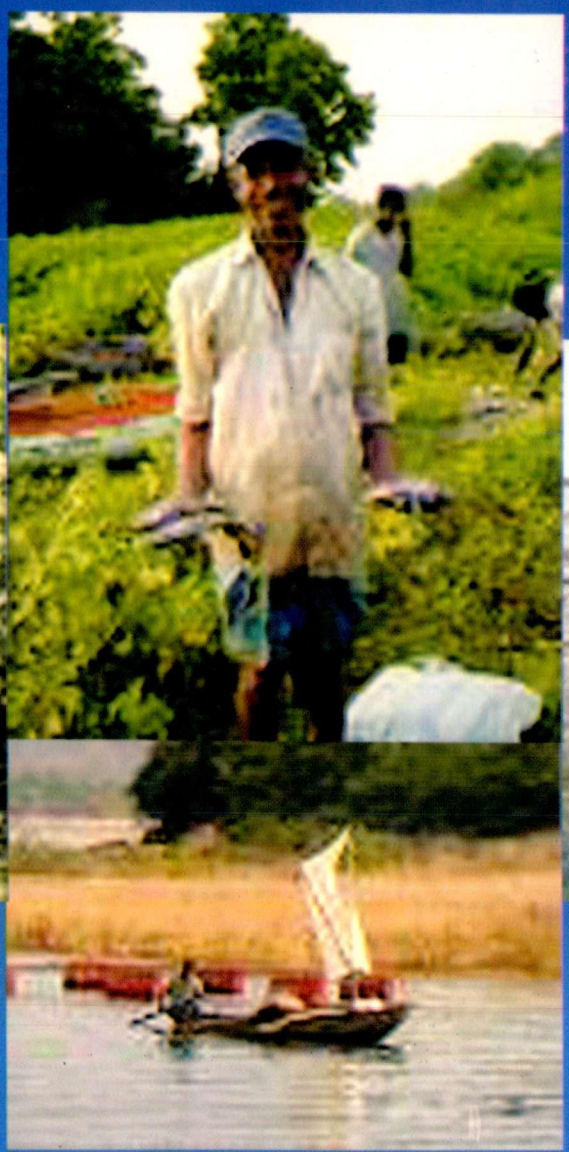
Aquaculture for Rural Development and Poverty Reduction in Sri Lanka: An Assessment of Potentials and Constraints

K.H.D.T Kasagala



Hector Kobbekaduwa Agrarian Research and Training Institute
114 Wijerama Mawatha
Colombo 07
Sri Lanka

Aquaculture for Rural Development And Poverty Reduction in Sri Lanka: An Assessment of Potentials and Constraints

K.H.D.T. Kasagala

Research Study No: 129

December 2008

Hector Kobbekaduwa Agrarian Research and Training Institute (HARTI)
114 Wijerama Mawatha
Colombo 7
Sri Lanka

First Published: 2008

Cover Page Design: Udeni Karunarathna - HARTI

ISBN: 978-955-612-099-8

Contents

Chapter Four: Distribution and Characteristics of Farming Systems

Chapter Five: Culture Technology

Chapter Six: Contribution to Economy

Chapter Seven: Research Needs, Constrains and Trends

Chapter Eight: Conclusions and Recommendations

List of Figures and Tables

List of Figures

List of Tables

Foreword

About a quarter of the population in Sri Lanka was found to be falling below the official poverty line by 2002 while over eighty percent of the poor lived in rural areas. It has been noted that about a two-fifth of those engaged in agriculture fell below the poverty line by the turn of the century. Similarly, a significant portion of the people is reported to be undernourished with children and women being mostly affected. The observed situation is in spite of many economic, social and infrastructure development as well as social safety net programmes that had been implemented by the government over the last six decades to benefit the rural and agrarian sectors.

A basic factor that seems to have an effect on the observed level of poverty and malnutrition with rural and agrarian population has been the lack of diversification of the rural economy. In this regard, the government as well as the national and international non-governmental organisations has made significant efforts to assist the diversification of rural economies and help the poor to graduate out of poverty. Many such efforts are centred on introduction of non-agricultural activities like processing and cottage industries on a self-employment basis. On the other hand, the potential of livestock and aquaculture for rural development, poverty alleviation and nutrition improvement has been little explored. This is in spite of the fact that the aquaculture and livestock sectors are integral parts of the rural cum agrarian economy of Sri Lanka. This report assesses how aquaculture could play a role in addressing problems like rural unemployment, rural and agrarian poverty and under nutrition.

The potential for aquaculture sector development in Sri Lanka is significant. The climatic variations within the country provide appropriate natural environment needed for rearing most of the tropical fish varieties. The high density of inland freshwater bodies including perennial reservoirs, seasonal village tanks and flood planes provide sufficient basis for developing the reservoir fisheries sector as a major industry. The Government of Sri Lanka (GOSL) also acknowledges the importance of the aquaculture sector for economic development of the country and is involved in formulation of policies, technology development, conservation and management of aquatic resources to help the development of the sector. There are suitable sites in coastal areas to culture pearl oyster, sea cucumber, milkfish, sea bass and grouper. Shrimp culture could be developed strategically to its full potential using existing resources. Being the fastest food-producing sector in the world, aquaculture also provides high potential for enhancing export incomes. Sri Lanka has shown significant development in the aquaculture sector during the last five decades.

Sri Lanka's small-scale aquaculture sector consists of mollusk culture, commercial growing of Indo-Pacific swamp crab, shrimp culture, aquatic plant culture, ornamental fish culture and reservoir fisheries. The aquatic plant culture is being practised as a cottage industry of low-income households. These activities that are yet in their embryonic stage could be developed to enhance diversification of economic opportunities in the rural sector, increase rural employment and income opportunities, improve nutrition of the population and reduce rural and agrarian poverty. The report deals with the existing state of the aquaculture sector along with the potentials, constraints and strategic areas needing policy concentration.

Aquaculture sector presents many possibilities for rural and agrarian development as well as nutrition improvement of the population. A significant number of perennial tanks in Sri Lanka are being used for inland fish production though a huge number of existing seasonal tanks are under utilised in terms of fishery production. There are about 10,000 hectares of brackish water resource readily available for finfish culture. Such aquaculture sub-sectors like ornamental fish industry have marked an annual growth rate of 16.9 percent though Sri Lanka contributes from 2 to 3 percent of the total world demand for ornamental fish. Some aquaculture products such as shrimps have a ready market both here and abroad. Aquaculture products can improve nutrition inadequacies of the Sri Lankan diet. Lysine and methionine are limited amino acids found in customary rice-based Sri Lankan diet and aquaculture products can help closing such gaps. For instance, fish is a rich source of omega-3 polyunsaturated fatty acids (PUFAs), fat-soluble vitamins (A, D and E), water-soluble vitamins (B complex) and minerals (calcium, phosphorus, iron, iodine and selenium). Increased supply of aquaculture products can help reducing nutrition-associated problem of Sri Lankans' diets, if the price is also correct.

Aquaculture can increase rural employment and incomes if promoted as a means of rural economic diversification. Unlike cottage industries that are being supported through various intervention programmes suffer from the lack of effective demand or marketing niches, the aquaculture products have ready markets. For example, it is reported that about 90 percent of the urban and rural households prefer fresh fish in their daily diet, though this is particularly so for marine fish. On the other hand, the fish production in the country has declined and the prices have escalated keeping the poor out of reach of this important food item. Increased production of freshwater fish could be a solution to this problem. But, the shortage of freshwater fish — even in interior agricultural areas still exists in spite of many possibilities of increasing production. For example, a great majority of seasonal tanks could be used for fish production during the monsoon season. In addition to reviving the traditional system of fish farming in irrigation reservoirs, fish culture could be promoted as a source of additional income for farmers in paddy fields. Such paddy-fish integrated farming systems are widespread in paddy growing countries in the region. There are additional benefits of rice–fish culture. For instance, the present study quotes evidence to support that pesticides can be reduced by 70-100 percent without influencing the rice productivity when the paddy fields are introduced with fish. Farmers also could gain 3-5 percent extra rice outputs in such integrated systems.

As the author notes, aquaculture has many backward and forward linkages with the industrial sector. For instance, aquaculture by-products like oyster shells can be used as calcium carbide, calcium hydroxide, white cement and agricultural calcium. The unpopular fish species could be used as inputs for making fishmeal. The shrimp waste from processing plants has been successfully used to improve the quality of grass (*Brachiaria briantha*) silage for cattle. Fingerling production for perennial reservoirs and seasonal village tanks is a potential income generating activity for people in the north-central province. Shrimp farming has helped to expand the lime industry, fibreglass manufacturing, feed outlets, machinery supplies, repair facilities and laboratories. Thus aquaculture can be used to enhance industrial development and rural employment significantly.

A comprehensive strategy — towards the development of the aquaculture sector along with rural development and rural poverty in focus — should be designed and implemented. Such a strategy should pay attention to aspects like optimal allocation and use of existing resources with minimal harmful environmental impacts, resolution or minimisation of

conflicts associated with existing resources that are often used as common properties and conservation of natural resources. Community organisation is necessary for reducing resource-use related conflicts and transfer of appropriate technology.

I am much thankful to Dr K H D T Kasagala of the Veterinary Research Institute of Sri Lanka for compiling this report. I am also much thankful to Dr Dhanawardana Gamage, Research Fellow of HARTI who initiated work at HARTI to examine the existing state in the rural sector and explore how livestock and aquaculture etc can be developed to help reduce rural and agrarian poverty. HARTI is indeed indebted to Swedish Agency for Research Cooperation (SAREC) for funding this report. Mr Gamini Senevirathne, then Director/HARTI had obtained SAREC funds for a study in the rice sector in Sri Lanka, which remained unspent until 2007. When Dr Gamage initiated a programme to assess the "State of the Smallholder Farming Sector in Sri Lanka" provision for it, was made available from the saved SAREC funds. I am thankful to SAREC and Mr Senevirathne for securing the funds with which we could address major issues emerging in the smallholder farming sector such as agrarian poverty.

I am also thankful to Miss M K Nadeeka Damayanthi, Research Officer, who has assisted in many ways in getting this report out. She is also thanked for proof reading the report quickly.I am also thankful to Mr Nandana S Talagune, Editor for excellent editorial assistance, to Mr S Rameshwaran- Acting Head, Publication Unit of HARTI for final proof reading of the report and making necessary arrangements for publishing the report speedily and Mr L A Palitha Gunarathna for designing a good lay-out at short notice.

V K Nanayakkara
Director
30/12/2008

Acknowledgements

I express my gratitude to Mr V K Nanayakkara, Director and Dr Dhanawardana Gamage, Senior Research Fellow, Hector Kobbekaduwa Agrarian Research and Training Institute for giving me the opportunity to write this paper.

I would like to thank Dr A D N Chandrasiri, Additional Director General, Department of Animal Production and Heath, Dr J Dharmawardene, Director of Veterinary Research, Dr M Somarathne, Head, Veterinary Investigation Centre of Veterinary Research Institute, for their valuable guidance.

I also sincerely thank Dr Udeni Edirisinghe, Senior Lecturer in Aquaculture, Department of Animal Science, Faculty of Agriculture, University of Peradeniya, and Dr L P Rupasena, Deputy Director/Research, Hector Kobbekaduwa Agrarian Research Institute for reviewing this chapter. My sincere thanks go to Dr A J Weeramunda, former professor at the Department of Sociology, University of Colombo for his valuable suggestions and professionalism towards improving the presentation of this study.

I am also thankful to Mr S Ramaeshwaran, Acting Head- Publication Unit of HARTI for making necessary arrangements for publishing the report speedily. I also thank Mr Nandana Talagune, Editor/HARTI for excellent copy-editing and Ms Dilanthi Hewavitharana for incorporating the edited correction.

Words would not suffice to thank my father Mr K H Premadasa, former Chairman, Ruhuna Development Bank, my mother, and my wife, Neeroda, for their encouragement and support.

Finally I would like to thank those not mentioned here who encouraged me in this study in many ways.

