquaculture products could make aquaculture even more profitable.

- Prawn and shrimp culture, despite coping with major disease issues, has survived and shown an ability to compete in the export market.

- Except for a few entrepreneurs, there seems to have been very little experimentation or innovation within the aquaculture sector. There has been more investor interest in aquaculture of ornamental fish.

- Sri Lanka enjoys a location and transport advantage exporting perishable products to the Persian Gulf countries. Some buyers from the Gulf countries have explored Sri Lanka as a source of farm-raised fish for Asian construction workers living in the Gulf countries.

- Major investment in better post-harvest collection, processing and handling will be required to successfully compete in the export market and to sell into the growing market of tourists expected to visit Sri Lanka.

- There are a number of steps that will achieve the objective of encouraging limited growth in aquaculture activities in Sri Lanka, but the path to significant industry growth requires competing in the export market.

1. Introduction

This report is an assessment of the aquaculture and inland fisheries sector with the potential for generating new income sources and employment opportunities in the Eastern Province of Sri Lanka. Aquaculture is the farming of freshwater and saltwater organisms such as finfish, molluscs, crustaceans and aquatic plants. Also known as aquafarming, aquaculture involves cultivating aquatic populations under controlled conditions, and can be contrasted with commercial fishing, which is the harvesting of wild fish. One half of the world commercial production of fish and shellfish that is directly consumed by humans comes from aquaculture. Mariculture refers to aquaculture practiced in marine environments. Particular kinds of aquaculture include algaculture (the production of kelp/seaweed and other algae), fish farming, shrimp farming, oyster farming, and the growing of cultured pearls. Inland fishery, which is essentially a capture fishery in Sri Lanka, is unique in that it is a fishery confined to manmade lakes.[1]

FAO estimates total worldwide fish imports to have exceeded USD 100 billion in 2008, for the first time in history. The value of fish exports is estimated slightly lower. About half of world fish exports originate in developing countries, while 80% of world imports go to the developed part of the world. Net exports from developing countries reached USD 25.4 billion in 2008, thus emphasizing that fishery products are an important source of foreign exchange earnings for developing countries. Japan regained its top position among fish importers in 2008, after losing it in 2007 to the U.S. The European Union (EU) accounts for more than 40% of world fish imports in value terms, but intra-EU trade is included in these figures.

China consolidated its position as top fish exporter with USD 10.2 billion in 2008. Fishery products imported as raw material and re-processed in the country form a considerable portion of exports. In fact fish imports are growing every year and reached USD 5.2 billion in 2008. The International Food Policy Institute predicts the supremacy of developing nations, including China, in farmed seafood production. Norway is the second major exporter of fishery products, with USD 7.4 billion, an 18% increase over 2007. A huge proportion of this increase comes from higher salmon exports. Chile, only second to Norway as the largest world producers, now competes with wild Alaska salmon in the canned salmon market.

FAO estimates that production of fish products (excluding seaweed and marine mammals) reached 141.6 million tons in 2008, a slight increase (0.9%) over 2007. While capture fisheries were more or less stable at 90 million tons, aquaculture grew by 2.5% to 51.6 million tons. Aquaculture production contributes 45% of total fish as food supply. Per capita consumption remained stable at 16.9 kg in 2008, of which 8.5 kg came from capture fisheries and the remainder from aquaculture.

Shrimp tops the list of the U.S best-selling seafood species - mostly farmed and imported, and mostly from Asia. Tilapia moved from tenth to ninth, edging out flatfish in only its second year on the top ten. Despite the high amount of imported Asian farmed products, the biggest foreign supplier to the U.S. seafood market is still Canada, with imports topping USD2 billion.

[1] In Sri Lanka, there is no riverine commercial fishery. Most riverine fisheries and the lack of extensive floodplains and the rapid flow of rivers over steep gradients in Sri Lanka prevent or minimize the establishment of fish populations of fishable magnitude.

Americans consumed a total of 2,230 million MT of seafood in 2007. The average American ate 7.4 kg of fish and shellfish in 2007, 1% decline from the 2006 consumption figures of 16.5 pounds. But even though U.S. seafood consumption is flat, global consumption continues to grow; a major study in the *Journal of Science* predicts the global collapse of the world's major fisheries by the middle of this century. Already, over the past 50 years, there has been a 90% reduction of the ocean's large predatory fish, including sharks, swordfish and tuna. Consequently there is significant potential in the growth in imported farm-raised seafood coupled to meet the decline in global fish stocks.

The fisheries sector plays a key role in Sri Lanka's social and economic life. From an economic viewpoint, there is significant scope to increase the level of contribution from the sector through increased output, exploiting the potential for value addition, and exports. Fish products are an important source of animal protein for the population and the sector contributes around 2% to GDP. Fish production in Sri Lanka totaled 319,000MT in 2008 of which 275,000MT (86%) came from commercial fishing in marine waters and 44,500MT (14%) came from inland and aquaculture fisheries. More than 90% by weight of these fish were sold (or consumed) within the country. In addition, Sri Lanka imported over 18,000MT of canned fish worth USD16 million and USD100 million worth of dried fish.[2]

Aquaculture products (pond raised fish and shrimp) are selling successfully in the local market in Sri Lanka, demonstrating that they have entered the fish supply chain and that they can compete both with marine-caught fish and imported fish. Cultured shrimp and prawns were a growing export success for Sri Lanka for many years until they were hit with disease problems. Today the sector is in decline, but a few producers still export to niche markets. Even small scale aquaculture operations can provide a reliable source of supplemental food or income for local farmers and fishers in rural areas. In the right locations, aquaculture can also be an employment opportunity for persons without land or displaced by conflict. In Sri Lanka, aquaculture development complements capture fisheries in that the facilities built and operated to support the marine fisheries sector (ice, cold storage, and refrigerated transport) can also be used to process and market tilapia, shrimp, sea bass, or other fish cultured in ponds, cages and pens.

The fisheries sector of Sri Lanka consists of three main subsectors, namely coastal; offshore and deep sea; and inland and aquaculture. These three subsectors employ around 200,000 active fishers and another 100,000 in support services. The USAID/CORE program completed a study on the coastal, offshore, and deep sea fisheries sub sectors titled "Fisheries Sector Assessment in Eastern Sri Lanka" in mid 2009. This report looks at existing inland fisheries and aquaculture sub sector practices in the Eastern Province as well as discusses various alternative aquaculture activities that can generate increased incomes and employment based on observations made by the authors on their review and field visits to the Eastern Province in August 2009.

[2] Fishery Statistics, 2008; Statistics Unit, Ministry of Fisheries and Aquatic Resources (2008).

2. Elementary Physical Requirements for the Successful Aquaculture Operations

Successful aquaculture on a commercial scale starts with meeting the physical requirements for the production, processing, and storage of aquatic animals and plants. In practical terms, "meeting" these requirements means finding a location to operate that meets all the basic requirements at a competitive cost. The elementary requirements are suitable water (freshwater, marine or brackish), land, feed supplies for the fish or shrimp, replacement stock (fish fry/fingerlings or PL for stocking ponds cages and pens) and support and logistical facilities for processing, transport, and storage.

2.1 Freshwater

The culture of freshwater fish such as Indian and Chinese carps as well as the freshwater prawn (*Macrobrachium rosenbergii*) requires large quantities of inexpensive freshwater of suitable quality. Normally freshwater is obtained from rains, surface streams, lakes, ponds or springs. In Eastern Sri Lanka large inland reservoirs or tanks collect and channel most surface water through irrigation canals. The climate in the Eastern Province of Sri Lanka includes a long dry season with uneven and unreliable rainfall. Reliance on rainfall alone to fill excavated ponds leaves many ponds dry for nearly half the year. Using canal water to fill aquaculture ponds is generally not encouraged because this usage would compete directly with irrigation for prioritized paddy production and other existing agricultural activities.

2.2 Marine and brackish water

Marine and brackish water is readily available for the land adjoining sea shores, lagoons and estuaries. However, operations must use this water carefully to avoid contaminating groundwater with brackish or sea water. Furthermore, intakes and discharge pipes/canals must be sited so as not to interfere with boat landings or storage sites and other existing activities.

2.3 Land

One of the most important requirements for land based aquaculture activities is the availability of inexpensive land. Even cage culture of fish requires a landing site for boats and other support activities, especially if value addition (sorting and dressing) near the culture site is planned. Pond culture of fish and shrimp requires relatively level land sites located near ample water supplies. Again, ponds need to be constructed so that they will not leak and contaminate local ground water, and so that they can be drained and cleaned at intervals without causing environmental damage. Although individual ponds can be as small as 0.5 ha, commercially viable operations are typically no smaller than 10 ha. Large scale operations in Thailand are spread over 50 ha.

Land tenure and competing uses are also issues to consider. The investment in aquaculture is easier to finance if the investors have the land title. At the very least, long term lease arrangements are a necessity. Fluctuations in land values can make land too expensive for aquaculture to be economically viable. Also aquaculture activities are best located in areas where they do not interfere with or have to compete directly with existing agricultural, commercial or residential activities.