K H D T Kasagala
Veterinary Research Institute
Gannoruwa, Peradeniya, Sri Lanka.
November 2008

Abbreviations

AQDC	- Aquaculture Development Centre
ARDQIP	- The Aquatic Resources Development and Quality Improvement Project
BOI	- Board of Investment
BPU	- Biodiversity Protection Unit
CBD	- Convention on Biological Diversity
CEA	- Central Environmental Authority
CITES	- Convention on International Trade in Endangered Species of Wild Fauna and Flora
DAPH	- Department of Animal Production and Health
DFAR	- Department of Fisheries and Aquatic Resources
EIA	- Environmental Impact Assessment
EUS	- Epizootic Ulcerative Syndrome
EUS	- Epizootic Ulcerative Syndrome
FAO	- Food and Agriculture Organisation of the United Nations
FCR	- Feed Conversion Ratio
FO	- Farmer Organisation
GC-MS	- Gel Chromatography – Mass Spectrometry
GDP	- Gross Domestic Products
GOSL	- Government of Sri Lanka
Ha	- Hectare
IARAD	- Inland Aquatic Resources and Aquaculture Division
IEE	- Initial Environmental Examination
Kg	- Kilogram
KHV	- Koi Herpes Virus
LC- MS	- Liquid Chromatography – Mass Spectrometry
MBV	- Monodon Baculow Virus
MFOR	- Ministry of Fisheries and Ocean Resources
MRI	- Medical Research Institute of Sri Lanka
Mt	- Metric Tons
NACA	- Network of Aquaculture Centres in Asia and Pacific
NAQDA	- National Aquaculture Development Authority
NARA	- National Aquatic Resources Research and Development Agency
NGO	- Non-Governmental Organisation
NPQS	- National Plant Quarantine Service
OIE	- Organisation for Animal Health
PCR	- Polymerase Chain Reaction
PGRC	- Plant Genetic Resource Centre
PL	- Post Larvae
PPC	- Plant Protection Centre
PPM	- Parts Per Million
PUFAs	- Polyunsaturated Fatty Acids
Rs	- Rupees
SAARC	- South Asian Association for Regional Co-operation
SEMBV	- Systematic Ectodermal and Mesodermal Boculovirus
US $	- United States Dollar
USA	- United States of America
VIC	- Veterinary Investigation Centre
VRI	- Veterinary Research Institute
WTO	- World Trade Organisation
YHV	- Yellow Head Virus

Abstract

Aquaculture is the fastest food-producing sector in the world. Sri Lanka has also shown a significant development over the past five decades — in the enhancement of food security, of the economy, trade and of rural livelihoods. At present small-scale aquaculture sector consists of mollusk culture, commercial growing of Indo-Pacific swamp crab, shrimp culture, aquatic plant culture, ornamental fish culture and reservoir fisheries. In addition, there are suitable sites in coastal areas to culture pearl oyster, sea cucumber, milkfish, sea bass and grouper. A large number of people in rural areas are economically and socially marginalised. As such, the government is burdened with providing social safety nets to a significantly large section of the population. Existing human resources and suitable culture sites for aquaculture are — the main potentials — to develop the rural economy as a better-organised economic sector. Shrimp culture could be developed strategically to its full potential using existing resources. The aquatic plant culture is considered a cottage industry of low-income people. The ornamental fish industry has an annual growth rate of 16.9 percent. Still, Sri Lanka contributes only 2-3 percent of the total world demand for ornamental fish. The climatic variations within the country provide appropriate physical environments for rearing most of the tropical fish varieties. The high density of inland freshwater bodies -- including perennial reservoirs, seasonal village tanks and flood plans — have promising scope to develop the reservoir fisheries sector as the major industry. In spite of social and economic benefits, there are several adverse effects caused by some of the aquaculture practices such as shrimp farming. The Government of Sri Lanka (GOSL) is involved in technology development, formulation of policies, conservation and management of aquatic resources for the benefit of aquaculture development. Since the aquaculture sector in Sri Lanka has a slow growth rate, policies and programmes are needed to enhance the contribution of aquaculture sector for rural development and poverty alleviation.

Chapter One

Introduction

1.1 Problem Statement

Aquaculture is defined as the husbandry of aquatic plants and organisms ; ranging from the propagation of aquatic organisms under human control to the manipulation of at least one stage of an aquatic organism's life— for the purpose of increasing production (Fisheries and Aquatic Resource Act, 1996). Aquaculture started 4,000 years ago in China (Billard, 1999: 101). World aquaculture production was 54.4 mt in 2004 with a total value of US$ 70.3 billion. This represents an annual average increase of 6.9 percent in quantity and 7.7 percent in value when compared to 2002. Since 1970, aquaculture growth rate has been 8.9 percent per year and it has thus become the fastest growing animal food-producing sector in the world (FAO, 2006: 16 -22).

Aquaculture had not been a traditional industry in Sri Lanka. It did not start aquaculture enterprises till the 1980s. Development of aquaculture in Sri Lanka can be justified as a means of promoting poverty alleviation, economic growth and food security. About a quarter of the population is below the national poverty line and over 80 percent of the poor live in rural areas. Still, aquaculture resources have not been used to the maximum. Aquaculture sector is an important area for attracting foreign and local investments.

Smallholder aquaculture could be defined as a system with a relatively small annual production, which is made of one or more small production units. Such units could be family or community-run, involving limited external labour at moderate input level (FAO, 2008). Such smallholder enterprises could have a mix of both commercial as well as subsistence purpose. The farm provides the principal source of income. Non-commercial aquaculture could be on an extensive or semi-intensive scale. Sometimes technological and socio-economic features are part of the indigenous knowledge of the social group. The smallholder aquaculture sector could undertake mollusk culture, crab fattening, shrimp culture, aquatic plant culture, and ornamental fish culture and reservoir fisheries (seasonal and perennial).

Raft culture of brown muscle in the Rumassala bay in Galle, was carried out during the period 1995-96 with financial support from the Southern Province Rural Development Project. Crab fattening is being practised in the Negombo lagoon as an economic activity since 1999 (Pathmi *et al*, 2003: 10). A brackish-water fisheries station was established at Pitipana by the Ceylon Fisheries Cooperation in 1960 for rearing *Chanos chanos* fry as fingerlings for bait during tuna fishing (Samaranayake, 1986: 88-90).

A small-scale shrimp farm began operations in the Batticoloa lagoon in 1977. But, it was abandoned after a short time due to civil disturbances in the eastern province (Wijegoonawardena and Siriwardena, 1996: 127-139). In the mid 1980s, shrimp culture had developed in the western and north-western provinces using lands adjacent to lagoons.

The ornamental fish export trade was carried out in the early 20th century using ocean steamers (Edirisinghe, 1999: 63-70). In the early 1930s, there were small-scale ornamental fish importers, breeders and hobbyists in the country. The aquarium industry was initiated in the capital city of Colombo and the first public aquarium was established at the Dehiwala Zoo in 1952 (Wijesekara, and Yakupitiyage 2001: 241-252). At present, cargo aircraft transport, improved technology on fish culture, information technology and communication facilities are important factors for taking the industry to international level.

Inland fish fauna of Sri Lanka includes 80 indigenous fish species with *Labeo dussumeiri* and *Puntius sarana*. They are primarily food fish (NARA, 2001: VIII). In 1951, exotic cichlids (*Oreochromis mossambicus*) were introduced to the country to promote reservoir fisheries. Over the years, 22 species have been introduced, of which 19 were exotic and three were transplanted within the country (Sugunan, 1997: 1-10, Table 01). The Inland Fisheries Division of the Ministry of Fisheries initiated freshwater fish culture in seasonal village tanks in 1979 with 23 tanks in the country's dry zone (FAO, 2003).

Table 01: Introduction and Transplantation of Inland Fish in Sri Lanka

Species	Origin	Ecosystem	Year
Exotics			
Salmo trutta	Europe	Hill stream	1882
Oncorhynchus mykiss	North America	Hill stream	1889
Cyprinus carpio	China	Reservoir	1915
Carassius carassius	China	Reservoir	1915
Osphronemus gourami	Indonesia	Reservoir	1939
Ctenopharyngodon idella	China	Reservoir	1948
Hypophthalmichthys molitrix	China	Reservoir	1948
Aristichthys nobilis	China	Reservoir	1948
Catla catla	India	Reservoir	1942
Cirrhinus mrigala	India	Reservoir	1981
Labeo rohita	India	Reservoir	1981
Trichogaster pectoralis	Malaysia	Lagoon	1951
Oreochromis mossambicus	East Africa	Reservoir	1951
Oreochromi niloticus		Reservoir	1956
Tilapia rendalli	East Africa	Reservoir	1969
Oreochromi hornorum	East Africa		1969
Tilapia zilli	East Africa		1969
Local transplantations			
Etroplus suratensis	Lagoon	Reservoir	1910
Chanos chanos	Lagoon		
Mugil cephalus	Lagoon	Reservoir	

Source: Revised by author

In addition to above culture system, there are suitable sites available for culturing pearl oyster, sea cucumber, sea horse, milkfish, sea bass and grouper. Some of them are in an experimental stage.

1.2 Aquaculture and Rural Development

GOSL has identified the potential role that aquaculture could play in rural development. The sustainable development of aquaculture along with the development of agriculture and livestock could provide the basis for a holistic and integrated approach and should be planned for the new millennium (Edirisinghe, 2003: 122-126).

1.2.1 Poverty in Sri Lanka

Sri Lanka is recognised as a country with a high record of poverty in spite of social achievements that parallel economically advanced countries (NACA, 2005: 1-14). The population of Sri Lanka is close to 20 million and the unemployment rate is 7.2 percent (Department of Census and Statistics, 2007). Poverty in Sri Lanka is primarily a rural phenomenon. A considerable proportion of the population falls below the consumption poverty line.

The incidence of poverty is the highest among casual labourers, small and marginal farmers, estate workers and rural women. About 33 percent of the population in the estate sector, 25 percent in the rural sector and eight percent of the urban population (making up 22 percent of the total population) were found poor according to Household Income and Expenditure Survey in 2002. While the poverty rates in the western and north-central provinces are below the national average, it is above the national average in seven other provinces (NACA, 2005: 1-14). There are wider variations in districts as regards the poverty level. For example, while the consumption poverty level in the Colombo district is 10 per cent, it goes up to 49 percent in the Moneragala district (Ministry of Environment and Natural Resources, 2003: 10). It could be inferred that a considerable percentage of Sri Lankans live below the poverty line. It has thus significantly increased the government expenditure on providing a social safety net.

1.2.2 Aquaculture for Rural Development

Rural development is the management of human development and the orientation of technological and institutional change in such a manner as to improve longevity, knowledge and living standards in rural areas, with equity and sustainability as long-term objectives (NACA/ FAO, 2001: 73-75). It is a fundamental human right to have adequate food and nutrition, freedom from hunger and malnutrition. Nearly 30 percent of people in the developing world are currently suffering from one or more of the multiple forms of malnutrition. Thus, the aquaculture sector has an important role in the alleviation of poverty and the achievement of food security in many parts of the world.

Aquaculture creates direct production related activities and indirect participation in the form of supporting industries. The capacity of poor people to engage in aquaculture depends upon their asset base - including human assets (labour, education and skills), natural assets (land, water, and wild fish), social assets (kinship, connections, and status), physical assets (road, tools, and equipment) and financial assets (income, credit, and insurance). The capacity of people to convert these assets into productive activity depends on the social structure of the area, institutional framework and government policies, market channels etc (Luu, 2001: 12-18). The development strategy has to be focused on local resources, priorities and livelihood objectives of rural poor. It needs capacity building for rural people (technology, materials, financial services, extension services and markets) and allows their participation in planning, implementation, monitoring and evaluation. The network of stakeholders (beneficiaries, decision-makers and donors) is needed to amalgamate skill, knowledge and education for a common purpose. It needs to develop environmental-friendly technologies to limit the degradation of natural resources through proper planning of aquaculture (Luu, 2001: 12-18). Small-scale aquaculture projects could be performed as family-scale operations in rural areas. It encourages women participation while providing viable employment alternatives to migrant labour especially as domestics in the Middle-East. They could engage in activities such as routine feeding and management of fish ponds with participation of children while being involved in domestic chores. By contrast, men could take the main decisions with regard to construction of ponds, the production system, harvesting and marketing (Funge, 1999: 17-22). The distance of the aquaculture operation from the house can be a constraint on women engaging in aquaculture activities. Cultural taboos may arise with regard to participation of women in some aquaculture activities.

1.2.3 Food Security

Food security is the availability of food, primarily carbohydrates, for human consumption in sufficient quantities. Fish is considered an essential food item with high nutritional value (NARA, 2006). Satisfaction of food security can be regarded as the starting point of rural development. FAO standard for per capita fish consumption is 26 kg (FAO, 2006). Medical Research Institute of Sri Lanka (MRI) has recommended a per capita consumption of fish of 21 kg (NARA, 2006).

The world per capita fish consumption is 16.6 kg in 2005 (FAO, 2006). Per capita consumption of fish in Sri Lanka was estimated at 15.7 kg in 2006. But, the per capita net availability for consumption was reduced up to 12.03 kg after adjustment was made leaving a margin for wastages. Per capita consumption was 11.38 kg in 2005 due to decline in local production. About 18.9 percent of per capita availability of fish is provided by imports (NARA, 2006).

The total fresh fish consumption per household has increased by 23 percent from 2002/2003 to 2005. But, the freshwater fish consumption only increased by 4.7 percent and shellfish and cuttlefish consumption decreased by 11.5 percent in 2005 in comparison to 2002/2003 period (NARA, 2006). It is reported that 89 percent of rural households and 90.7 percent of urban households prefer fresh fish in their daily diet. This indicates that there is no significant variation of fresh fish preference levels between rural and urban households (NARA, 2006). The per capita expenditure on fish and seafood was estimated as 12.9 percent of total household expenditure on food. This is the highest per capita expenditure for animal food sources (NARA, 2006). The median range of the number of meals consumed with fresh fish by rural and urban sub-sector households was almost none and 1-3 meals respectively. Nearly 55 percent of rural and 41 percent of urban households never consumed fresh fish. It is also reported that 42 percent and 43.5 percent of rural and urban sub-sector households have consumed in the range of 1-2000 g of fresh fish per week. Socio-economic and demographic factors, product related consumption barriers and customary food consumption patterns are considered the main factors for this consumption behaviour (NARA, 2006).

Today, over 40 percent of our children suffer from acute malnutrition and at least, over 70 percent of adults are poorly fed. Lysine and methionine are limited amino acids found in traditional rice-based Sri Lankan diet (Edirisinghe, 2003: 122-127). Therefore, fish could be an important source of protein. In fact, more than 53.9 percent of the animal protein consumed comes from fish in the daily diet (NARA, 2006). Fish is a rich source of omega-3 polyunsaturated fatty acids (PUFAs), fat-soluble vitamins (A, D and E), water-soluble vitamins (B complex) and minerals (calcium, phosphorus, iron, iodine and selenium).