2.4 Feed

For intensive or semi-intensive fish and shrimp farming, some supplemental feeding is necessary. For low intensity production of herbivorous fish, poultry feed and livestock manure may be sufficient but for more intensive production a formulated, enriched feed is necessary. Formulated feeds require expensive imported ingredients such as good quality fish meal, minerals, vitamins, attractants and binders as compared to cheaper domestic products with fewer imported ingredients. Prices of fishmeal have roughly doubled since 2002. In 2008 the world's five largest fishmeal producing countries exported 2.6 million tons.[3] Peru alone accounted for 1.6 million tons, and 53% of those exports went to China.

2.5 Fish fingerling and shrimp post larvae

Natural reproduction of fish or shrimp is usually too limited and slow to sustain commercially viable aquaculture operations, which have to harvest on a regular basis – especially if under contract with buyers for regular delivery of minimum amounts. To keep aquaculture ponds, cages or pens sufficiently full with juvenile fish or shrimp, hatcheries dedicated especially to production of juveniles must be built to provide an environment in which fish, shrimp or other organisms can spawn in large quantities.

2.6 Processing and cold storage facilities

Many technologies exist to maintain fish and fisheries products in a condition suitable for consumer acceptance. Processing of fish serves several purposes as it:

- Slows the spoilage and so allows marketing over an extended period;
- Enhances product safety; and
- Helps create a consistent quality on which the consumer can rely.

Drying and fermenting seafood have been used for centuries, while canning and freezing technologies are more recent. Most technologies are designed to control the activities and growth of microorganisms, which if permitted to reach critical levels, will spoil the fish or poison the consumer. Microorganisms in general and bacteria in particular are abundant in nature. Bacteria are found in the fish itself. Gut, body surface, and gill regions are heavily contaminated with bacteria. Ice is the preferred method of keeping the fish fresh. Given the perishable nature of fish and the susceptibility to bacteria, the major portion of the price paid by consumers reflects processing, handling, and value addition after the fish is caught or harvested.

[3] Food Outlook, Fish and Fishery Products, FAO, June 2009.

3. Aquaculture and Inland Fisheries Resources in Sri Lanka and the Eastern Province

The entire island of Sri Lanka has inland fresh water resources of approximately 261,941 ha and 120,000 ha of brackish water resources as shown in Table 1. These resources include a large number of water bodies including perennial reservoirs of various sizes, [large (>800 ha), medium (200-800 ha) and minor (<200 ha)], seasonal village tanks (1-25 ha), and estate tanks. The total extent of all these fresh waters is about 262,000 ha, including the 23,000 ha of Mahaweli reservoirs. There are five large reservoirs comprising 13,134 ha located in the East. The largest, Senanayake Samudraya (7,790 ha) is in Inginiyagala in the Ampara district. The Eastern Province has most of the brackish water resources in the form of deep and shallow lagoons and estuaries. See Appendix 1 for more information.

Table 1: Freshwater and Brackish Water Resources for Inland Fisheries and Aquaculture

Water Source	Area
Fresh water	Ha
Large irrigation reservoirs	70,850
Medium irrigation reservoirs	17,004
Minor irrigation reservoirs	39,271
Seasonal Tanks	100,000
Flood lakes and villus (plains)	4,049
Upland reservoirs	8,097
Mahaweli reservoirs	22,670
Sub Total	261,941
Brackish water	Ha
1. Deep Lagoons and Estuaries	80,000
2. Shallow Lagoons/Tidal Flats	40,000
Sub Total	120,000
Grand Total	381,941

Source: National Aquaculture Development Authority (2008).

The seasonal village tanks with almost 100,000 ha though significant, typically hold water for only 6-8 months of the year. The 100,000 ha of seasonal village tanks are made up of more than 834 tanks in the three districts of the Eastern Province. See Table 2 and Appendix 2 for more information.

Table 2: Seasonal Tanks in Eastern Province (Number of Tanks)

District	Working Tanks	Abandoned Tanks
Trincomalee	328	196
Batticaloa	132	110
Ampara	181	87
Total	441	393

Source: Agrarian Development Department (2008).

Fish production in the non-perennial reservoirs and seasonal tanks is dependent upon stocking with hatchery-produced fingerlings of freshwater fish like tilapia, Chinese and Indian carps. These fish feed exclusively on the natural productivity of these reservoirs. Currently in Sri Lanka tanks are stocked with tilapia (*Oreochromus mossambicus*, *Oreochromus niloticus*); Chinese carps (silver carp - *Hypophthalmichthys molitrix)*; bighead carp (*Aristichthys nobilis)*; grass carp (*Ctenopharyngodon idella);* Indian carps (*Catla catla)*; rohu (*Labeo rohita)*; and mrigal (*Cirrhinus mrigla)* which are caught year round by fishers in small non-motorized boats. Depending on the availability of PL selected tanks are also stocked with fresh water prawns (*Macrobrachium rosenbergii*).

Table 3: Inland and Aquaculture Fish Production in (MT)

Year	Metric Tons
2001	29,870
2002	28,130
2003	30,280
2004	33,180
2005	32,830
2006	35,290
2007	38,380
2008	44,500

Source: Fishery Statistics, 2008; Statistics Unit, Ministry of Fisheries and Aquatic Resources (2008).

The total annual production of fish and shrimp from these inland reservoirs and tanks was 44,500MT in 2008, an increase of almost 50% over the past seven years as shown in Table 3. More than half the total production in 2008 was tilapia as shown in Table 4 below. The three districts from the Eastern Province, with an estimated 6,400 inland fishers, accounted for 8,640MT (19%) of the national inland and aquaculture fish production. Table 5 also shows the striking growth in aquaculture production in the Ampara district over the last decade.

Table 4: Inland Fish Catch Estimates by Major Species (MT)

Species	2006	2007	2008	Increase 08/07	Pct of 2008 total
Tilapia	19,320	22,510	25,230	12%	57%
Rohu	1,970	2,190	2,840	30%	6%
Catla	3,980	3,840	5,660	47%	13%
Carp	2,060	1,650	3,360	104%	8%
Cultured Shrimp	2,480	3,580	2,230	-38%	5%
Fresh water prawns	180	210	310	48%	1%
Other	5,300	4,750	4,870	3%	11%
Total	35,290	38,730	44,500	0	100%

Source: Fishery Statistics, 2008, Table 4.6; Statistics Unit - Ministry of Fisheries and Aquatic Resources and National Aquaculture Development Authority.

Apart from existing capture fishery operations, the provincial government and non-governmental organizations (NGO's) are encouraging the growth of aquaculture to increase employment and provide additional income to residents of the Eastern Province, especially in rural areas.

Table 5: Inland and Aquaculture Fish Production by District in Eastern Province (MT)

Province	1998	2000	2005	2006	2007	2008
Batticaloa	1,950	3,592	2,460	2,800	2,530	1,750
Ampara	970	1,290	2,270	2,540	3,250	5,240
Trincomalee	3,460	3,960	1,240	1,200	1,310	1,650
Subtotal	6,380	8,842	5,970	6,540	7,090	8,640
All Sri Lanka	29,900	36,700	32,830	35,290	38,380	44,490
EP % of Total	21%	24%	18%	19%	18%	19%

Note: Fish production based on the eye estimates provided by the field staff of NAQDA.
Source: Fisheries statistics 2008, Table 4.5, Statistics Unit Ministry of Fisheries and Aquatic Resources.

Most aquaculture fish produced in the Eastern Province is also consumed there. These fish and prawns harvested in tanks and reservoirs are sold locally or transported to nearby towns in Trincomalee, Ampara and Batticaloa districts. Although ice is the recommended method of keeping the fish fresh, in Sri Lanka consumers regard iced freshwater fish either cultured or caught from the wild with suspicion because they fear that ice is used to disguise the fact that the fish is not fresh.

Most consumers in Sri Lanka prefer to buy fish at ambient temperature. This results in significant waste and loss of value due to spoilage. Inland fishers do not use ice or other cold storage techniques, but have little trouble selling the fish without ice. Lack of affordable ice or cold storage facilities in the Eastern Province has prevented the option of exporting fish and seafood products overseas. The Ceylon Fisheries Corporation (CFC) has ice making and cold storage facilities in Batticaloa and Trincomalee. These facilities are available to freeze and store fish, prawns and other aquatic products. A description of services provided by the CFC is shown in Appendix 3.

4. Aquaculture Products and Export Competitiveness

Aquaculture products can be consumed or sold in the domestic market or sold into the export market. The best choice for a producer or firm depends on the market price and any added costs necessary to meet market requirements. Historically some percentage of Sri Lanka's farm-raised prawns and shrimp were exported, although the exact percentage for aquaculture is unknown because export data shows only aggregate figures combining aquaculture and wild capture. That data show that up to 40% of the combined catch was exported in 2000, but only 7.4% in 2008. The severe decline reflects problems with disease, prolonged conflict, and competition from other exporters. Export percentages for other species are thought to be very small if not zero.

Sri Lanka has good reason to consider the possibility of exporting some products at least to nearby Middle Eastern countries for several reasons. Firstly, refrigerated transport is readily available. Dole Asia located fresh banana export operations in Sri Lanka to take advantage of short transport times and a number of vessels traveling between Colombo and Middle Eastern ports. Secondly, large numbers of temporary "Guest" workers (construction crews, hotel services) in the Gulf countries are from Sri Lanka or South Asia and reportedly have a taste for tilapia and carp, which are currently being imported from India and more distant countries.

The third reason to consider export possibilities is the potential for higher prices. No one can guarantee anything about prices except that they will change over time. The price of fish can change dramatically from year to year, season to season or even week to week. To a certain extent different fish species compete with each other, so increases in the supply of one species can influence the market price of others. That said it is still worth pointing out, that average wholesale prices for tilapia in the Colombo Fish Market ranged between LKR 137.50 and LKR 197.63 per kg and averaged LKR 166.26 per kg for the seven-month period from January to July, 2009.[4] That average price converts approximately to USD 1.02 per kg which can be compared with average wholesale import prices for frozen tilapia filets ranging between USD 5.00 and USD 5.60 per kg and prices just below USD 8.50 for fresh tilapia fillets.[5] The two prices are not directly comparable, of course, because a major part of the difference is due to value addition of sorting, scaling, cleaning, packing and transport to the U.S., but the difference does indicate that the consumers in developed countries are willing and able to pay more for tilapia that meets exacting standards, and has a value chain for exporters with the right product to access.

Meeting International Standards

A major portion of the added price for tilapia in the global market reflects the added cost of preparing the product to meet the high standards for health, safety, appearance, freshness, and taste expected by consumers in importing countries. Potential exporters from Sri Lanka would also have to cope with the requirement of meeting minimum volumes to justify the investment in processing, transport, and an ongoing trading relationship. For reference, China exported 29,000MT of whole frozen tilapia to the U.S. in 2008, and the seventh largest exporter of whole frozen tilapia to the U.S. in 2008 was Indonesia, exporting only 200MT. Sri Lanka's total production of 25,000MT of

[4] Monthly Fish Prices, July 2009, Table 1 Wholesale Price at Colombo Fish Market, Ministry of Fisheries and Aquatic Resources, available on line at www.fisheries.gov.lk.

[5] Globefish, the Tilapia Market Report (May 2009) and U.N. Food and Agriculture Organization, Fish information network - www.globefish.org.

tilapia suggests it could meet the threshold for quantity. However, the requirement that all boxed tilapia be uniform in size and appearance might still require an exporter to spend on efforts to collect and consolidate from several different sources in Sri Lanka.

As mentioned above, however, Sri Lanka should first consider nearer markets. For example, although China exported 29,000MT of frozen tilapia to the U.S. in 2008, the largest exporter of fresh tilapia fillets was Honduras, (8,900MT). Honduras' fresh filets sold for a higher price than China's frozen filets. Honduras could compete because of its much shorter transport distance to the U.S.

Scientific and Environmental Standards

Enterprises interested in practicing aquaculture on a significant scale in Sri Lanka will also have to arrange for scientific support to protect against diseases such as those that attacked salmon growing in Chile and devastated Sri Lanka's own cultivation of prawn and shrimp. Health agencies are increasingly wary of shortcut methods to protect against disease that rely almost entirely on the use of antibiotics. Imports of fish to the EU have been rejected for presence of antibiotics. For example in 2002 the EU banned the import of animal products including frozen shrimp and prawns due to the presence of chloramphenicol, an antibiotic detected in imported seafood products.

At least two different organizations, the World Wildlife Fund (WWF) and the Global Aquaculture Alliance (GAA), have issued guidelines for their tilapia farm certification. The GAA has completed Best Aquaculture Practices (BAP) for tilapia. The BAP standards and guidelines for tilapia farms, which share many points with the BAP standards for other cultured species, apply to cage and net pen farming as well as to pond culture. Whatever the system, farms must comply with regulations regarding the use of non-native species.

Conclusions about the competitiveness of a particular aquaculture species in Sri Lanka should be based on further detailed analysis and a technical and economic feasibility study. The pro-forma examples given in the appendices to this report are examples based on assumed prices, costs and yields from a variety of years and countries.

5. Present Status of Aquaculture in the Eastern Province

5.1 Brackish water Aquaculture – (Shrimp Culture)

The only aquaculture activity of any significant scale conducted by the private sector at present in Eastern Sri Lanka is the grow-out of marine shrimp (Black tiger prawns - *Penaeus monodon)*, in Oddamavidi in the Batticaloa district. The PL used to stock the shrimp ponds are obtained from hatcheries located in the North Western Province coastal belt that extends from Negombo to Chilaw. Approximately 25 million PLs are stocked annually in 70 ha of shrimp ponds. The sole producer, located at Oddamavadi, also trades in feed, chemicals, and accessories. No post larval shrimp are imported from overseas to stock these ponds. This area has 94 operational shrimp ponds and more ponds are not in production. These ponds vary in size from 1 ha to 0.5 ha. Shrimp production from these ponds decreased by about 50% in 2008 due to an outbreak of disease. To reduce the danger of shrimp virus diseases like "white spot" and "yellow head", the managers are harvesting shrimp at an earlier, smaller size in the range of 19 to 25 grams, than practiced previously. There is increasing availability of pathogen free PL to stock these ponds. Polymerase Chain Reaction (PCR) assay apparatus for pre-sale screening of shrimp larvae for white spot and yellow head disease infection are now available in government and some private sector laboratories located in Colombo and the North Western Province. Hopefully the use of pathogen free shrimp PLs will reduce the incidence of disease.

Picture 1: Harvesting shrimp in Oddamavedi, Batticaloa

Source: USAID/CORE Program (2009).

The cost of shrimp PLs in July 2009 varied between 35 to 90 cents per individual PL depending on the demand and purchase arrangements. The cost of grower feed is LKR 160 per kg. The cost of special feed for shrimp PLs is LKR 200 per kg. This feed is being imported from Indonesia and has high protein content. Two shrimp ponds out of a total of six are currently in operation in Kinniya DS Division of the Trincomalee district. A large number of abandoned shrimp farms were observed in Kokkadicholai, where commercial shrimp culture in Sri Lanka was first introduced.

Picture 2: Abandoned Shrimp Pond in Kokkadicholai, Batticaloa

Source: USAID/CORE Program (2009).

With funds from the Asian Development Bank (ADB), the National Aquaculture Development Authority (NAQDA) is constructing a marine shrimp hatchery with the capacity to produce 20 million PL per annum at Pudukudirippu in the Batticaloa District. The construction work is 80% completed. NAQDA has also reserved six ha of land at Vattavan in the Batticaloa District to establish a model shrimp grow-out farm. A team of scientists from the National Aquatic Resources Research and Development Agency (NARA) and Eastern University has completed zonal plans for shrimp culture development in the Batticaloa and Trincomalee Districts. Their recommended sites for shrimp farming in the Trincomalee and Batticaloa Districts are given in Tables 6 and 7 below.

Table 6: Sites Recommended for Development of Shrimp Farming in Trincomalee

Divisional Secretariat	Area (ha)
Kuchchaveli	2,022
Town & Gravet	100
Mutur	177
Seruvila & Eachchilampattai	314
Total	2,613

Source: National Aquaculture Development Authority.

Picture 3: Shrimp Hatchery under Construction in Pudukuduirrupu, Batticaloa

Source: USAID/CORE program (2009).

Table 7: Sites Recommended for Development of Shrimp Farming in Batticaloa

Divisional Secretariat	Area (ha)
Koralai Pattu North	1,439
Koralai Pattu South	522
Koaralai Pattu (Valachchenai)	75
Eravur Pattu	70
Manmunai North	359
Manmunai West	307
Manmunai South-West	67
Total	2,839

Source: National Aquaculture Development Authority.

5.2 Freshwater Aquaculture

5.2.1 Fish Breeding Center

The NAQDA operates a fish hatchery in Inginiyagala, Ampara district, near the Gal Oya National Park for spawning carp and tilapia. This is the only fish-breeding center catering to the fish fingerling requirements for the entire Eastern Province. In 2008 the Inginiyagala hatchery produced 1.47 million carp fingerlings and 430,000 tilapia fingerlings (Table 8).

Table 8: Fish Seed Production in NAQDA Breeding Centers (2008 in 1000s)

Center	Carp			Tilapia	
	Post larvae	Fry	Fingerlings	Fry	Fingerlings
Udawalawe	26,330	6,884	1,189	-	-
Udawalawe Tilapia Center				4,050	1,053
Dambulla	35,104	16,051	2,131	2,152	290
Inginiyagala	28,800	9,675	1,468	2,830	429
Nuwaraeliya	820	382	139	-	-
Total	91,054	32,992	4,927	9,033	1,773

Source: National Aquaculture Development Authority.

All fingerlings produced in the center are used to stock inland reservoirs (tanks) in the three districts of the Eastern Province. The center is being managed by qualified and well trained aquaculturists.