1.3 Aquatic Resources

During a relatively short period, the aquaculture sector in Sri Lanka has come of age as an organised economic sector characterised by more state patronage and stronger private sector participation. Aquatic resources of Sri Lanka cover 7.5 times the country's total land area (marine and inland waters). Unfortunately, their contribution to national GDP (Gross Domestic Product) has always been less than 3 percent. The freshwater resources of the country are ever increasing due to construction of large and small reservoirs (Edirisinghe, 2003: 122-127). Different culture methods and diversity of aquatic species could be applied in a rational manner to both exploitation and conservation of aquatic resources.

1.3.1 Artemia Culture

Artemia culture is an important industry for producing fish and shrimp larvae. Sri Lanka imports artemia mainly from USA and spends a significant amount of money. Puttalam Salt Ltd does artemia culture on a small scale. Salt farms in Sri Lanka are thalassohaline in nature (the sea being a natural source of saline water). They are located in semi-arid areas and have a suitable climate for artemia culture. Natural populations of artemia could be found in the Hambantota, Bundala and Palavi areas (Kuruppu, 1987: 1-19). Sri Lankan artemia is completely parthenogenetic. The size of freshly hatched artemia naupli is important in larval feeding of ornamental fish and shrimp. The appropriate sizes could be selected for commercial purposes from natural populations (Kuruppu and Ekaratne, 1995: 153-160). Harvesting, processing of cysts, cleaning and washing, drying, storage and packing of cysts could be applied using simple technology (Kuruppu, 1987: 1-19).

1.3.2 Indo-Pacific Sea Horse Culture

The wild collection of Indo-Pacific sea horse (*Hippocampus kuda*) for export is prohibited. Aqua Marine Ltd with Coastal Aquaculture Development Centre of National Aquaculture Development Authority has developed the technology for sea horse breeding and growing. The sea horse has an esthetical value in USA and European Union. Sea horse is also used for indigenous medicine in China and Hong Kong.

1.3.3 Mollusk Culture

Bays, estuaries and lagoons in the coastal area are excellent for mollusk culture and crab fattening, which needs low capital and low technological inputs. It could be promoted as additional income for coastal fishing populations. Sri Lanka has the potential to culture brown mussel (*Perna perna*) found in the Rumassala bay. The Trincomalee bay and the Puttalam estuary are suitable for green mussel (*Perna viridis*) culture. The spat fall season for brown mussel in Rumassala, Mirissa and Rekawa are between May and July.

The spat fall season for green mussel at the Trincomalee bay is between January and April. The brown mussel spats could be found in the coastal areas of Sri Lanka — from Chilaw to Tangalle. Brown mussels are not found in the eastern coast of the country (Wanninayake, 1998: 1-10).

1.3.4 Crab Fattening

Lagoons in Negombo, Puttalam, Kalpitiya, Mannar and Batticaloa are excellent for crab fattening. The marketing of crab poses no barriers. Crabs have a good demand in local and international markets for their excellent meat and taste. They are packed live in bamboo baskets and air-freighted to Singapore, Malaysia etc. Crabmeat processing is basically a hand picked operation needing much labour for weighing, cooking, picking and packaging (Chin and Amandakoon, 1991: 165-169).

1.3.5 Milkfish, Sea Cucumber and Grouper Culture

The abandoned shrimp ponds in the north-western and western provinces could be utilised for culturing of milkfish, sea cucumber and grouper (*Mugil spp*). Traditional fishermen currently inhabit the coastal areas. They have the inherent ability to be involved in fish-based activities and could be motivated to participate in the catching and culture of fish species that will be a source of enormous economic benefit (Edirisinghe, 1999: 63-70).

1.3.6 Aquatic Plant Culture

Aquatic plant culture has a potential to be promoted as a cottage industry for most of the low-income people (Corea *et al*, 1993: 15). Seaweed production could be increased from well-managed natural stocks. But, seaweed exports in future will have to depend on the development of culture techniques as an industry. Experimental trials of *Gracilaria edulis* have been performed in Rekawa and Kalpitiya in the open lagoon waters and in enclosed environments. The open water culture method is suitable for small-scale, household-based aquaculture practice (Pahalawattaarachchi and Siriwardena, 2003b: 9). Sri Lankans do not have the habit of eating seaweeds although it is an ancient dietary tradition in Hawaii, Fiji, Philippine, Indonesia and Malayisia. *Gracilaria* is rich in micronutrients (vitamins and minerals) and is fit for human consumption. *Gracilaria* could be used for small-scale agar production as a household enterprise. Home production of agar for puddings, soups and jellies could be seen in some areas of Sri Lanka too. Agar porridge flavoured with coconut milk and lemon juice is popular among fishermen in the seaweed producing areas.

In Thailand, there are simple methods for agar extraction using locally available materials and domestic kitchen equipment (BOBP, 1989: 1-6)

1.3.7 Ornamental Fish Culture

Ornamental fish industry generates employment opportunities and foreign exchange with less capital investment using family labour and locally available resources. There are no cultural taboos for ornamental fish culture in the country (Edirisinghe, 1999: 63-70). Availability of suitable lands and low cost labour in rural areas are opportunities for bringing ornamental fish farming to the village. The promoting of a buy back system with the support of exporters is useful to establish a market channel for small-scale ornamental fish farmers in rural areas. The freshwater ecosystem of Sri Lanka supports a rich biodiversity of endemic fish species. These fish species have a very good export market.

Existing laws prohibit the export of endemic fish species in order to prevent their extinction (Export and Import of Live Fish Regulations, 1998). Studies have shown that some of the fish species, namely Ornate Paradise fish (*Malpulutta kretseri*), Combtail (*Belontina signata*), Barred Danio (*Danio pathirana*), Vateria flower Rasbora (*Rasbora vaterifloris*), Cuming's Barb (*Puntius cumingii*), Blotched filament Barb (*Puntius srilankensis*), Black Ruby Barb (*Puntius nigrofasciatus*) (Kithsiri, 2003: 85-93), Cherry Barb (*Puntius titteya*) (Sundaradarathy *et al*, 2004: 137-149) and Stonesucker (*Garra ceylonensis*) could be bred artificially (Thenmoli *et al*, 2005: 196-201). Captive breeding of endemic fish species is a new trend in the ornamental fish export trade.

1.3.8 Reservoir Fisheries

A significant number of seasonal tanks (667 ha) in Sri Lanka are under fish culture at the moment (FAO, 2003). But, there are 100,000 ha of seasonal tanks (NACA, 2005: 2) and 10,000 ha brackish water resource readily available for finfish culture (Samaranayake, 1986: 88-90). Fingerling production for perennial reservoirs and seasonal village tanks is a potential income generating activity for people in the north-central province. Sri Lanka has the highest density of inland water bodies per unit area (2.3 ha/km2) (NACA, 2005: 2). The country has a widespread network of roads and is armed with trained people and good infrastructure for food-fish culture. The cooperation of private sector and public interest has to be promoted (De Silva *et al*, 2001: 44). There is also a need to initiate programmes to popularise inland fish, transportation of harvest to urban areas using refrigerated storage facilities, dry fish preparation and introduction of high valued species (Chandrasoma, 1988: 63-66). Some scientists have suggested that the country should focus on tilapia in place of carp species for better fish harvests (Fernando, 2000: 1-26). However, the present results indicate that carp-based freshwater fishery has a bright future.

1.3.9 Freshwater Prawn Culture

Pambala Station of NAQDA is currently involved in freshwater prawn (*Macrobrachium rosenbergii*) breeding. It has produced 89,000 *Macrobrachium* post-larvae during 2001 (NARA, 2001: 12). NAQDA launches a free stocking programme in selected medium irrigation tanks such as Kandalama, Soraborawewa, Giritale, Pimburatthawa, Mahawilachchiya, Hakwatuna oya, Muthukandiya and Siyambalankotuwa. For example, in 2007, 25,000 freshwater prawns in their post-larval stage were stocked in the Siyambalankotuwa tank that is situated in the Puttalam district (NAQDA, 2007).

Freshwater prawn could be stocked in village tanks and grow-out ponds as monoculture or in poly culture with carp species (Wijenayake *et al*, 2005: 249-258). Feeding is done with poultry feed by broadcasting three times a day. Cow dung and lime are used to fertilise the pond before stocking. Freshwater prawn is resistant to main diseases that affect black-tiger shrimp.

Freshwater prawn culture is a backyard industry in Thailand. The prawns are fed with kitchen waste. These traditions could be applied in Sri Lanka too.

1.3.10 Rice-Fish Culture

Traditional paddy cultivation is a means of living in many parts of the rural areas of Sri Lanka. Fish culture could be promoted as an additional income source in a rice-fish integrated farming system. Studies have shown that pesticides can be reduced by 70-100 percent without influencing the rice productivity. In addition, farmers gain 3-5 percent extra rice production and a considerable amount of fish as an additional income when a pond-refuge method is used (Cruz, 1990: 6-7). Such a system provides a net profit of 1.5 times higher than the rice cultivation only (Luu, 2001: 12-18). Rice-fish integration could be used for larval culture and ornamental fish culture in Sri Lanka.

1.3.11 Livestock-Fish Integrated Farming

Livestock-fish integrated farming is one method for small-scale rural farmers to increase farm returns from the per -unit- area of land while fulfilling their own protein requirement. In addition, this system insures farmers against risk by diversifying production activities. Moreover, integrated farming facilitates productive use of agricultural by-products that are considered wastes. The farmers could combine their already existing animal enterprises with fish culture using animal wastes to increase net farm returns (Amarasinghe, 1991). Poultry-fish integrated farming system is a widespread integrated system present in Sri Lanka. In some countries, the fish farmers also integrate geese, ducks, rabbits, goats, sheep, cattle and water buffalo with fish culture on a small scale as an income generating activity. The species stocked in integrated farming systems, either as mono or poly culture are common carp, Chinese carp, Indian carp and *tilapia spp* (Vincke, 1991). Fish farming as an integrated system requires the construction of a pond and purchase of fish fry and could use family labour for production activities. Realistic technical assistance is needed on economies and technical aspects of integrated farming. Feed mixing at village level through a cooperative society would supply feed at considerably low prices than the open market to reduce cost of production (Amarasinghe, 1991). This production system could be a valuable protein source from waste at affordable prices to rural communities. It is based on the concept that "there is no waste" and waste is only misplaced resource, which can become valuable material for another product (Vincke, 1991). Pond fish culture in Sri Lanka should be developed for fry production and ornamental fisheries.

1.4 Community - Based Management of Seasonal Village Tanks

Farmer organisations (FOs) have a crucial role in organising agrarian communities for agriculture and management of minor irrigation structures. The agrarian community is the target group in community-based aquaculture rather than ordinary fishermen (NACA, 2005: 1-14). The development of rural aquaculture consists of several aspects including optimal allocation of resources, resolution or minimisation of conflicts, minimisation of environmental impacts, conservation of natural resources (NACA/FAO, 2001: 73-75), marketing and technology transfer (NACA, 2005: 1-14). Community participation is necessary to transfer appropriate technology, adopt methods to involve target groups. The role of the government is limited to facilitation of such participation and enacting certain regulations rather than having ownership of projects (NACA, 2005: 1-14). In community-based systems, group members invest in community-owned ventures. The community sets up the rules for commonly managed enterprises and shares benefits on an-agreed-upon basis (NACA, 2005: 1-14). The main steps for sustainable rural aquaculture development are ; the larval rearing up to fingerlings and the stocking in the water bodies. The community should participate in implementing these steps. Breeding of *Oreochromis niloticus* and *Cyprinus carpio* using simple techniques through community participation would be suitable for Sri Lanka (Ariyaratne and De Silva, 2003: 1). However, if the fish breeding centres of

Udawalawe and Dambulla are managed properly, they could produce sufficient post-larvae for a carp-based fishery.

Aquaculture leads to development of basic infrastructure such as electricity and transport. The agrarian community and unemployed youth in rural areas have to be motivated for aquaculture, agriculture and livestock integrated farming systems. It will provide a valuable protein source at cheaper prices to rural and urban consumers and generate additional income for rural population.

The collaborative efforts of the Ministry of Fisheries, NAQDA, provincial councils, NGOs and the farmers would be needed to meet the challenges in community-based management activities in seasonal tanks for the inland aquaculture sector (NACA, 2005: 10). The strategies must identify the roles of the different stakeholders, assigning the responsibilities and benefits (De Silva *et al*, 2001: 44). Such a co-management system has been already developed in the Dambulla reservoir (Edirisinghe *et al*, 2003: 21).

1.5 Value-Added Products

Frozen mussels, canned mussels, pickled mussels and oyster sauce are some of the value-added products in mollusk culture. A pickled mussel is a value-added method developed for green mussel (*Perna viridis)* in India. Sucked mussel meat is mixed with salt at a ratio of 7:1 and left in jars for about a week. They are packed in lining plastic bags and come in containers. Sometimes spices are used as the medium. The shelf life of the product is about 20 days without refrigeration.

Most of the fish are sold as raw fish in the country. A small proportion is dried, salted or smoked. Dried freshwater fish has a good demand. The excess harvest should be converted to value added products such as canned fish, fish sausages, fish sauce, etc. These could be sold in urban areas or in export markets. Food technologists should focus on developing new recipes from food fish species. The quality of the product is important to gain export orders. The role of the fish farmer has to change from merely raising fish to being a part of a chain in the production and delivery of safe, high quality products to the consumer (NACA/FAO, 2001: 267).

1.6 By-products

Some of the countries use oyster shells as a raw material of calcium carbide, calcium hydroxide, white cement and agricultural calcium. The excess harvest of the unpopular fish species could be converted to fishmeal in the animal feed industry. The shrimp waste from processing plants has been successfully used to improve the quality of grass (*Brachiaria briantha*) silage for cattle (Premarathne *et al*, 1995: 55-157) and as an ingredient in fish feed (Perera *et al*, 1995: 159-160). There are potentials to develop many allied industries from aquaculture and boost the rural economy solving unemployment and alleviating poverty.

Chapter Two

Main Species in Aquaculture

2.1 Introduction

The climatic variation of the country facilitates culturing of a variety of aquatic species such as mollusks, crabs, shrimp, aquatic plants, ornamental fish and food fish. In addition, there are suitable sites in the coastal areas to culture pearl oyster, sea cucumber, milkfish, sea bass and grouper. Some of these activities are in an experimental stage.

2.2 Mollusk Culture

Brown mussel (*Perna perna*), green mussel (*Perna viridis*), Crassostrea madrasensis and Saccostrea cucullata are the edible mollusk species present in Sri Lanka that could be cultured.

2.3 Crab Fattening

Indo-Pacific swamp crab*(Scylla serrata)* is the main species commercially found in the country.

2.4 Shrimp Culture

Shrimps are crustaceans, which inhabit sea and estuaries. The majority of the shrimp species spawn in the sea. Black tiger shrimp *(Penaeus monodon)* is the major shrimp species cultured in Sri Lanka.

2.5 Aquatic Plant Culture

Sri Lanka has been exporting aquatic plants for many years. But, the figures of species and quantities are not available. At present, 70 percent of naturally occurring indigenous plant species are in Sri Lanka and several exotic plants species are used in aquatic plant exports (Corea, 2005: 9). *Aponogeton spp* (Jonathan, 1993: 37-38) *Echinadorus, Ceratophyllum* and *Bacopa, Cabomba* etc are economically important aquatic plant varieties (De Alwis, 1992: 4-18).

2.6 Ornamental Fish Culture

More than 70 percent of exports of freshwater fish species by number are viviparous species (Edirisinghe, 1999: 63-70). Guppy (*Poecilia reticulate*) is the most popular breeding variety in the country. Guppy carries 67 percent of total exports and is followed by swordtail (*Xiphophorus helleri*), angelfish (*Pterophylum scalare*) and platy (*Xiphophorus maculates*) as noted by Wijesekara and Yakupitiyage (2001: 241-252).

The present demand for guppy may be due to various colour combinations, inherent qualities together with low price. The climatic variation of the country facilitates the culture of different varieties of fish species. The coastal area especially has optimal conditions for rearing most of the tropical fish having a high demand (Edirisinghe, 1999: 63-70). The number of ornamental fish species cultured is less than 50, but there may be a few hundreds of cultured varieties that could be produced through selective breeding (Jonathan, 1993: 4-17).

2.7 Reservoir Fisheries

Milkfish (*Chanos chanos*) inhabits in lagoons and estuaries of the country. Fish fry could be collected in tidal pools from March to June in the Mannar and Kalpitiya areas. Milkfish fry could be stocked in brackish ponds and village tanks (Samaranayake, 1986: 88-90). The freshwater ecosystem of Sri Lanka has 80 indigenous fish species mainly riverine and marsh dwelling types but it lacks truly lacustrine species. Hirikanaya (*Labeo dussumeiri*) and Mas petiya (*Puntius sarana*) are primarily considered indigenous food-fish species. The contribution of indigenous fish species to the inland fish production is insignificant (NARA, 2001:VIII). Olive barb (*Puntius sarana*) constituted 10 percent of total fish catch in the Kotmale, Victoria and Randenigala reservoirs (De Silva, 1992: 12-22). The inland fish production mainly depends on exotic fish species introduced to the country. Tilapias (*Oreochromis mossambicus, Oreochromis niloticus*) ranked the highest of inland fish capture and the estimated production was 21620 mt. in 2005 (NAQDA, 2007). Tilapia species are dominant over carp species due to its ability to colonise lacustrine habitats and since carp fingerlings have not been stocked in sufficient numbers. Giant gouramy (*Osphronemus gouramy*) was introduced as food fish in 1939 from Indonesia, but it is no longer important as a food fish. Chinese major carps (*Ctenopharygodon idella, Hypophthalmichthys molitrix, Aristichthys nobilis*) with common carp (*Cyprinus carpio*) and Indian major carp (*Catla catla, Labeo rohita Cirrhinus mrigala*) were introduced to Sri Lanka to develop poly culture in tanks and ponds (FAO, 2003). Tilapia was used for stocking major reservoirs and carp were produced for stocking seasonal tanks and ponds (World Fish Centre, 2001). It was reported that carp species perform much better than tilapia in seasonal reservoirs (Thayaparan, 1982: 133-167). According to existing knowledge, maximum annual fish production from perennial reservoirs is 150 kg/ha and it could be increased up to 700 kg/ha by introducing carp fingerlings in a rational manner. In addition, invasive tilapia has become a threat to Sri Lankan endemic and indigenous fish. Carnivorous fish are not cultured in Sri Lanka due to high cost of production (World Fish Centre, 2001). Principal carnivorous fish in the market are *Channa striata, Clarias brachysoma and Anguilla nebulosa* that have been captured from the wild.

Chapter Three

Institutional Framework and Government Policies

3.1 Introduction

The Government of Sri Lanka has formulated policies and established the institutional framework for management of aquaculture and conservation of biodiversity — to attain the goals of food security, enhancement of the rural economy and rural livelihoods.

3.2 Institutional Framework

3.2.1 Ministry of Fisheries and Ocean Resources (MFOR)

MFOR is mandated to protect aquatic resources, breeding and distribution of fish food for stocking inland water bodies. There are several departments and agencies under the ministry to hold specific responsibilities.

a. National Aquatic Resources Research and Development Agency (NARA)

NARA is the principal national research institution mandated for aquaculture research and development activities. Inland Aquatic Resources and Aquaculture Division (IARAD) of NARA conducts services for disease diagnosis of fish and shrimp, testing of water and soil quality, site selection and environmental impact assessments for aquaculture practices, and conducts training programmes on exotic and endemic breeding, propagation of aquatic plants. The Post Harvest Technology Division of NARA is involved in developing new food products utilising locally available resources and introducing improved processing techniques for aquatic organisms. It provides laboratory services on microbiological assessment, quality control, chemical analysis and nutrients. It conducts training programmes on quality controlling, product development and proper handling practices (NARA, 2006).

b. National Aquaculture Development Authority (NAQDA)

NAQDA is involved in the extension and development of aquaculture in marine and inland aquatic resources. It is mandated to develop freshwater, brackish water, coastal aquaculture and mari-culture operations to increase fish production and consumption, develop small, medium and large-scale private sector investment in aquaculture and creation of employment opportunities, promote the farming of high-valued species and optimum utilisation of aquatic resources, conserve and develop aquatic resources through environmentally friendly aquaculture programmes (NAQDA, 2007).

c. Department of Fisheries and Aquatic Resources (DFAR)

DFAR is responsible for framing, updating and implementing of aquaculture management regulations, formulation of development projects for fisheries cooperatives, issuing licences for the live fish exportation, registering fish processing establishments, monitoring the quality of fish exports and issuing of export permits.

3.2.2 Department of Animal Production and Health (DAPH)

DAPH, which is under the Ministry of Livestock, is mandated to perform inspection, quarantine and certification of imports and exports of animals including all aquatic organisms (under the Animal Disease Act of 1992).

3.2.3 Department of Agriculture

National Plant Quarantine Service (NPQS) of the Agriculture Department promotes the exportation of healthy plants and plant products. It also conducts research and development activities in plant quarantine of the country. The Plant Protection Centre (PPC) is involved in the management of noxious aquatic weeds and other invasive species in agricultural habitats. The Plant Genetic Resource Centre (PGRC) conducts activities related to conservation, evaluation and enhancement of plant genetic resources.

3.2.4 Department of Wildlife

The Department of Wildlife regulates the species of animals that can be imported and exported. A number of indigenous fish species and some other aquatic organisms are restricted or prohibited from exporting. Export permits are required for protected plants and other animals.

3.2.5 Sri Lanka Customs

The Biodiversity Protection Unit (BPU) of the Sri Lanka Customs inspects imported and exported shipments of aquatic animals and plants for necessary official documents like permits and health certificates for aquatic organisms. They function together with the Department of Wildlife and Animal Quarantine Division of the Department of Animal Production and Health.

3.3 Government Policies on Aquaculture

Sri Lanka is a member of the South Asian Association for Regional Cooperation (SAARC), Network of Aquaculture Centres in Asia and the Pacific (NACA) and World Trade Organisation (WTO). Sri Lanka is party to the Convention on Biological Diversity (CBD) and the Bio-safety Protocol. Sri Lanka is also party to the Convention on International Trade in Endangered Species of Wild Fauna and Flora (CITES).

3.3.1 Regulations for Aquaculture

The Fisheries and Aquatic Resources Act No 2 of 1996 provides for the management, regulation, conservation and development of fisheries and aquatic resources in Sri Lanka. Part I of the Act deals with fisheries administration. It contains provisions to establish a fisheries and aquatic resource advisory council to advise the Minister of Fisheries on all matters concerning the management of fisheries and aquatic resources. Part IV of the Act covers the protection of fish and other aquatic resources. Part VI of the Act relates to aquaculture (see Annex 01).

Certain zones are reserved for the purpose of aquaculture, for which a licence is required, and to which certain terms and conditions are attached. Aquaculture Management Regulation Act of 1996 covers the licensing procedure for pen culture, cage culture, raft culture, seaweed culture, and ornamental fish culture and hatchery production.

The Fisheries and Aquatic Resources (Amendment) Act of 2006 has provisions for new sections, viz licensing of aquaculture operations, appointment of licensing officers, licence application

procedures, duration and renewal of licences, suspension or cancellation of licences, and appeals and complaints against licensing officers. Section 45A deals with aquaculture disputes.

The Coast Conservation Act of 1981 (amended in 1988) prohibits any person from engaging in any development activity (which includes aquaculture) within the coastal zone unless the Director General of Coast Conservation issues a permit. The Director General shall require the applicant to submit an environmental impact assessment (EIA).

Act No 56 of 1988 to issue environmental protection licences to shrimp farming projects exceeding the area of 4 ha — amended the National Environment Act No 47 of 1980, Section 232. To control the expansion of the industry, the National Environmental Regulations No 01 of 1993 was published under National Environment Act No 47 of 1980 describing the procedure for approval of projects. The North Western Province Environmental Authority — which is the project-approving agency for the north-western province — grants approval for shrimp farming projects (North Western Province Environmental Statute No 12 of 1990).

3.3.2 Technical Issues

NARA was established in 1981 under the provisions made by NARA Act No 54 of 1981. The objective was to ensure the application and utilisation of science and technology for the development of aquatic resources. National Aquaculture Development Authority (NAQDA) was established in 1999 under the provisions of the National Aquaculture Development Authority Act No 53 of 1998. This organisation is mandated to develop the inland fisheries sector in the country. Veterinary Research Institute (VRI) of the Department of Animal Production and Health (DAPH) is the central organisation for veterinary research in Sri Lanka. Presently, it is armed with fish disease diagnostic facilities and supports the Director General of DAPH and the chief animal quarantine officer to implement necessary actions.

3.3.3 Diseases Control

The Animal Disease Act No 59 of 1992 defines animals and animal products (cooked, canned, dried, salted, smoked) applicable to aquaculture including all varieties of fish, crab, prawn, lobsters and turtles of marine and freshwater origin. The Act No 59 of 1992 lists a number of measures taken by the Director General of DAPH in case of animal disease outbreak. It includes sealing of infected premises and the areas, the power to close roads for preventing animal movement, disinfections, destruction and disposal of animal products. The Act gives provisions to deal with the import and export of animals, animal products and imported animals in quarantine. The Controller of Imports and Exports issues import permit, on the recommendation of the Director General of DAPH. This act is further empowered by Animal Diseases (Control and Prevention) Regulations 1998.

These regulations enable — the provisions for notification of importation of diseased live animals and investigation, sealing of infected premises, declaration of infected area by the Director General of DAPH, seizure of animals, destruction of animals, disinfecting premises by the owner and enforcement and inspection,etc. Aquaculture Management (Disease Control) Regulations 2000 was adopted under the Fisheries and Aquatic Resources Act. The regulations monitor aquaculture enterprises mainly to avoid/ control the spreading of disease under hygienic conditions.

Animal Diseases Act regulates the issuing of licences for the manufacture of veterinary drugs and veterinary biological products (such as vaccines) as well as their import and export. On the recommendation of the Director General of DAPH certifying the safety of the veterinary drug or veterinary biological products, the Controller of Imports and Exports issues the import permits. The Act also makes provisions for the establishment of a veterinary drug control

authority. The Cosmetics, Devices and Drugs Act (1980), which prohibits the manufacture, preparation, preservation, packaging or storage for sale of drugs (including drugs for animals) under unsanitary conditions and of adulterated drugs is applicable to veterinary drugs. The Act also prohibits the import, sale and distribution of drugs and addresses labelling, packaging and advertising requirements.

3.3.4 Food Safety

The Food Act No 26 of 1980 as amended in 1991, prohibits the manufacture, import, sale or distribution of food unfit for human consumption. It bans the labelling, packaging and advertising of food in a false or misleading manner. Part X of Fisheries and Aquatic Resources Act No 02 of 1996 includes regulations on handling and distributing and maintaining quality of fish including fish products and other aquatic resources. The Act gives the conditions to licensing of establishments for fish processing and other aquatic resources. Fish Products (Export) Regulations (1998) mentions the rules related to hygiene, requirements for establishment of fish processing and exporting of fish products. It includes licensing procedure for fish processing establishment. Aquaculture (Monitoring of Residues) Regulations (2002) regulates licensing of self-monitoring procedures to ensure appropriate withdrawal period to prevent exceeding the maximum permitted limits of residue. These regulations also provide the provisions for the establishment of a national residue-monitoring plan.