5.2.2 Seasonal Tank Aquaculture

The Eastern Province is endowed with 741 working seasonal reservoirs (Trincomalee - 428, Ampara - 181, Batticaloa - 132). Due to various reasons 393 of these seasonal tanks are abandoned as shown in Appendix 2. NAQDA is continuing the implementation of the program to utilize selected seasonal tanks for fish culture in the Eastern Province with the participation of the village community. These reservoirs are small shallow manmade water bodies built for the purpose of irrigation with a watershed area less than 80 ha that retains water for only 6 to 8 months of the year. They are scattered in the Eastern Province. They generally receive water from the North-East Monsoon. The filling of the reservoirs commences with the October rains and gradually the maximum water level is reached around January/February. Most of their water is derived from seasonal streams and run-off from surrounding land. From February/March onwards the water level commences to recede and with the onset of drought the evaporation process will be accelerated and the majority of these reservoirs may dry up completely by July/August. Irrigation and evaporation are the main causes that lead to the decrease in the water level in these reservoirs. However, in most there will be an effective water area which will retain water for a period of 4 to 5 months thus enabling the culture of fish for food. These tanks are considered to be comparable to village fish ponds which could have the potential to produce much needed fish for the villagers in addition to being used to irrigate paddy fields, bathing, watering cattle and domestic uses. The selection of seasonal tanks for fish culture is done after an assessment based on criteria and rating developed by NAQDA as shown in Appendix 4.

The culture of fish in qualified seasonal tanks offers several advantages, including:

- Easy start-up where owner and/or operators can make use of existing water bodies and avoid major capital expenditures in the land preparation;
- Nutrition where in most seasonal tanks are high in nutrient content and continue to receive a significant nutrient load through the period of water retention due to human activity, making them highly productive for fish culture; and
- Poverty reduction potential, where most seasonal tanks are located in the rural areas of the dry zone, where the diets are deficient in protein.

5.2.3 Land based mini nurseries

There are two land based mini nurseries (Rajawewa and Kirawana) established by NAQDA in partnership with fisheries cooperative societies in the Ampara district. The operation and management of the nursery is by the selected members of the community based organization (CBO). The Rajawewa nursery covers a pond area of 4,600 sqm and the Kirawana pond area is 4,030 sqm.

Picture 4: Mini-Nursery (Fry to Fingerling) in Rajawewa, Ampara

Source: USAID/CORE Program (2009).

In 2009 up to the end of the month of June, Rajawewa mini nursery has produced 344,000 fingerlings and Kirawana has produced 571,000 making a total of 915,000. They buy the fish fry from Inginiyagala breeding center at LKR 0.25, nurse them up to fingerling size, and sell them to CBOs managing reservoirs at LKR 2 per individual. The culture period is about forty-five days for this process.

6. Opportunities & Obstacles for Aquaculture Development in the Eastern Province

This section summarizes the key opportunities as well as the obstacles and risks facing aquaculture development in the Eastern Province, starting with opportunities.

6.1 Opportunities

- **Availability of land with access to fresh, marine or brackish water**

The Eastern Province is home to only 8% of Sri Lanka's population, and land appears at first glance to be more readily available than on the Western and Southern Coasts. First impressions are no guarantee that the right land can be found and obtained. Successful aquaculture will require land with access to fresh, brackish or saltwater. The amount of land required for an aquaculturist to support him/herself and family varies with the product. Approximately 0.5 ha may be sufficient for an aquarium fish or plant producer while 4 ha of ponds may be needed for a producer of freshwater fish like carp or tilapia. Large areas of land might not be readily available or inexpensive enough to attract investor interest. Only ornamental fish or plant producers can afford to pay high prices for land because they can operate and earn sufficient profits even with small plots of land. Land with access to brackish or saltwater appears to be much easier and cheaper to obtain on the East Coast than in Western Sri Lanka. Land near brackish water is less likely to be used for other purposes like agriculture or industry.

- **Availability of fish fingerling and shrimp post larval (PL)**

As mentioned earlier, NAQDA operates a fish hatchery in Inginiyagala, Ampara district, near the Gal Oya National Park for spawning carp and tilapia. All fingerlings produced are used to stock inland reservoirs (tanks) in the three districts of the Eastern Province. The capacity of this hatchery is under expansion with funds from the ADB funded Aquatic Resource Development and Quality Improvement Project (ARDQIP).

The authors visited a mini-nursery for tilapia and carp in Rajawewa, in the Ampara District. This hatchery is a community based operation started by NAQDA. This program has built 25 mini-hatcheries out of which only 2 are in the East; this one and one in Kirawana. This hatchery has 12 growing ponds (2500 M^2) fed with water from a "tank" or inland reservoir (see Picture 4).

As mentioned earlier, this hatchery buys fry from a breeding station at LKR 0.25 per fry. Fry are raised to fingerling size in 45 days. It then sells fingerlings for LKR 2 each. The fry have an 80% survival rate. The Reservoir Fishers Cooperative, composed of 14 families, decides who works in the nursery and how profit will be shared. At the time of our visit, all the ponds in this hatchery were completely dry so no fish fry or fingerlings were being produced.

6.2 Obstacles and Risks

- **Availability of low cost locally produced feed for fish and shrimp**

Enough trash fish (offal and waste fish) are available in the Batticaloa area to support a limited expansion of sea bass farming. The trash fish constitute undersized, un-saleable, or otherwise undesirable whole fish discarded alive or dead at the time of capture or shortly afterwards from marine or inland waters. However, there will be supply problems if this practice expands significantly. Therefore efforts must be made, probably with the participation of a local feed manufacturer, to formulate a feed for Sea bass (*Lates calcarifer*) using as many local ingredients as possible to make the feed economical to local producers.

Ceylon Grain Elevators (CGE) a subsidiary of Prima Group of Companies of Singapore currently produces poultry feed. However, poultry feed does not contain enough protein for use as fish feed. This company used to and can produce shrimp feed if there is sufficient demand. However, the closure of many shrimp farms in Sri Lanka has lowered the demand for this feed. CGE says they need a minimum order of 20 metric tons per month to justify resumption of production. Most feed ingredients are imported into Sri Lanka. Therefore, the cost of such feed is relatively high, more than LKR 150 per kg. CGE does produce small quantities of fish feed for the ornamental fish industry and government run hatcheries. With the development of aquaculture the demand for fish feeds would rise enabling larger scale, more efficient production and operation and possibly lower feed prices. Global conditions however appear to be pushing feed prices higher.

- **Lack of cold chain facilities and reasonably priced ice**

One obstacle that could be overcome with moderate investment is the lack of cold chain facilities in the East. The few existing ice plants in the east sell ice only in the form of 50kg blocks. Batticaloa has two ice plants with a production capacity of 25MT per day while Trincomalee has two ice plants with a production capacity of 45MT of ice per day. Only block ice each weighing 50kg are produced in these ice plants. For many users the ice is expensive due to the high cost of electricity and the cost of transport if one is not located near the ice plant. There are several newer technologies for making ice in ways that are less expensive and more convenient for fishery operations. The CFC is looking into selling or contracting out some of its ice plants to private sector operators. A new private sector operator in Sri Lanka, Iceman Technologies (Pvt) Ltd, is working on ice plant and cold storage solutions for Sri Lanka and the Maldives. If Sri Lanka aims to develop aquaculture on a small-scale basis dispersed over wide rural areas, it needs to create many points of ice production. This strategy deserves a more detailed examination regarding the costs and locations of facilities and collection arrangements. For some additional information regarding ice making and cold storage, see the USAID/CORE Assessment of Logistics in Sri Lanka's Eastern, North Central, and Uva Provinces.

- **Long travel times to Colombo and airport**

In addition to the actual distance between the Eastern Province and the major population centers of Colombo and Kandy, frequent police and military checkpoints in the Eastern Province delay the movement of perishable products such as seafood. Though the situation has improved since mid 2009, the transport routes need to be further streamlined to reduce the delays so that seafood can get to the destinations in the Western Zone more quickly.

- **Disease risk in pond raised shrimp and fish**

Concentrated culture of any animal life in a small area increases the risk of disease. Even advanced countries such as Chile have faced serious disease problems with the cultivation of salmon. There is a greater risk, of course, of infection entering and spreading if best management practices are not followed. This has happened in Sri Lanka with pond raised shrimp. The introduction of specific pathogen free shrimp PL and broodstock should help to reduce the incidence of disease in shrimp ponds. Reducing the stocking intensity of PLs in shrimp ponds should also help to reduce disease susceptibility in shrimp ponds.

- **Low tidal amplitude**

The average tidal amplitude is about 45cm. During spring tide it is 60cm, and during neap tide it is 30cm in Eastern Sri Lanka. Therefore extensive inter-tidal zones suitable for commercial scale bivalve culture are not available in Eastern Province.

- **Market risk**

Even when all technical conditions are satisfactory, there is no escaping the fact that aquaculture remains subject to market risk and risks from competition. After several Asian countries started-up and increased shrimp production between 1997 and 2001 the supply of shrimp reaching the market increased 100% between 1999 and 2004 (FAO Fisheries Technical paper 475) causing market prices to drop well below what they had been when investments were made (from USD 5.20 in 1997 to USD 4.25 in 2001). Conversely, tilapia growers around the world in 2008 saw prices increase as production from China fell off to unusually cold temperatures in China. In the longer term, however, the demand for fish appears to be outstripping the available supply and fish culture is becoming an increasingly feasible commercial enterprise.

7. Policy Issues

There are several policy issues worth mentioning that affect Inland fisheries and aquaculture production in Sri Lanka. The first involves wavering support from the government due to a religious concern. In 1984 the government decided to withdraw all patronage for inland fisheries because some Buddhist monks opposed government sponsorship of activities that intended to eventually slaughter an animal (See Appendix 5). In 1999, after a 14 year hiatus, the government resumed aquaculture promotion, and religious objections do not appear to be a current obstacle. As shown in Table 3, there has been a 50% increase in aquaculture output over the last seven years. That jump in output came after a long period of neglect. One legacy of that neglect, however, is that there has been little or no progress in addressing the problems related to fishing tanks and reservoirs as "Common property". In the case of smaller reservoirs the government has entrusted fishing rights to local FCS on an exclusive basis. More needs to be done with these societies to encourage proper management of their rights and enterprises. Even more needs to be done in the case of reservoirs and tidal areas that now or soon will be resources used and shared by several economic actors.

A second policy issue involves security and the role of NAQDA extension officers who are currently tasked with extension work and law enforcement against poaching or illegal fishing. NAQDA officers have complained and proposed creation of a separate section specifically devoted to enforcement issues. This security issue is related in part to the common property problem mentioned above.

8. Alternative Species for Eastern Province Aquaculture

Many tropical species new to aquaculture in Sri Lanka are being raised in Philippines, Thailand and other Southeast Asian countries. Among these species are milkfish (*Chanos chanos*), cat fish (*Clarias sp*), brine shrimp (*Artemia sp),* Spirulina (*Spirulina sp*), mud crabs (*Scylla serrata*), sea cucumbers (*Holothuria sp*), and seaweeds (Gracillaria) and (*Echeuma cottonii* & *E.denticulatum*).

- **Mud Crab**

A good example of an aquaculture species raised in Southeast Asia that can also be raised in Sri Lanka is the mud crab. Small mud crabs can be fattened in estuaries and coastal lagoons. The international market for crabs is generally strong. Most Asian Pacific countries have a significant domestic demand for crabs. In many countries, over fishing of mud crabs has depleted natural crab populations. Mud crabs are still readily available in Eastern Sri Lanka. Mud crabs are reasonably hardy animals and can be transported live, packed dry in boxes. This makes marketing and transportation much simpler than for many other aquatic organisms. In addition to the live mud crab trade, there is also a market for just molted soft-shell crabs (particularly in Southeast Asia). Crab fattening is one of the aquaculture activities covered in new booklet from NAQDA available in Sinhala.[6]

- **Sea Bass in Cages**

Another promising new aquaculture activity recently introduced to the East coast is the cage culture of sea bass. Although still in the pilot stage, this initiative shows promise of expansion and profitability. In Palakuda, Batticaloa district, the Sewalanka Foundation with International Union for Conservation of Nature (IUCN) funding has installed 20 cages to raise sea bass (*Lates calcarifer*) (see picture 5 below). At present this project is in its second production cycle. A collaborating private company provides sea bass fingerlings and the initial training to the selected members of the community-based organization that is entrusted to operate and manage the cages. After stocking the sea bass fingerlings in the cages the farmer feeds trash fish (offal and waste fish) at a cost of LKR 15 to LKR 25 per kg. Each cage cost about LKR 42,000. It is envisaged that 4 net-cages could support one family and the plastic nets to last 6 production cycles.

[6] *Cost Benefit Analysis of Aquaculture*, NAQDA, 2009 in Sinhala. See also "A Guide to Investment Opportunities in Aquaculture Ventures, also by NAQDA, 2009.

Picture 5: Marine Fish (Sea bass) Cages in Palakuda, Batticaloa

Source: USAID/CORE Program (2009).

There is a buy-back arrangement with Aqua 'N Green (A'NG), a private company in Negombo that imports sea bass fingerlings from Thailand. A'NG exports chilled fish by air freight. The Colombo market price for sea bass is approximately LKR 400 per kg. A'NG is satisfied with the quality of these cage reared fish. However, quantities are still too small. There is a problem with theft of fish in cages so security needs have to be addressed. All the sea bass fingerlings offered by A'NG are imported from Thailand as 45 day old post larva and raised up to fingerling size in their facilities at Basiyawatte in Negombo. The hatchery facility of A'NG is now being upgraded to spawn and rear larvae of sea bass. Sea bass culture is one of the aquaculture activities profiled in NAQDA's recent publications on investment opportunities and cost benefit analyses (see footnote 6).

- **Eucheuma Seaweed**

A small experimental operation to raise seaweed Eucheuma (*Eucheuma cottonii*) is in operation in open sea at Panama in the Batticaloa District (see picture 6). Ceylon Biscuits Limited (CBL) is funding this project as one of their social responsibility projects and the local NGO, Sewalanka is implementing the project. Rectangular frames made of two inch diameter PVC pipes are used to hang the Eucheuma cuttings. The frame is covered with netting materials of one inch mesh to prevent the grazing of seaweed by the fish especially rabbit fish. Initial results show that when the Eucheuma cutting weighing 100 grams when hung inside the cage and allowed to grow for 6-8 weeks the cutting weighed 1.5kgs. Sewalanka has planned to increase the number of cages.

Picture 6: Seaweed Cage Culture Technology Panama, Batticaloa

Source: USAID/CORE Program (2009).

To appreciate its potential as a livelihood option for fishers, some highlights from a 1999 survey of seaweed farming in Sabah, Malaysia are presented in Appendix 6 along with a strengths, weaknesses, opportunities and threats (SWOT) analysis of potential Eucheuma culture in Sri Lanka in Appendix 7. This information is based mainly on reports from a mariculture specialist who worked in Sri Lanka on potential strategies for development of mariculture under the ADB funded ARDQIP.[7]

- **Milkfish**

Milkfish (*Chanos chanos*) is another example of a species raised in several other South East Asian countries. It has great potential in Sri Lanka. It has several advantages as an aquaculture product such as:

- It feeds low on the food chain reducing the need for expensive feeds;
- It is tolerant of a wide range of salinities from fresh water to full strength seawater and it does especially well in brackish water;
- It can be raised together with tilapia and other popular food fish in the same pond;
- Milkfish fry can be collected from the wild in coastal areas of Sri Lanka;
- There is a market for milkfish both as a food fish and as bait for the tuna long line fishery; and
- Milkfish is also one of the species covered in recent NAQDA publications.

- **Other Species**

Other aquaculture species that could be developed in the Eastern Province of Sri Lanka include tuna, the algae Spirulina, grouper, corals, and many other species as well. However, until the technology for these species is better developed and their markets are identified and developed the authors recommend that money and efforts of foreign donors focus on aquaculture species whose costs and

[7] For more information: http://www.surialink.com/abc_eucheuma/toc.htm.

returns are better known. An example of a value chain map for the collection of sea cucumber in Kalpitiya, Sri Lanka is presented in Appendix 8. The following table summarizes the pros and cons of species that could be successfully cultured in Eastern Sri Lanka.

Table 9: Species Commercially Produced in Eastern Province

Species	Advantages	Disadvantages	Comments
Shrimp	Technology well developed, PL's available	prices volatile, disease prone	Less intensive production more likely to be sustainable
Tilapia and Carp	Easy to raise	Low price, small size of product	Limited fresh water supply will limit expansion
Sea Bass	Easy to raise	Feed availability	Potentially profitable but ice needed for export
Ornamental Fish	High sale price	Has to be close to airport, difficult to penetrate market,	Good air connections needed to become Viable alternative
Ornamental Plants	High sale price	Difficult to penetrate market	Possible alternative with support from government
New Species			
Seaweed	Easy to raise	Needs shallow lagoon sites	Good potential in suitable areas
Mud crabs	Easy to raise, easy to transport	Low percentage of meat after peeling	Good potential in Estuaries
Artemia	Easy to raise	Suitable site hard to find	Good potential if suitable site is found
Milkfish	Easy to raise	Considered too bony	Good potential in abandoned shrimp ponds
Local Cat Fish (*Clarias* sp)	High demand, farming technology developed, accepts formulated feed	Carnivore, cannot stock in reservoirs only in ponds	Muslims in Eastern province cherish smoked cat fish

9. Recommendations for Aquaculture Development in Sri Lanka

As mentioned in the conclusion section there are a number of steps that will encourage an expansion in aquaculture production, and steps that can improve the incomes of farmers and fishers practicing aquaculture in post-conflict zones. The recommendations below are made with those objectives in mind.

9.1 Overall Recommendations

1. The Government of Sri Lanka (GoSL) should continue to support the development of aquaculture in ponds and cages. The GoSL should consider special incentives and financing to encourage private sector operators to refurbish abandoned shrimp ponds in the East and return them to production – although not necessarily to the production of shrimp and prawns.