3.3.5 Environmental Protection

The National Environmental Act No 47 of 1980 (as amended in 1988), makes provisions for the regulation, management, protection, and enhancement of the environment to maintain and control pollution control and prevention. The Act gives provisions to establish Central Environmental Authority (CEA) as an administrative body. The discharge or disposal of waste into the environment is prohibited under the Part IV A of the National Environment Act and the National Environmental (Protection and Quality) Regulations (1990). Standards —for emissions (discharge of effluents) into inland surface, brackish and marine coastal waters, in particular for the discharge of aquaculture wastewaters — have been set by the CEA. Aquaculture farmers are required to obtain the environment protection licence to discharge, deposit or emit wastes into the environment in keeping with standards established under the Act. The Act and the Regulations prescribe the licensing procedure, including renewal, suspension and cancellation of licences. Part IV C of National Environment Act of 1980 as amended in 1988 requires approval of initial environmental examination (IEE) or environment impact assessment (EIA) from project-approving agencies for prescribed projects. The Ministry of Fisheries and Aquatic Resources considers EIA of the project-approving agencies over fisheries matters under National Environmental (Impact Assessment) Regulations, 1992. National Environment (Procedure for Approval of Projects) Regulations (1993) sets out the procedure to be followed by the project-approving agency. The procedure requires submission of preliminary information by the applicant, submission of the initial environmental examination report (IEE), granting or refusal of approval, notification of the report for public inspection, implementation of the proposed project. North Western Province Environmental Statute No 12 of 1990 has given provisions to the establishment of the North Western Province Environmental Authority and an environmental council — for the protection, management and enhancement of the environment and for the regulation, maintenance and control of the quality of the environment. The statute prohibits the discharge, emission or deposit of wastes into the environment except in accordance with the standards set by the respective provincial authority as well as criteria, conditions or rules prescribed under Part V of the Statute. Part VI concerns the restrictions, regulations and control of pollution of the province's inland waters. North Western Province Environmental Authority is the project-approving agency that administers IEE and EIA for the north- western province.

Costal Conservation Act of 1981 amended in 1988 prohibits any person from engaging in a development activity (which includes aquaculture) within the coastal zone, unless authorised permit issued by the Director General of Coast Conservation. The latter may require the applicant to submit an environmental impact assessment (EIA) report for stability, productivity and environmental quality of the coastal zone. Costal Conservation Regulations (1982) further defines the criteria to issue the permit. The proposed development activity should not cause an adverse impact on the coastal zone and ecosystem, discharge of unacceptable levels of effluents or toxic substances. The development activity may not be sited in areas reserved or in use as a wild life habitat.

3.3.6 Fauna and Flora Protection

The Fauna and Flora Protection Ordinance No 38 of 1949, Acts Nos 44 of 1964, 01 of 1970 and 49 of 1993 specify protected fish species and make provisions for the establishment of natural reserves and sanctuaries within which no person shall take fish or other aquatic animals without a permit issued by the Director General of Department of Wildlife. The plants that require export permits are indicated in schedule V.

The Plant Protection Act No 35 of 1999 provides for the prevention and eradication of potentially harmful organisms viz plant, bacteria, virus, algae, fungi, etc or weed that could be introduced or spread in the country. It also restricts or bans the importation of plants, products and organisms, and makes provisions — to test, quarantine, disinfect and clean or destroy — if plant, product, package or container that has been infested. In addition, it allows for restricting or banning the cultivation of any plant over a determined period of time in any location in the country. The National Plant Quarantine Service (NPQS) has the responsibility of enforcing the implementation of the Plant Protection Act No 35 of 1999 and regulations of plant quarantine activities.

The Export and Import of Live Fish Regulations (1998) specifies the species of live fish that could not be exported and imported (Annex 02). The Director General of Fisheries and Aquatic Resources should issue a licence for live fish exportation. Export permits are required for the forest products specified by the Gazette Notification 1161/6 of 05/12/2000 and published under Forest Act No 23 of 1995.

3.3.7 Aquaculture Investment

The Board of Investment (BoI) Act (2002) gives provisions to promote and facilitate investment in Sri Lanka and provides for the establishment of the Board of Investors. BoI has identified aquaculture as a priority sector for attracting foreign and local investments. Incentives and concessions are given for aquaculture, fish marketing and distribution, post harvest technology, ornamental fish outgrowing and fish-processing enterprises to facilitate and promote investment in the country. Ten companies were registered as BoI projects for culturing and processing of shrimps in 2006 and the investment was Rs 360 million (NARA, 2006).

Chapter Four

Distribution and Characteristics of Farming Systems

4.1 Introduction

As already examined, there are many types of aquaculture systems that can be used for improving food situation and nutritional conditions, diversifying the rural economy, enhancing economic opportunities in the rural and agrarian sectors and reducing rural poverty. The distribution and characteristics of main aquaculture systems that prevail in the country are examined below.

4.2 Mollusk Culture

The mollusk culture is in the experimental scale at the moment (Wanninayake, 1998: 1-10). A few small-scale oyster farmers in Egodauyana, Moratuwa are involved in this activity with the technical support of NARA.

4.3 Crab Fattening

Cab fattening is basically carried out in the Negombo lagoon. Most of the tidal flats, mangrove areas and lagoons of Sri Lanka are excellent for crab fattening (Chin and Amandakoon, 1989: 165-169).

4.4 Shrimp Farming

The shrimp industry in Sri Lanka has three operative divisions, viz shrimp hatchery, shrimp farming and shrimp processing. The entire shrimp culture is concentrated in the north-western, western and eastern coastal areas. Most of the hatcheries in Sri Lanka are medium-scale operations. Many of them are concentrated around the Chilaw and Iranawila areas. Accurate information on the number of hatcheries in operation is not available. But, there were 70 hatcheries involved in shrimp breeding in 1999 and the estimated production was 750 million post larvae per year (Siriwardena, 1999: 79-84). Figure 01 shows the shrimp production from 1990 to 2006.

About 70 percent of shrimp farms are located in inter-tidal and supra-tidal areas in the lagoons of Chilaw, Mundel and, Puttalam and the Dutch Canal, which has been the common water body for most of the culture practices (Corea *et al*, 1995: 423-427). There are a few shrimp farms located in the eastern coast around the Batticaloa lagoon. An estimated 3940 ha are under shrimp culture ranging from farm sizes between 0.5 ha to 200; there were 1344 farms in 1999. But, 47.7 percent of them were unauthorised.

The unauthorised farms occupied 39.4 percent of total land area under culture and 82 percent of them were less than 2 ha (Siriwardena, 1999: 79-84). A majority of shrimp farmers are medium-scale operators and the shrimp culture system was semi-intensive in nature (Jayasinghe, 1993: 21-24). There were 12 shrimp processors involved in exporting shrimp products (Siriwardena, 1999: 79-84) and today it has been reduced to two.

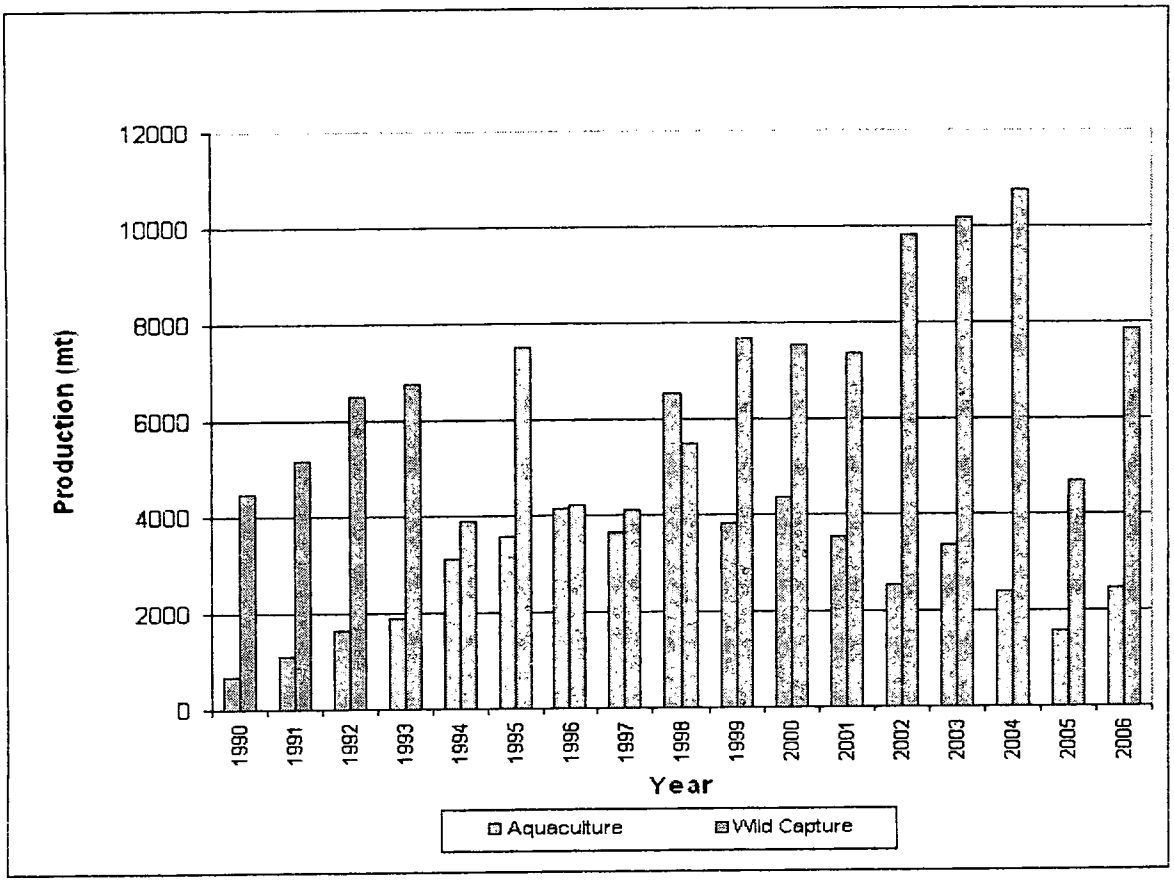
4.5 Aquatic Plant Culture

The aquatic plant exportation is a developing industry. Exportation of collected plants from the wild is now banned due to the threat of extinction of endemic species (Corea *et al*, 1993:

15). But, nine threatened endemic species and two threatened indigenous species are still being exported (Corea, 2005: 9).

Aquatic plants could be cultured in abandoned paddy fields, marshy lands or cement tanks in home gardens with fertiliser and good water supply. The exporters mainly focus on collecting from the wild due to less production as it involved less capital and labour. Presently, there are less than 25 plant culturists and 17 plant exporters in the country (Corea, 2005:9).

Figure 01: Prawn Production from 1990 to 2006 (MT)



Source: NAQDA, 2007

4.6 Ornamental Fish Culture

Most of the ornamental breeders and growers are in the western province. But, there are a considerable number of small-scale fish farmers in the north-central and north-western provinces. A majority of farmers are involved in fish breeding and growing activities (Haputanthri *et al*, 2001: 5-12). Many of the recently started ornamental fish breeders and growers are small-scale operators. The size of the farms may vary from small backyard systems to well-managed farms of several hectares (Jonathan, 1993: 4-17). Ekarathne (2000: 3-8) reported that 25 exporting companies undertake exports from Sri Lanka and two companies handle 50 percent of export volume. Fish exporters are classified in terms of the quantity of fish they handle.

The ornamental fish have different varieties in the local market. Some of the rejected fish species for exports are sold in the local market. The local ornamental fish industry has spread out across major cities and small villages. A majority of the investors are small-scale holders who purchase fish — from importers, exporters and large-scale producers, — to be sold to local customers with a considerable amount of profit. Some of them do fish breeding activities and sell aquarium accessories too. Local customers prefer both imported and locally bred fish. Fish species are imported from Singapore, Thailand, Indonesia, Malaysia and Japan. Generally,

goldfish, guppy, swordtail, koi carps and platy have good demands (Wijesekara and Yakupitiyage, 2001: 241-252). Today, some fish species are even imported from Madagascar in order to re-export.

4.7 Reservoir Fisheries

The seasonal village tanks located in the dry zone — receive water during monsoons. The average water area in seasonal village tanks is between 5 ha and 7 ha and the productivity is 0.46 mt/ha (FAO, 2003). Generally, fingerlings are stocked in the seasonal tanks during the September-December period of the previous year and harvested from June-September of the following year (Chandrasoma, 1988: 63-66). The harvests of the seasonal village tanks are sold at village level (FAO, 2003). Freshwater fish have low consumer preference and fetch a low price at the market (Chandrasoma, 1988: 63-66). Sri Lankans do not prefer to eat freshwater fish of less than 100 g. The prices vary according to size and variety of the fish species and the season. Generally, Tilapia spp and Catla catla have a higher level of consumer preference. Freshwater prawns fetch a higher price than finfish species. GOSL has identified seasonal village tank culture as a priority area for poverty alleviation, increasing food security, improving rural livelihoods and increasing the national per capita consumption of fish.

Chapter Five

Culture Technology

5.1 Introduction

There are aquaculture technologies for different types of species, geographic location and management systems. They also differ in terms of the level of innovation and scientific knowledge adopted in management, production and marketing. Commonly, the techniques adopted by the small-scale aquaculture farmers need improvement. Culture technologies of main aquaculture systems in the country are examined below.