2. The GoSL, other donors, and NGOs should offer more training to farmers to manage ponds and cages.

3. The GoSL, other donors, NGOs, and the private sector should encourage and invest in experiments and innovations testing new species and new techniques at various locations. Physical and economic conditions vary from place to place. Therefore more pilot production testing of the technologies of culturing species such as mud crabs, seaweed, sea cucumbers, brine shrimp, milkfish, and catfish should be done for localities in the Eastern Province.

4. The private sector and GoSL should investigate alternate methods for producing ice and chilling sea water.

5. The private sector should partner with the GoSL, other donors, and NGOs to explore means to make the export of fish, crabs and shrimp less expensive and more practical for producers, especially in the post-conflict areas.

6. The NGOs committed to having a more tangible impact on the sector should partner with private companies to develop new export opportunities and new aquaculture species. More efforts should be made by both the public and private sector to develop foreign markets for Sri Lankan aquatic products.

7. The NGOs and private sector partners should begin their investigation into aquaculture projects with a market and a cost-benefit analysis of both the project and the value chain needed for the project's products to reach the desired market. In the case of export-oriented projects this should include a comparison of costs and returns from producing in Sri Lanka with costs and returns from production in India and other Asian countries.

9.2 Recommendations for the Eastern Province

1. Pond culture of fish such as tilapia, milkfish and carp species (in fresh water) has several advantages for new entrants into aquaculture. Although the market price of these species may be lower than that for shrimp, they are easier and less expensive to raise and **less vulnerable to disease**. Tilapia and milkfish can be raised in brackish or saline water which is more readily available in the Eastern Province than freshwater. Where freshwater is available efforts should be made to stock freshwater shrimp (*Macrobrachium rosenbergii*) in ponds with tilapia and carp. Fish raised in ponds should be targeted to local markets since these markets are willing to purchase fish fresh without ice or other forms of processing. In the Ten Year Development Policy Framework of the Fisheries and Aquatic Resources Sector 2007-2016, the Ministry of Fisheries and Aquatic Resources recommends that abandoned shrimp ponds in the North and East be restored to production. The authors recommend that these ponds be restored for fish rather than shrimp production since the volatile nature of shrimp prices along with the danger of disease does not bode well for the economic success of shrimp farming at the present time. Instead semi-intensive production of herbivorous fish such as milkfish and tilapia are more likely to be profitable than shrimp farming. In addition development of fish production in these ponds will encourage the development of ancillary industries like ice and cold chain facilities that will contribute to increasing economic development of the Eastern Province.

2. Cage culture of marine fish such as sea bass is feasible at the present time in Batticaloa and Trincomalee districts. Interested NGOs can partner with private companies such as A'NG in their efforts to produce sea bass fry and fingerlings in Sri Lanka. As this activity expands efforts will be needed to source a local high protein feed that can be used to supplement and eventually replace the trash fish presently being fed to caged fish.

3. Mud crabs (*Scylla serrata*) are interesting because a local capture fishery already exists; the crabs sell well in the local market and are also exported. Crabs are easier and less costly to transport. Again an expansion of crab-fattening will eventually run up against depletion of the supply of trash fish being used as feed for crabs or sea bass. The NAQDA should continue to do more research and increase its efforts to develop the technology for fattening mud crabs in cages and overcome various problems including disease and poaching that will occur as mud crab aquaculture expands.

4. Seaweed farming has potential in the shallow marine lagoons near Batticaloa and Trincomalee. The advantages of seaweed culture include the low investment required to begin production and the labor intensive nature of this activity which can employ fishers and villagers. However, marketing channels need to be developed once production increases. There is a local market for carageenan and agar extracted from seaweed that can be grown in coastal waters. However NAQDA, Sewalanka Foundation and other NGO's will probably have to get involved to overcome production and processing problems and develop market channels for the seaweed raised. A large private biscuit company has shown interest in working with Sewalanka Foundation to develop seaweed aquaculture in Sri Lanka. Locally grown seaweed would reduce the need for this company to import seaweed products needed for its biscuits.

5. Ornamental fish and plants are a significant export item from Sri Lanka. In 2008 the export value of ornamental fish raised in Sri Lanka was 9 million dollars. However this figure has not increased since 2000. Developing ornamental fish culture in the Eastern Province appears to be problematic in that all the fish produced have to be exported by air from the Bandaranayke International Airport near Negombo within 24 hours after packing to ensure better survival. It is

unlikely this can be achieved on a regular basis from the Eastern Province. There are plans to build a holding facility for the live fish near the airport but until then the transport time to the airport will discourage investment in this form of aquaculture. A more serious problem is the competitive nature of this industry. There are no barriers to the entry of new ornamental fish producers in other tropical countries to compete with existing producers such as those in Sri Lanka. Even small-scale fish producers in developed countries with access to enclosed buildings or geothermal water can compete with existing producers. This ease of entry will also discourage ornamental fish producers from getting started in the East of Sri Lanka.

6. Shrimp farming is an existing activity in the Batticaloa district. In spite of disease problems and high feed costs that have greatly reduced volumes, shrimp farming for local and even export markets continues. To help keep this industry competitive the authors recommend that production shift to a less intensive model. This means that less shrimp PLs should be stocked per pond, less feed should be added and only specific pathogen free PLs should be used. Although total production will decline the cost of production will decline as well. Furthermore the average size of harvested shrimp will increase. In India low intensity shrimp farming in the backwaters of the south Indian state of Kerala has proven to be more profitable than intensive shrimp farming elsewhere in India. The scope for expansion of shrimp farming in the Eastern Province is limited because of the low tidal range which, in other shrimp producing areas, can be used to exchange water for shrimp ponds. In the East diesel or electric pumps are used to pump water into the shrimp ponds which increases the cost of production when compared to shrimp raised in other countries.

7. High value temperate aquaculture species such as crayfish, salmon or sturgeon are not appropriate for the Eastern Province because water temperatures are too high and there is no cool period. The trout present in the highlands of Sri Lanka need to be replenished with eggs imported from colder countries.

In the process of the field visits made for the research into this report, the authors encountered several private sector businessmen with plans or ongoing activities that might be of interest to USAID/CORE and to others. Given time and other constraints, it was not possible to explore or investigate the opportunities in a fully satisfactory way. They are presented below without significance to their order for consideration and possible further study.

9.3 Other Recommendations

1. Supporting establishment of a land based mini-nursery

NAQDA has only one fish-breeding center serving the entire Eastern Province. As aquaculture activities expand, NAQDA has begun seeking the assistance of private sector participation to rear the fry produced at its breeding center. NAQDA will facilitate the sales of fingerlings produced by the private sector to various FCS that need the fingerlings for stocking in reservoirs. NAQDA has already established two mini nurseries in partnership with FCSs and they are functioning quite satisfactorily with profits to their members.

A private entrepreneur relatively close the NAQDA fish breeding station at Inginiyagala has invested in and commenced digging ponds on his own land for nursing the fish fry to sell as fingerlings to FCS. NAQDA extension staff has helped him design the ponds and other technical inputs. However, pond construction has run into problems due to a layer of rock at the intended location. It is not known if this is a major physical or only a cost constraint to pond construction. However, the individual

involved is seeking to partner with other investors or anyone interested in investing in freshwater aquaculture.[8]

2. Supporting establishment of a model brackish water fish farm

There is a private sector entrepreneur with a site suitable for culturing brackish water fish such as milkfish. The site is located in a village call Mankikattu in Manmunai west D.S. Division- Batticaloa. The entrepreneur has obtained land extending to seventeen ha on a government lease for 35 years for the purpose of fish farming. There is no brackish water fish farms yet established in Batticaloa. If this pioneering attempt is developed properly and succeeds, it will be a model and catalyst for other investors.

3. Supporting further development of Sea bass culture

A company named Aqua 'N Green Ltd (A'NG) has been a successful operator of shrimp ponds in Western Sri Lanka. The firm is already experimenting with sea bass culture in cages in Western and Eastern Sri Lanka. For production of sea bass fingerlings the company has developed brood-fish that are already mature and ready to use as spawners. A'NG has several sets of fish cages installed in Trincomalee and Batticaloa Districts, operated and managed in association with NGOs.

4. Support experiments in seaweed processing as a cottage industry

Eastern University is working at an experimental level to develop a suitable methodology to process seaweed collected from natural sources before exporting so that higher value could be obtained through exports.

5. Work with select Fishery Cooperative Societies (FCSs)

FCSs are local cooperatives entrusted with fishing rights in reservoirs. Each of these organizations is similar to a private sector cooperative engaged in an activity to benefit its members. In addition to needing help with best practices of aquaculture, they also need to meet and work with potential buyers in developed areas to learn other ways to market than simply selling to the nearest middlemen. Stories are told of FCS who turned down contract opportunities that would require sorting or dressing of fish because they were not interested. Such causes suggest the need for more awareness and instruction about the benefits these opportunities might bring.

[8] His name is Ranjith Srilal Wijesooriya Arachchi at No 3 Samudra Mawatha, Inginiyagala (Tel +94632242239). He is a local small time businessman, who also owns and operates a licensed wine store in Inginiyagala.

10. Conclusions

The major conclusions of the assessment are:

1. There are no major technical or natural obstacles to aquaculture producing fish, shrimp or seaweed in the Eastern Province of Sri Lanka.

2. The high cost of fish and shrimp feed will be a constraint to the rapid expansion of caged fish culture and shrimp farming. However this constraint would not prevent smaller scale growth in aquaculture. The constraint could be overcome or lessened by using fish offal and other wastes that will become more available when fish canning begins, or if Sri Lanka farmers decide to grow feed grains in response to new local demand.

3. The availability of suitable, affordable land and brackish water is a big advantage that will most likely outweigh other constraints to aquaculture development.

4. Production of most common aquaculture fish species should be profitable even at local market prices. Existing aquaculture operations (mainly tilapia and carp) have demonstrated an ability to compete in local markets with marine-caught fish. New species for Sri Lanka such as mud crabs, brine shrimp and sea cucumbers are especially promising. Export of aquaculture products could make aquaculture even more profitable.

5. Prawn and shrimp culture, despite coping with major disease issues has survived and shown an ability to compete in the export market.

6. Except for a few entrepreneurs, there seems to have been very little experimentation or innovation within the aquaculture sector. There has been more investor interest in aquaculture of ornamental fish.

7. Sri Lanka enjoys a location and transport advantage exporting perishable products to the Persian Gulf countries. Some buyers from the Gulf countries have explored Sri Lanka as a source of farm-raised fish for Asian construction workers living in the Gulf countries.

8. Major investment in better post-harvest collection, processing and handling will be required to successfully compete in the export market and to sell into the growing market of tourists expected to visit Sri Lanka.

9. There are a number of steps that will achieve the objective of encouraging limited growth in aquaculture activities in Sri Lanka, but the path to significant industry growth requires competing in the export market.

APPENDICES

Appendix 1: Brackish Water Resources by District

Province and District	Mangroves	Salt Marshes	Lagoons	Total Brackish Water Resources	Length of Beach (km)	Density by beach Length (ha/km)
Western	192	192	3,529	4,218	80	52.73
Gampaha	122	497	3,442	4,061	40	101.53
Colombo	70		87	157	40	3.93
Southern	732	503	5,632	6,867	265	25.91
Galle	187	185	1,144	1,516	75	20.21
Matara	6			6	55	0.11
Hambantoa	539	318	4,488	5,345	135	39.59
Northern	2,296	15,634	70,503	88,433	480	184.24
Jaffna	260	4,963	45,525	50,748	275	184.54
Killinochchi	312	4,975	11,917	17,204		
Mannar	1,261	5,179	3,828	10,268	155	66.25
Mullativu	463	517	9,233	10,213	50	204.26
Eastern	3,204		39,234	46,162	420	64.11
Batticaloa	1421	2,196	13,682	17,299	100	172.99
Ampara	292	127	7,235	7,654	110	69.58
Trincomalee	1,491	1401	18,317	21,209	210	101.00
North-Western	2,264	3,461	39,119	44,844	300	149.48
Puttalam	2,264	3,461	39,119	44,844	300	149.48

Source: National Aquatic Resources Research and Development Agency.

Appendix 2: Seasonal Tanks in the Eastern Province

Appendix 2a: Trincomalee District Summary of Seasonal Tanks

ID No	Govijana Kendraya (Agricultural Services Center)	Working Tanks	Abandoned Tanks
16/1	Kuchchaweli	15	14
16/2	Nilaweli	21	20
16/3	Sambaltivu	3	3
16/4	Uppuweli	8	8
16/5	Pulmoodai	57	57
16/6	Tambalagamuwa	2	-
16/7	Pankulam	37	13
16/8	Gomarankadawala	133	29
16/9	Agbopura	15	8
16/10	Kantalai	4	1
16/11	Echchalampattuwa	7	5
16/12	Serunuwara	-	-
16/13	Padavisripura	32	13
16/14	Van Ela	4	2
16/15	Mollipotana	4	-
16/16	Kurunchankerny	4	1
16/17	Kinniya	4	-
16/18	Sampur	65	21
16/19	Thoppur	9	1
16/20	Muttur	4	-
16/21	Kiliweddi	-	-
16/22	Munnampodivrddi	-	-
Total		428	196

Source: Agrarian Development Department.

Appendix 2b: Ampara District Summary of Seasonal Tanks

ID No	Govijana Kendraya (Agricultural Services Center)	Working Tanks	Abandoned Tanks
15/1	Mayadunne	-	-
15/2	Uhana	2	-
15/3	Central Camp	-	-
15/4	Namaltalawa	3	-
15/5	Hingurana	-	-
15/6	Maha Oya	-	-
15/7	Padiyatalawa	47	45
15/8	Sainthamarthu	-	-
15/9	Chenakudirippu	1	-
15/10	Kalmunai	-	-
15/11	Neelavanai	7	-
15/12	Nintavur	-	-
15/13	Palamunai	-	-
15/14	Akkaraipattu East	-	4
15/15	Karthivu	-	-
15/16	Thambiluvil	60	-
15/17	Lahugala	10	6
15/18	Pottuvil	6	6
15/19	Pallanoya	1	-
15/20	Addalachenai	-	-
15/21	Panama	10	6
15/22	Akkaraipattu West	-	-
15/23	Madanagama	2	1
15/24	Komari	26	19
15/25	Malwatta	-	-
15/26	Samanthurai	-	-
15/27	Chavalakadai	3	-
15/28	Eragama	3	-
Total		181	87

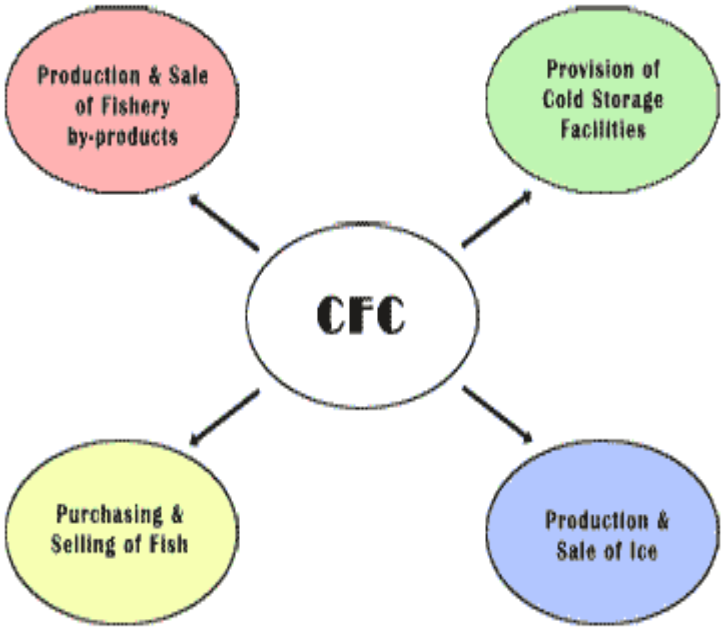
Source: Agrarian Development Department.

Appendix 2c: Batticaloa District Summary of Seasonal Tanks

ID No	Govijana Kendraya (Agricultural Services Center)	Working Tanks	Abandoned Tanks
14/1	Kaluwanchikudy	30	1
14/2	Kokkodichcholai	7	7
14/3	Vellavely	3	-
14/4	Palugamam	8	-
14/5	Mandoor	4	-
14/6	Araipattai	2	-
14/7	Kallady	1	1
14/8	Mandapathady	17	8
14/9	Alythiyamalai	1	1
14/10	Karadiyanaru	13	2
14/11	Eravur	1	3
14/12	Vantharamoolai	19	26
14/13	Kiran	17	35
14/14	Valaichenai	1	3
14/15	Vaharai	7	18
14/16	Thnthamala	1	5
Total		132	110

Source: Agrarian Development Department

Appendix 3: Facilities & Services Provided by the CFC



The core activities of the CFC consist of the following:

1. Purchase & Sale of fish
2. Production & Sale of fishery by products

The Corporation also provides the following cold storage facilities:

* 1. 1000 M.T. cold storage (-20LC)
2. Blast freezing 20 M.T per day (-40LC)
3. Chilled storage 100 M.T (+5LC)

Source: Ceylon Fisheries Corporation Website, www.fisheriescorporation.gov.lk.

Appendix 4: Criteria for Selection of Seasonal Reservoirs for Fish Culture

The following criteria were developed by the Aquatic Resources Development and Quality Improvement Project in the National Aquaculture Development Authority in the Ministry of Fisheries and Aquatic Resources of Sri Lanka. It is important to select the most suitable seasonal reservoirs. Eliminate reservoirs which do not meet minimum requirements. Criteria used for this purpose is given under A. Reservoirs which meet the minimum requirement will have to be assessed and rated for its suitability based on the criteria given under B.

A. Criteria for elimination of unsuitable seasonal reservoirs for fish culture

Reservoirs with following characteristics are considered unsuitable for aquaculture.

1. Technical characteristics
    1. Water retention period less than 5 months
    2. Presence of high turbid waters, due to suspended colloidal particles.
    3. Effective water area less than 4 ha.
    4. Reservoirs covered with aquatic weed to a greater extent and cannot be cleared and maintained
2. Social characteristics
    1. Unwillingness of the communities around the tank for fish culture.