5.2 Mollusk Culture

Spat of mussels could be collected from Rumassala, Mirissa, Rekawa, Chilaw, Negombo, Tangalle and Trincomalee during the spat fall seasons. Generally, spat seasons are irregular in Sri Lanka. Spat collectors should be kept underwater during the spat fall season. Bamboo poles, wooden stakes, ropes, broken tiles, coconut shells and plastics are used as spat collectors. The spats must be transported early in the morning to avoid dehydration due to sun and hot wind. These spats are grown in collector ropes attached to a raft anchored in the lagoon. Generally, the mussel rafts are 8m×6m in size and each could bear 300-400 collector ropes. The length of the rope varies with the depth of the water. Mollusks are filter feeders and do not need external feeds. The brown mussel could be harvested after 6-7 months. The yield of a muscle raft is 1.2-2 mt per crop annually. Maintenance of the raft and removing of predators and fouling organisms should be done periodically (Wanninayake, 1998: 1-10).

5.3 Crab Fattening

Crab fattening is a value adding process. Crab juveniles are collected from the wild and fattened in cages by using trash fish. The average weight gain is 200-300 g. Generally, the culture period is 115 days. Most of the crabs are exported live and only a limited amount is used for crabmeat processing (Chin and Amandakoon, 1989: 165-169).

5.4 Shrimp Farming

Shrimp hatchery management is a sophisticated practice. It needs skilful technology and a considerable amount of investment. Mother prawns are captured from the sea. The price of a gravid female depends on the stage of maturity and the number of eggs. Parents undergo quarantine procedure and are reared for spawning in a dark environment. Males and females are kept at a sex ratio of 1:1. Eyestalk ablation is carried out to stimulate spawning. Eggs hatch into post larva (PL) after going through a series of larval stages, namely nauplius, zoea and mysis. Artemia, algae and formulated feed are used as feeds for shrimp larvae. The algae species (*Skeletonema spp, Chaetoceros spp, Tetraselmis spp*) are cultured in hatcheries. Nauplius depends on yolk sack and does not need external feed. Zoea is a phytoplankton feeder. The mysis is considered a zooplankton feeder.

Maintaining water quality parameters viz salinity, pH, dissolved oxygen, unionised ammonia, etc. and a clean tank bottom is very important for the health of shrimp larvae. Zoea is the most vulnerable stage in the shrimp life cycle and a 15 day-old post larvae (PL-15) is the popular stocking size in Sri Lanka (Kasagala, 2002: 20-24). It takes nearly 26 days for a shrimp egg to become a PL-15. The post larvae are tested for MBV (Monodon Baculow Virus) and SEMBV

(Systemic Ectodermal and Mesodermal Baculovirus) before stocking. The price of PL varies due to the quality and health of PL, season, and disease epidemics at farm level.

The important aspects of shrimp farming are: pond preparation; seed selection; stocking; water quality management and feeding. During pond preparation, agricultural lime is used to adjust the pH level. Tea-seed cake could be applied to remove the predator fish and other competitive organisms. Fertilisation should be done before stocking for growth of natural feeds. The popular pond size is 0.4 ha (one acre) and the stocking density is 12-20 post lava/ m2. Modern shrimp farming largely depends on commercially formulated feeds. Shrimps are nocturnal feeders and consume 70 percent of the feed at night.

The important aspects of feed management are: the stage of growth; water quality; water temperature; feed stability; type and quality of the feed; feeding rate; feeding management; natural feeds and health of the shrimp (DPI&F, 2006: 87-90). They need a higher dietary protein content and frequent feeding in the early stages of growth. As shrimps grow older, a management shift is necessary to prevent overfeeding and underfeeding and to maintain water quality in order to avoid slow growth rates and cannibalism. Feed intake is high during the warm months and it decreases in the high temperatures of more than 35^{0}. Feed intake could be reduced during molting and lower temperatures (DPI&F, 2006: 87-90).

The important water quality parameters are salinity, dissolved oxygen, pH, turbidity and ammonia. Keeping records on water quality parameters is important for water treatment and water exchange. Salinity meter (refract meter), pH meter, secchi disc, oxygen meter and ammonia test kits are frequently used at the farm level to measure water quality (Kasagala, 2002: 25-28). Optimum water quality would minimise the stress and reduce vulnerability to infections. Some farmers use probiotics to improve deteriorated pond water. Shrimps are grown for 4-5 months in earthen ponds and the harvesting size is 35-45 g. Early harvesting is carried out during disease periods.

5.5 Aquatic Plant Culture

Farmers use various methods to culture aquatic plants. They separate small plants coming from mother plant or cutting of mother plant and planting individually. Cow dung, chicken manure, compost and commercial fertiliser are used for better growth. Sometimes plants are kept in individual plastic pots inside a simple ground pond with nutrient rich, fertilised water (Jonathan, 1993: 37-38). Most of the water plants do not produce seed. The natural vegetative propagation of aquatic plants is not adequate to meet present demand. Tissue culture is a suitable method for mass propagation aquatic plants according to a scheduled programme. According to Dissanayake *et al* (2003: 84) tissue culture propagation of ornamental aquatic plants has been carried out successfully in wendi brown (*Cryptocorin wendtii*) and marble queen (*Echinodorous cordifolious*).

5.6 Ornamental Fish Culture

Breeders select better quality, colourful and healthy fish from out-grower tanks and keep as brood stock. Fish species are selected on market demand, exporter request, technology, availability of brood stock and the condition of water (Jonathan, 1993: 4-17). Most breeders improve their fish species through selective breeding. A few breeders have imported improved brood stock for best colour varieties. Some of the fish breeders use synthetic gonadotropin to induce spawning. Most breeders have similar facilities and use similar methods for spawning.

Conditioning is done— before spawning —using high protein live feed or formulated diets. The breeding tank is prepared according to breeding strategies of fish species. Breeding of livebearers is relatively simple than that of egg layers. Guppy (*Poecilia reticulate*), molly, platy

(*Xiphophorus maculates*) and swordtail (*Xiphophorus helleri*) are livebearers. Their breeding tanks are filled with aquatic plants or polythene stripes for protection of larval stages from hungry parents. Generally, glass tanks are used for spawning of angelfish. Angels prefer an angled surface for spawning.

Circular or rectangular concrete tanks are used for breeding of goldfish (*Carassius auratus*), Oscar (*Astronotus ocellatus*), gourami (*Trichogaster spp*) and koi carps (*Cyprinus carpio*). Goldfish and koi carps scatter and lay adhesive eggs. Broad, leafy plants are needed for egg adhesion. Oscar is an egg depositor, which needs a flat surface for egg deposition. Gourami (*Trichogaster spp*) is a bubble nest builder. It needs clam water and floating a Styrofoam piece for bubble nest building. The circular tanks are important to reduce the stress on the brood stock during confinement. Most of the time parent stock is removed after spawning due to cannibalism. But, species like discus fish (*Symphysodon spp*) and angels (*Pterophylum scalare*) show good maternal behaviour. Eggs are hatched to larvae within a few days depending on the species and the temperature.

Optimum nutrition level is essential for fast growth and best colouration of ornamental fish species. To get a good quality final product, breeders and growers use both live and artificial feeds. Live feeds are basically used in the early stage of fish life. Paramecium Artemia, Monia, Daphnia, Microworms and Tubifex worms are the widely used live feeds in ornamental fish culture. Live feeds spread well in the water and are easily ingested by the tiny fish larvae. Live feeds contain enzymes and digestion is easy. Guppies are fed with artemia in the first two weeks of the birth. Artemia is a live feed with a very high amount of crude protein. Monia and Daphnia are the other important zooplanktons that could be used instead of Artemia. But, artemia is the best among live feeds in terms of nutritional quality (Parameshwaran *et al*, 2001: 421-430). Paramecium and micro worms could be used as larval feed, whereas tubifex worms are good brood stock feed for conditioning. After 2-3 weeks, the larval stages are fit to tolerate grow out conditions.

Generally, large-scale operators and breeders supply larval fish for small-scale out-growers. But, some of the large-scale operators are involved in fish growing activities too. Fry, fish feeds and medicines are provided to out-growers on the basis of cutting down from the final amount of money. Sometimes, initial training and free technical service would be provided on water quality management, feeding and disease prevention. The out-grower is responsible for protecting fish from predators and diseases. This practice is a kind of buy back system (Wijesekara and Yakupitiyage, 2001: 241-252).

The species like guppy are cultured in cement tanks but some of the species are cultured in mud ponds. Mud pond could be considered a semi-intensive form of aquaculture, which contains natural feeds and supplemented with artificial feeds too. Mud ponds have several advantages over cement tanks. Since mud ponds contain natural feeds, growth rate is high and the fish have better colours. The capital investment in a mud pond is lower than in a cement tank. Mud ponds are generally bigger than cement tanks. The size of the mud pond could vary with the scale of operation. Mud ponds could be disinfected using lime. Animal dung is added for the growth of natural feeds before stocking (Jonathan, 1993: 4-17).

The nutrition of fish is very important for fast growth, health and colouration. Generally, fish are fed 3 percent of their body weight. Important aspects of fish feeding are feeding frequency, optimum time of feeding and efficient ration distribution into the aquaculture system. The optimum ration size gives best growth and optimum FCR (Feed Conversion Ratio). The proper distribution of feed is important to minimise wastage and deterioration of water quality. Feeding has to be modified according to the size, age and species of the cultured organism with respect to water quality and temperature. Generally, feed manufacturers supply a feeding guide, but daily observation of fish behaviour is essential and adjustments should be made

(De Silva and Anderson, 1995: 211-244). Factory prepared fish feeds and self-mixed feeds are used in out-grower ponds. Some use shrimp feeds for brood stock because of their water stability and high level of crude protein content. Colour enhancers could be added to the fish feeds in order to get best-coloured varieties with high demand (Jonathan, 1993: 4-17).

Fish could tolerate a wide range of water quality. But, maintaining water quality parameters at a favourable level would be important to prevent stress and disease outbreaks (Jonathan, 1993: 4-17). The important water quality parameters are pH, ammonia, nitrite, nitrate, dissolved oxygen, temperature and total hardness. Water exchange and water treatment are the best solutions in undesirable water quality conditions. Fish grow well in waters having a pH 6.0 to 9.0. The total ammonia nitrogen level higher than 0.02 ppm (parts per million) is unfavourable for fish growth. Dissolved oxygen concentration above 3 ppm is preferred for most of the fish species. The total hardness should be above 50 ppm for healthy fish. The low hardness could be corrected using lime and calcium chloride (NARA, 1993: 1-4).

The growth period varies among species. Generally, it is two months for most of the popular ornamental fish varieties. Fish are harvested using hand nets or draining the pond after culturing, and grouped according to sex, body condition and colour. They are packed in oxygenated polyethylene bags and sent to exporters for conditioning or to retail outlets. Fish are starved for two days during conditioning to keep the gut empty. Many exporters put antibiotics for packing water to prevent bacterial infections. Some exporters put anaesthetic agents to keep fish in sedation to create low activity in high stocking densities. Clove oil is an effective anaesthesia for guppy (Jayathilaka et al, 2003: 235-241). But, the action of clove oil should be re-evaluated in sedating fish for a considerable transport period. Finally, the fish bags are packed in rigiform boxes for exportation by air.

5.7 Reservoir Fisheries

Aquaculture Development Centres (AQDCs) in Udawalawe, Dambulla and Inginiyagala of NAQDA are engaged in production of Chinese and Indian carp fish seeds. These major carp species undergo induced breeding and the eggs are hatched artificially to get post-larvae. The post-larvae are stocked in earthen or cement ponds or plastic pools for nursing. After 2-3 weeks, post-larvae are allowed to grow up to 2.5-3 cm fry stage. Then the fry are transferred to rearing ponds to grow into fingerlings (5-7.5 cm in size). During the year 2007, 20.4 million fish fry have been issued to community-based seed production units and private pond operators for rearing fingerlings (NAQDA, 2008: 7). Previously, there was a seed-stocking programme for seasonal tanks, ponds and perennial tanks (Tennakoon *et al*, 1988: 43-61). Fisheries societies had to purchase fingerlings from NAQDA and private sector out-growers. Different organisations gave loans to fisheries societies to purchase fingerlings under the supervision of NAQDA. Some small-scale farmers in the Polonnaruwa district breed common carp as fingerlings — to supply the government authorities and fisheries societies. Still, they have not been able to breed Chinese and Indian major carp species. At present, the government has taken a decision to issue fingerlings to reservoirs free of charge. Four hundred seasonal village tanks were stocked from 2.4 million fingerlings during the period 2006-2007 (NAQDA, 2008: 7).

The management system adopted in inland aquaculture was stocking seasonal tanks with fingerlings and subsequent harvesting. These tanks hold water for 6 to 8 months, which stocked 2000-3000 fingerlings/ha, produce 750 to 1000 kg/ha harvest per annum. Supplementary feeds are not used. Natural productivity of the tanks is dependent on the nature of the bottom soil, catchment area and amount of organic wastes of different origin. The harvest could be increased up to 2000 kg/ha/annum using supplementary feed with higher stocking densities (FAO, 2003). Regular fishing activities cannot be performed in seasonal tanks. Therefore, target groups formed among surrounding agrarian communities were used in place of regular fishermen (NACA, 2005: 5).