B. Criteria used for rating of seasonal reservoirs that meets minimum requirements

1. Water retention (20 marks)

Seasonal reservoirs mainly built for irrigation purposes. Water retention period depend on the command area and other users. Low water retention period such as 5-6 months will score low rates and if it is 8 – 10 months higher scoring will be given.

2. Location of the reservoir (20 marks)

Location of seasonal reservoirs may affect the fish farming. Rating will be done considering the following factors.

(a) Location in close proximity to human habitation.
(b) The villagers are very co-operative and have leadership to undertake fish culture.
(c) There is confidence to prevent poaching due to the organizational ability.
(d) No conflicts with religious, cultural and community traditions.
(e) It is centrally located and forms a good demonstration tank for fish culture.

3. Presence of weed (15 marks)

The presence of aquatic weeds and its percentage coverage mainly affect the productivity of the tank and harvesting of fish. If the reservoir is free of aquatic weeds, higher rating will be given. In reservoirs where water weeds are present, rating will depend on the ability to manage and maintain it.

4. Presence of obstacles (10 marks)

Partial and complete harvesting may be carried out in the seasonal reservoirs at the end of the culture cycle. Absence of the tree stumps or any other harvesting obstacles is a desirable character. If the tank is free of obstacles in the water retaining area, higher rating will be given. Rating will depend on the level of obstructions caused by these obstacles.

5. Possibilities for complete drying during dry season (10 marks)

Complete drying of the reservoir during the dry season helps to minimize or eradicate predators and help to increase nutrient level of the tank. Complete drying out is considered a desirable characteristic and will receive a higher rating.

6. Productivity based on visual observations (10 marks)

Productivity mainly depends on the content of planktons and nutrients levels in the water body. Organic fertilizers, especially cow dug and deposition of plant materials, enhance nutrient content of the tank. Productivity assessment based on visual observations will be used to grade these reservoirs.

7. Availability of market (10 marks)

Availability of marketing channels or markets in close proximity to the tank is considered important and higher rating will be given for this.

8. Accessibility (05 marks)

Easy accessibility to the tank is important for transportation of fingerlings and fish yield. Rating will be given on the basis of level of accessibility.

Appendix 5: Brief History of Public Policy on Aquaculture Development in Sri Lanka

There is no tradition of culturing fish in Sri Lanka. Perhaps religion could have played a part in this predominantly Buddhist country because Buddhism prohibits the taking of life in any form. However, it does not forbid the eating of flesh. Many Hindus are vegetarians some eat seafood if defined as fruits of the sea. Many Christians are found especially in the coastal areas and are fishers. Though marine and inland water fishing seems to be unaffected by religious belief, harvesting of fish in villages and eating farmed fish seems to be affected by Buddhist belief. From time to time, the raising of animals for food has come under stricture by some Buddhists. Yet fish, mostly marine fish, is acceptable to most Sri Lankans including Buddhists and Buddhist priests. Some opined that the sudden and arbitrary decision taken in 1990 without consulting those engaged in the industry by the then executive President to withdraw the state patronage to inland fisheries and aquaculture was mostly to satisfy Buddhist sentiments. The real reason behind the decision was never made public. Rumors were afloat at that time that the local importers of canned fish had lobbied strongly behind the scene. The drop in import of canned fish in 1989 and 1990 that picked up again in 1991 was mentioned as supporting evidence. The period immediately following the ban (i.e. 1990-94) showed a sharp decline in inland fisheries and aquaculture from 38,000 metric tons to 12,000 metric tons in 1994. Termination of fish fingerling production, subsidies, extension and technical support by the government were the major causes of this decline. The reservoir fishery and seasonal tank aquaculture programs also suffered severe setbacks. A new government that came to power in 1994 reversed this policy and gave priority for the development of inland fisheries and aquaculture and incorporated the development of inland fisheries in the five-year National Fisheries Development Plan 1995-2000. A separate Aquaculture Development Division was established in 1994 for the purpose of undertaking development, management, production and extension in inland fisheries and aquaculture.

The six-year Fisheries Development Plan 1999-2004 also gave priority to this sector. The NAQDA was established with the enactment of the NAQDA Act No. 53 of 1998, which provides the legal powers to carry out and discharge a range of functions related to management, regulation, and enforcement in inland fisheries and aquaculture. Since then inland fisheries and aquaculture production picked up gradually and by end 2008 it stood at 44,490, a 50% increase from levels in 2001.

Appendix 6: Highlights from Eucheuma Farming in Sabah Malaysia

In Sabah in Eastern Malaysia, commercial farming started in 1989. Ten years later, 3,600MT dry weight seaweed (28,800MT wet weight, i.e. weight ratio 8:1) was produced, involving more than 1,000 farming families. By 2002, the production had grown to 4,000MT. As most successful aquaculture activities, the development in Sabah has been demand or market driven and has only received some extension and small incentive support to the newcomers.

The farm areas are situated in "open bays" or "reef lagoons" with sandy or coral rubble sea bottom. The depth is 8-10 m, the tide 3 m and the current 20 cm/s. An average farm was about 1 acre (4,049 sqm) having 30 long-lines. If fully cultured the harvest would be 3-5MT/acre/Yr (7.5-12.5 t/ha/yr) all dry weight with a required work input of 3-8 hours a day depending on the time of the week production cycle. Production volumes of 12-18 MT/ha/yr are also reported by others as fairly typical for well tended family farms.

A long-line can be a 200 m long 6 mm rope or a nylon monofilament line kept afloat by reusing plastic bottles tied to the line with 4-5 m interval. The line is moored at both ends but also has intermediate anchors attached along the long-line to avoid it from colliding with neighboring long-lines. The seaweed cuttings are tied to the rope with a frequency of every 30 cm or so.

The propagation of re-seeding of the culture is quite easy, as the stocking material consists of 100-200 g cuttings/propagules of young shoots taken from the just harvested material (5% of harvest).

After harvest the farmers spread out the seaweed for drying on designated deck areas on a platform in the stilt-village. The seaweed is dried for at least 4 days to achieve the optimum price of USD 0.1 per kg (30-35% moisture content). Lower prices (USD 0.52 per kg) were obtained for the moist quality, i.e. if the surface of the seaweed did not show white salt crystals.

The production cost was reported at USD 0.16 per kg for the driest seaweed. It is not known if this figure includes depreciation/amortization. Anyhow, it means that in 1999 a one acre farm would have a turnover of USD 1,830-3,050 per year or a 'profit' of USD 1,350-2,250. In addition to this, most of the farmers were part-time fishermen.

The overall farming leases in Sabah were each given to a stilt village in the lagoon area, i.e. one 'extended' family structure of more than 50 huts. The success of seaweed farming could be seen from the stilt village. The huts in the center owned by pioneer farmers were improved wooden huts with corrugated iron roof while the outskirt huts, owned by newcomers given a sublease by the 'extended' family were made from palm leaves. In general the living standard was above 'subsistence level' as seen from the presence of power generators, TV aerials and 40-50 hp outboard engines on the fishing canoes.

In 1995, when there was only one exporter, the farmers were paid USD 0.29 per kg. In 1999 when the volume produced attracted 3 exporters, the ex-farm price increased to USD 0.61 and the production tripled to 3,600 tons. The exporters would sell at USD 1.1 per kg but would dry the product further, press it and pack it.

Two processing plants for Semi refined carrageenan (SRC) started in Sabah in the beginning of the year 2000. One of the planned refineries was quoted to have a capital requirement of about USD 1.5million of which USD 0.5 million was investment in equipment/machines. The necessary SRC production was 400MT requiring an input of 1,600MT dry seaweed.

Appendix 7: SWOT Analysis on Commercial Potential for Eucheuma Seaweed

Strengths

- Low initial investment, low input and easily adopted technology.
- No need for special infrastructure.
- No hatchery dependence as seedlings are self-generated.
- Eucheuma is available in Sri Lanka in small quantities but one cutting can become 10,000 t of propagules in 18 months if intensively produced i.e. equivalent to 100 million propagules.
- No feeding.
- No immediate limitations to nutrients and sun.
- The coastal current (Bay of Bengal current) is optimal.
- No negative environmental impact apart from the physical occupation of culture area.
- No major diseases.
- Even appealing to Buddhists i.e. not involve killing of farmed animals.

Weaknesses

- Area availability may be a limiting factor for large scale development, unless the more open areas off the east coast or in Koddiyar Bay, Trincomalee.
- No tradition in Sri Lanka to enter mariculture.

Opportunities

- International commodity in increasing demand.
- Strong growing demand for dried seaweed with some exporters established.
- When production has reached a certain volume local value added/production of SRC will become feasible reducing transport costs of bulky dried seaweed.

Threats

- During start-up phase grazing may be a constraint.

Appendix 8: Value Chain Map for Beche de Mer (sea cucumber) in Kalpitiya

Link	Gross Output Values LKR/kg (dried equivalent)	Gross output values % of final
Divers	2,510	34
Collectors	2,671	36
Processors	5,806	79
Exporters	7,391	100

Source: NARA Capacity enhancement Project-GCP/SLR/054/CAN.

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