Chapter Six

Contribution to Economy

6.1 Introduction

Food security, employment, local and international trade are the main contributions of aquaculture to the economy of Sri Lanka. Aquaculture and inland fisheries produced a total of 38 000 mt in 2007 representing an annual average increase of 9 percent compared with the previous year (Central Bank of Sri Lanka Annual Report, 2007: 38).

6.2 Mollusk Culture

About 106 mt of mollusks were exported in 2006 earning a total of Rs 55 million (Department of Census and Statistics, 2008). But, the total production was captured from the wild, while farm reared mollusk production was insignificant.

6.3 Crab Fattening

Crab production mainly comes through crab fishery and a small amount from crab fattening. Sri Lanka has exported 568 mt of crabs in year 2006 and earned Rs 238 million (Department of Census and Statistics, 2008). Sri Lankan crabs are highly preferred in Malaysia, Singapore and Hong Kong on their excellent meat and taste (Chin and Amandakoon, 1989: 165-169). Currently, crab fattening is profitable. 80 – 90 percent of the investment could be earned from one culture cycle (Pathmi *et al*, 2003: 10).

6.4 Shrimp Culture

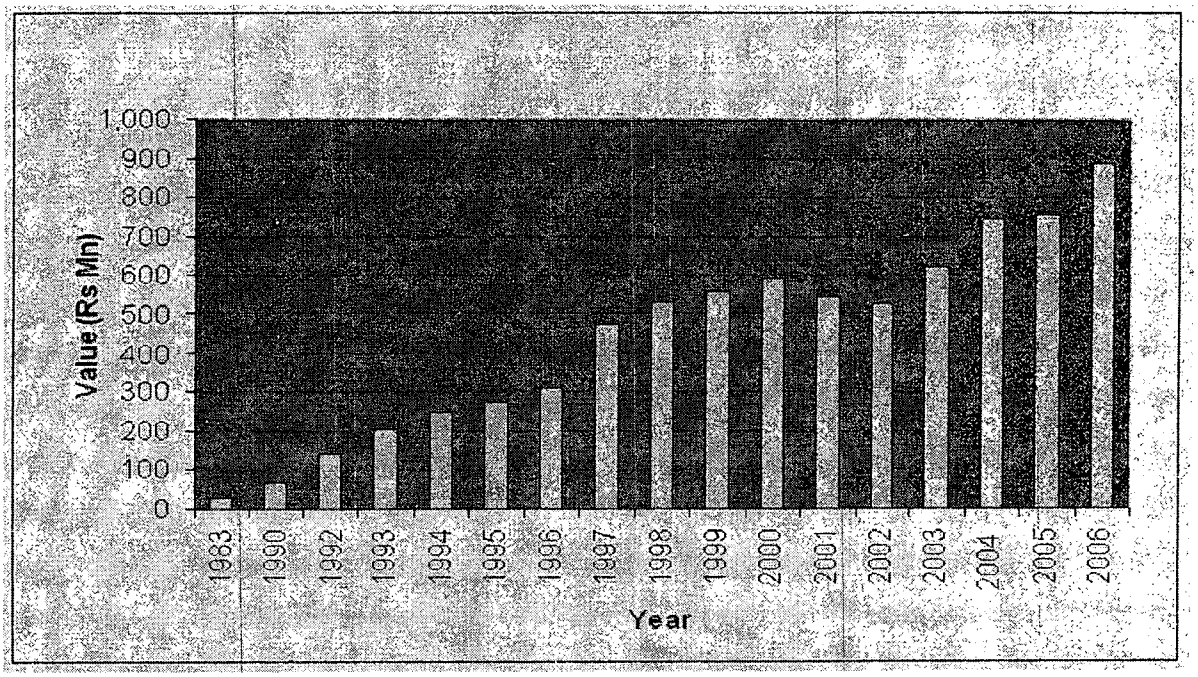
Shrimp industry in Sri Lanka consists of wild caught and farm reared shrimps. Shrimp culture had developed slowly towards the iatter part of 1980s and expanded rapidly in the first half of 1990s. After that, the growth was inhibited mainly due to disease outbreaks. Sri Lanka has the potential for 8300 mt of farm-reared production per year (Jayasinghe, 1997a: 21-25). The highest farm reared production was reported in 1998 as 6520 mt (NAQDA, 2007).

The total shrimp production was 12,000 mt in 1998 and earned US$ 68.9million. The farm reared production declined to 2480 mt and total export earnings became US$ 20.55 million in 2006 (Figure 01). In 2005, inland and aquaculture production declined by 1 percent as a result of the white spot disease in shrimp. Illegal shrimp farming without adhering to environmental regulations has led to the pollution of ecosystem and the spread of disease (Central Bank of Sri Lanka Annual Report, 2005: 24). A few support industries have developed along with shrimp farming activities such as lime producers, fibreglass manufacturers, feed outlets, machinery supplies, repair facilities and laboratories. The employment was 40,000 both from shrimp farming and indirect allied industries in 1999. It was 11 percent of the total labour force in the fisheries sector (Siriwardena, 1999: 99-110).

6.5 Ornamental Fish Culture

The ornamental fish industry consists of culturing or wild capture of fish species from freshwater, brackish water and marine environments. Rs 855 million were earned from the export of ornamental fish in 2006 (NAQDA, 2007, see Figure 02).

Figure 02: Export Value of Ornamental Fish (Rs Million)



Source: NAQDA, 2007

Aquarium fish exports of Sri Lanka are increasing annually at a 16.9 percent growth rate (Ekarathne, 2000: 3-8). But, still the island contributes one percent of the total world demand (Central Bank of Sri Lanka Annual Report, 2003: 89). Freshwater species contribute 80 percent of the total weight of the total exportation, while 90 percent of freshwater fish species are farm bred. But, over 80 percent of total foreign exchange is generated by less than 20 percent of marine and brackish water species captured from the wild (Edirisinghe, 1999: 63-70). USA was the biggest market for Sri Lankan ornamental fish (see Table 02),while Japan and Germany were the second and third in 2006 (NAQDA, 2007).

Table 02: Marketwise Distribution of Exports by Aquarium Fish (Value in US $ Mn)

Country	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006
USA	1.414	1.697	1.685	1.842	1.473	1.323	1.74	2.23	2.43	2.81
Japan	1.846	2.034	1.738	1.526	0.803	0.778	0.85	0.91	0.95	0.91
Germany	0.854	0.926	0.984	0.931	0.754	0.734	0.69	0.61	0.63	0.86
UK	0.678	0.657	0.693	0.638	0.618	0.719	0.78	0.89	0.92	0.97
France	0.668	0.704	0.705	0.838	0.637	0.433	0.53	0.54	0.55	0.58
Italy	0.467	0.309	0.483	0.481	0.375	0.363	0.53	0.65	0.48	0.58
Netherlands	0.355	0.330	0.321	0.366	0.333	0.284	0.25	0.17	0.21	0.24
Australia	0.059	0.084	0.145	0.136	0.156	0.164	0.20	0.21	0.19	0.23
Canada	0.050	0.064	0.070	0.058	0.100	0.125	0.10	0.12	0.12	0.17
Belgium	0.163	0.162	0.166	0.129	0.089	0.081	0.05	0.06	0.03	0.05
Other	1.462	1.214	0.942	0.884	0.645	0.458	0.78	1.01	0.99	1.15
Total	8.016	8.181	7.932	7.829	5.983	5.532	6.50	7.40	7.50	8.55

Source: NAQDA, 2007

Sri Lanka exports ornamental fish to over 40 different countries (Edirisinghe, 1999: 63-70). The value of ornamental fish in the local market was estimated around US$ 0.22 million in 1996 (Wijesekara and Yakupitiyage, 2001: 241-252). About 2500 people were involved in the ornamental fish sector as direct and indirect employees (Haputanthri *et al*, 2001: 49).

6.6 Reservoir Fisheries

The inland fish production in Sri Lanka came mainly from reservoir fisheries, seasonal village tanks and freshwater ponds. The total inland fish production was estimated around 32,000 mt in 2005 (NAQDA, 2007) and the total production of seasonal village tanks was estimated as 330 mt, which is 1.2 percent of the total inland fish production (FAO, 2003). The contribution of aquaculture plays a minor role in the supply of food fish in Sri Lanka. It was estimated that around 2000 found employment in the sector on full or part-time basis (World Fish Centre, 2001).

Chapter Seven

Research Needs, Constraints and Trends

7.1 Introduction

The lack of clear, long-term, national research policy and identification of priority areas of aquaculture research is a major constraint. In addition, there is no proper mechanism to transfer research findings to the field level. This chapter examines research needs, constraints and trends of aquaculture industry in Sri Lanka.

7.2 Research Needs

NARA is the national institution responsible for aquaculture research. Other than that, a few universities (Kelaniya, Peradeniya, Ruhuna, Sri Jayewardenepura, and Wayamba) and Rice Research Institute are involved in aquaculture research. In addition, the Kelaniya, Peradeniya, Ruhuna, Sri Jayewardenepura universities conduct postgraduate programmes on aquaculture. The core areas of aquaculture research include planning, research, development and management activities on biological resources of fresh and brackish water aquaculture systems for selected indigenous and exotic species including environmental assessment (Jayasinghe and Jayasekara, 1999: 1-11). Priorities for aquaculture research should be identified from different stakeholders mainly farmers, researchers, planners and NGOs. The research outputs are technology development, improvement of existing technologies, formation of policies, and conservation and management of aquatic resources. These research activities are conducted only by the government sector. The private sector is yet to enter research activities (Jayasinghe and Jayasekara, 1999: 1-11).

Seaweed, sea cucumber, artemia, milkfish, sea bass and groupers have potential for research in costal aquaculture sector. Sea farming research activities have not been started yet in the country. Priorities in shrimp culture should include the development, identification and prevention of diseases, water treatment systems, water quality management, soil management and coastal zone planning (Jayasinghe and Jayasekara, 1999: 1-11).

Research on shrimp culture should be further extended up to brood stock domestication, development of disease resistant strains, identification of suitable species for crop rotation, action of therapeutic agents used in shrimp culture and their effect on estuarine environment (Corea and Jayasinghe, 2005: 11). Indigenous fish breeding and assessment of ornamental fish resources are the main priority areas in the ornamental fish sector. So far, researches in reservoir fishery sector has focused on the creation of feed for carp brood stock, fry and fingerling production, and on the development of a scientific database on culture-based and capture fisheries (Jayasinghe and Jayasekara, 1999: 1-11). But, the research programmes on environmental and health management, brood stock development, breeding and culture techniques, breeding of indigenous fish are not adequate to meet the present needs.

The research capacity is minimal in marine culture, improvement of breeding techniques and legal and economic aspects of aquaculture (Jayasinghe and Jayasekara, 1999: 1-11). Most researches are highly academic and focus on solving field problems. Also, there is poor linkage between research and target beneficiaries including farmers, policy makers, and extension workers (FAO, 2003). A long-term, national aquaculture research policy and planning would be needed to identify research priorities and coordinate different stakeholders in order to continue research activities for future benefits (Jayasinghe and Jayasekara, 1999: 1-11).

7.3 Constraints

The introduction of aquaculture for developing rural economy brings with it some risks. The rapid expansion of coastal shrimp aquaculture led to both environmental and social problems. Mangrove deforestation, land degradation, habitat loss and disease are results of poorly planned activities. Many of the people who have suffered from degradation of the system have not benefited from the industry (NACA/FAO, 2001: 73-75). Negative results have been observed in many countries that have used aquaculture in rural development due to weak institutional context, poor coordination between sectors, imprecise mandates, vague public/private sector responsibilities, weak regulatory regimes and enforcement capacity, and little involvement of primary stakeholders (NACA/FAO, 2001: 78).

Interventions have to be strategically planned to manage resources and participation of different stakeholders. Presently, farmer organisations are facing many challenges to their existence and could mobilise user-groups toward consolidated action in such areas as repair of village tanks and strengthening the institutional framework necessary to achieve multiple benefits (NACA, 2005: 1-14). However, lack of village level organisations on management of seasonal tanks and insufficient seed supply for stocking are major constraints on inland aquaculture (FAO, 2003). The unavailability of suitable laws for management has hampered the development of fisheries cooperative societies and the inability of reservoir fisheries in rationally stocking sufficient numbers of carp fingerlings has affected the full utilisation of reservoirs.

Globalisation is both an opportunity and a threat to small-scale farmers. New market opportunities are emerging but international competition is intensifying and market access requirements are becoming more advanced. There is a danger that these pressures, particularly the costs of complying with food safety and environmental requirements, may exclude small-scale producers from the global market place. There is a need to assist smallholders to adapt to these changes and to increase their competitive position and the sustainability of both their production base and their livelihoods. Through a collaborative approach, groups of small-scale producers can cooperate to achieve the economies of scale, improved market leverage and resource use efficiencies required to remain competitive, and to facilitate more effective servicing of the sector (NACA, 2008).

7.4 Trends

The Ten Year Plan of the Ministry of Fisheries and Aquatic Resources increased fresh and brackish water aquaculture production to 74,450 mt in 2016 and promoted living standards of the fishing community (NAQDA, 2007). The government started restoration of large-scale village tanks in 2004 and planned to restore 1000 tanks every year. Also, it hoped to develop 600 ha of village tanks through a community-based aquaculture programme in 2003 (NACA, 2005: 6). The Aquatic Resources Development and Quality Improvement Project (ARDQIP) commenced in mid 2002 and funded by the Asian Development Bank (ADB) — planned for development of aquaculture and inland fisheries — to ensure food security and uplift the socio-economic standarsd of the rural population in non-coastal areas.

A culture-based fishery in seasonal tanks is a major activity implemented under ARDQIP (NAQDA, 2008: 7). The national fisheries and aquatic resource policy of the government has given priority to develop aquaculture as an environmental-friendly, socially acceptable and market-driven industry. the private sector participation and foreign investments are encouraged especially in relation to ornamental fish culture, shrimp culture and inland aquaculture projects with community participation. The policy has given attention to restore the environment affected by shrimp farming by providing common infrastructure facilities and best management practices.

The plan is to minimise post-harvest losses, increase employment opportunities and improve the socio-economic status and increase foreign exchange earnings from the exportsof fish products (MFOR, 2006). Farming of red tilapia and shrimp in the Hambantota district, farming of ornamental fish and aquatic plants and rehabilitation of the Dutch Canal are the current projects coming under the National Fisheries and Aquaculture Resource Policy and Development Plan (NARA, 2001: 57).

Chapter Eight

Conclusions and Recommendations

8.1 Conclusions

8.1.1 Mollusk Culture

Site selection is of utmost importance to mollusk culture. Most of the coastal water bodies of Sri Lanka are polluted with industrial and domestic wastes. Mollusk could easily ingest heavy metals, bacteria and diano flagellates in water bodies. In addition, mollusk may contain harmful viruses viz Calici viruses, Hepatitis A virus and bacteria viz *E. coli spp*, *Salmonella spp* (Hernroth *et al*, 2005: 7) Therefore, consumption of mollusk may be lethal and involve a significant health risk for humans. The depuration of mollusk has to be done before consumption. Post-harvest handling is very important in mollusks for maintaining quality. Mussels are kept in moisture jute sacks when they are transported to nearby places to prevent exposure to heat and dry air. They should be packed in sealed polyethylene bags without water for a long distance journey. These bags should be kept in Styrofoam boxes containing ice. There should not be any contamination of mussels from ice during transportation for optimum quality and minimum mortality (Wanninayake, 1998: 1-10).

Environment pollution is low in mollusk culture but organic load could be accumulated in culture sites due to poor water exchange in shallow waters. Sometimes, there will be conflicts with local capture fisheries with regard to navigational rights. The experimental mussel culture was difficult in the Rumassala bay in Galle due to high tidal current and wave action during the southwest monsoon period (Wanninayake, 1998: 1-10). The consumption of mussels and oysters are not popular in the country except by foreign tourists. This could be popularised among local people through awareness programmes,while giving attention to development of the industry. Small-scale mollusk farmers in the Moratuwa area have established a farmer level organisation to get technical and financial support for mollusk farming activities.

8.1.2 Crab Fattening

At present, a commercial crab hatchery does not exist to provide seed stocks and commercial feed, as crab fattening is also not available in Sri Lanka. (Chin and Amandakoon, 1991: 165-169). There is limited availability of juveniles in the wild to collect as seed. The overexploitation of juveniles in the wild is a threat to biodiversity. The pollution of water bodies from domestic waste, urban sewage and industrial effluents has a direct effect on the reduction of crab population (Chin and Amandakoon, 1991: 165-169). Mortality is high in existing culture systems due to cannibalism and transport stress (Samarasinghe *et al*, 1991: 161-164). Wide variation in growth, poor meat yield due to molting cycle, difficulty in controlled production and government regulations on environment are the existing constraints on crab fattening in Sri Lanka (Chin and Amandakoon, 1991: 165-169). The recent proliferation of crab farms has resulted in the deterioration of water quality of the Negombo lagoon. Unionised ammonia, sulphate and moisture content of soil were high in crab fattening areas and it may affect the community, which depends on lagoon fisheries (Pathmi *et al*, 2003: 10).

8.1.3 Shrimp Farming

All shrimp hatcheries depend on wild brood stocks for post larval production. The inadequate supply of wild brood stocks to hatcheries is a current problem (Siriwardena *et al*, 1988: 123-145).

Post larval production is highly correlated with environmental parameters such as maximum temperature and rainfall. The hazardous environmental effect could be minimised in indoor hatcheries (Jayasinghe *et al*, 1994: 278-279). In disease situations, farmers are reluctant to continue farming activities. Therefore, the hatchery operation is becoming an unreliable industry and most of the hatcheries have ceased their production.

The best management practices have to be established for shrimp hatcheries in order to prevent disease outbreaks. The hygiene of incoming water should be thoroughly maintained in a hatchery using sand filters, charcoal, netting (10 micron) and ultraviolet filters. There must be a separate maturation area for brood stock tanks and another specified quarantine area for brood stock rearing. Brood stock is tested for WSSV (Using PCR) and treated with 50 ppm formalin for 15 minutes (200 ppm could be used for 10 minutes). WSSV negative brood stocks are kept in maturation tanks at the rate of 4 per square metre.

These tanks should be cleaned, properly maintained and free from any substratum viz sand and limestone. Crabmeat or any other crustacean meat should be avoided from feeding. Spawners also should be treated with formalin and tested for WSSV using PCR. The eggs and naupli should be destroyed if spawners are positive for WSSV. Separate tanks should be used for spawning, hatching and larval rearing. The eggs and naupli should be subjected respectively to 0.1 ppm and 200 ppm for 30-second formalin treatment. An algae room, artemia incubation room and small laboratory should be maintained inside the hatchery. The utensils of different sections should be in different colours, disinfected, washed thoroughly and sun dried before the next usage. Boots, footbaths and hand wash facilities should be provided for workers and visitors in hatchery premises. The wastewater should be directed to a sedimentation tank before discharge to the environment (Chandraratne, 2007: 2-5).

A majority of shrimp farms were built on pyrite soil in the inter-tidal zone. The pyrite oxidizes and pH depletes during pond construction. Heavy liming usually masks this condition. The oxidation process is stressful for the culturing organism and favourable to disease outbreaks (Jayasinghe, 1995: 357-376). The shrimp harvest is low in acid sulphate soil in comparison to non-acid sulphate soil. The total bacterial count of shrimp is high in acid sulphate soil including coliforms and fecal coliforms. Diseases viz antenna rot, black spot, blank gill, soft shell and tail rot have a direct relationship with soil acidity (Narayana *et al*, 1998: 17-18).

The main water resources for shrimp culture are presently over-exploited by shrimp farmers. Scarcity of water of required quality is one of the major constraints on shrimp culture. It is economical to cut down 30 percent daily water exchange level up to 20 percent. In addition, it will reduce the pressure on main water resources (Edirisinghe *et al*, 1997: 55-59). The reduction of water exchange rate to 20 percent has no effect on shrimp growth, plankton population, benthic production, total soil nitrogen, organic matter and soil Mg++ content (Wijesekara, *et al*, 1994: 52).

Costal water bodies of Sri Lanka are bar-built, typically shallow and pose elongated narrow mouths to connect with the ocean. Therefore, poor water exchange is observed with the ocean although the freshwater supply is mostly seasonal. The poor water exchange results in large daily temperature fluctuations and strong seasonal salinity variations (Arulananthan, 2005: 4). Development of high salinity in the water bodies is a climate related factor, which causes growth retardation of cultured shrimp. The favourable salinity range is 15-25 ppt (parts per thousand) for black tiger shrimp. But, the salinity goes up to 40 ppm in many months of the year of the Mundal Lagoon and the Dutch Canal (Jayasinghe, 1997a: 21-25). The typical Puttalam estuary is converted seasonally into a hyper saline estuary due to human interference (Arulananthan, 2005: 4). Deep wells are more suitable to maintain salinity in culture ponds. Yet, water treatment methods are needed to reduce iron and manganese levels before pumping water to culture ponds. Shallow well water should be treated to remove excess hydrogen

sulphide (Jayasinghe *et al*, 1995: 150-151). However, some studies have revealed that water recirculation is more suitable than the use of groundwater (Dissanaiyake *et al*, 1998: 7-8).

Feed cost is a critical factor determining the profitability of shrimp farming since 60 percent of the total input is for shrimp feed. This seems to be a great barrier for the development of small-scale operations (Siriwardena *et al*, 1988: 123-145). The most popular feed brands in the market are imported from Thailand, Taiwan and India. A few companies are producing shrimp feed locally. Research has revealed that manufactured feeds using locally available raw materials are equally successful in terms of economy of production than commercially available shrimp feed (Jayasinghe *et al*, 1995: 114). Wheat flour could be used as an effective binder for shrimp feed produced locally to minimise disintegration and loss of water-soluble nutrients (Gunawardena and Edirisinghe, 1995: 82).

The shrimp industry faces periodic disease outbreaks of bacterial, viral, parasitic and fungal origin. Luminescent vibriosis is a prominent hatchery disease causing up to 100 percent mortality of Penaeus monodon from zoea and mysis to post larval stages (Wijegoonawardena and Siriwardena, 1996: 127-139). The Vibrio species isolated from shrimp farms has shown biochemical characteristics similar to *V.angullarium, V.splendidus, V.harveyi and V.fesheri* (Priyanjith *et al*, 1995: 172-172). Apart from that, black spot, tail rot and filamentous bacterial diseases are reported in shrimp culture from time to time (Ahmed and Kumara, 2005: 113-115). Shrimp culture has experienced several viral epidemics in its short history, namely MBV (Monodon Baculow Virus) in 1989 (Jayasinghe and Macintosh, 1993: 336-346), SEMBV (Systemic Ectodermal and Mesodermal Baculovirus, White Spot Syndrome Virus) in 1996 (Jayasinghe, 1997a: 21-25) and mixed infection of SEMBV and Yellow Head Virus (YHV) in 1998 (Siriwardena, 1999: 79-84).

The SEMBV and YHV are OIE listed shrimp diseases (OIE listed diseases, 2007) introduced into the country through the illegal importation of infected post larvae and shrimp brood stocks. Some diseases, especially SEMBV, occurred recurrently in subsequent years causing heavy production losses. The loss due to SEMBV outbreak in 1996 was estimated as Rs 1000 million and 90 percent of the farmers ceased their farming activities (Jayasinghe, 1997a: 21-25). SEMBV has an effect in reducing the profit only up to the first month of culture cycle.

The profit could be assured if shrimp were protected in the crucial period (Kumari *et al*, 1998: 15-16). The protozoan parasites frequently cause disease, but are not serious as viral and bacterial infections. The disease causing protozoa includes *Zoothamnium, Epistylis and Vorticella*. The black gill is a fungal disease caused by *Fusarium spp, Lagenidium spp and Sirolipidium spp*. The former causes adult mycosis and the latter is involved in larval mycosis (Ahmed and Kumara, 2005: 115-116). The miscellaneous diseases are the result of nutritional deficiency, physiological disorders, pesticide exposure, poor water and soil quality or inadequate management practices. Soft shell syndrome and muscle necrosis are considered diseases of miscellaneous origin (Ahmed and Kumara, 2005: 117-118).

Over 90 percent shrimp farms are located around the lagoons of Chilaw, Mundel, Puttalam and the Dutch Canal, which are interconnected water bodies allowing the quick spread of viral diseases. The white spot syndrome virus could remain in brackish waters for two days. Some wild shrimp, common estuarine and sea crabs are considered carriers of this virus (Jayasinghe, 1997b: 1-9). A densely arranged farming system (Siriwardena, 1999: 79-84), location of farms on acid sulphate soils, bad management practices, relatively high stocking densities, poor water exchange (Jayasinghe, 1995: 357-375), pH fluctuation in a pond more than one unit per day and depleted dissolved oxygen levels to less than 2 mg L-1 are the factors favourable for SEMBV outbreaks (Siriwardena, 1999: 79-84).

The disease management options consist of water treatment methods, water exchange and use of feed supplements to enhance immunity. Water treatment is considered the main

preventive measure for SEMBV outbreaks. The construction of sedimentation tanks for incoming water will reduce ammonia, nitrite and biological oxygen demand. The oysters, mussels and seaweed are important to purify pond water biologically (Jayasinghe, 1997b: 1-9). Fish could be used to removing wild shrimp and crabs that are supposed to be the carriers of SEMBV. Filtering of incoming water using 60-holes in a square inch mesh is effective to trap wild shrimps and crabs. The retention of water in a storage tank for 3-4 days could minimise the spread of free-living virus.

Chemical treatment using chlorine is very effective against the carriers of SEMBV. Chlorine acts as a disinfectant and has no adverse effect on water quality (Wijesekera *et al*, 1994: 52). The effluents from shrimp farms should be discharged to a settlement pond to reduce suspended solids and nutrients. The settlement pond should be 10-20 percent of total pond area. It could also contain oysters and mussels to improve the quality of water (Jayasinghe, 1993: 21-24). The adaptation of water-recirculating methods is important to increase the survival rate and reduction of total bacterial counts including luminous vibriosis. In addition, it reduces the organic load in the pond and minimises disastrous environmental impacts (Narayana *et al*, 2003: 15-22). Buffer zones between farms with mangrove belt coverage could neutralise harmful substances within natural capacity (Jayasinghe, 1993: 21-24).

Water exchange and maintenance of a clean pond bottom would be the main hygienic measures to prevent bacterial, fungal and parasitic disease. Potassium permanganate, oxytetracycline and kenamycin are used to treat bacterial infections in hatcheries. These antibiotics are generally infective against luminous vibriosis. Formalin is effective to control protozoan parasitic diseases. Better pond preparation such as liming and drying can reduce disease incidence. Treflan is a fungicide used as a prophylactic treatment for larval mycosis (Ahmed and Kumara, 2005: 115-118). The use of chloramphenicol and nitrofuran is banned due to residual accumulation in shrimp tissues.

Maximum residual limits (MRL) are established for most of these chemicals by the European Union on food safety. Therefore, the disease management and control would have a more important role rather than chemotherapy. Development of resistant bacteria and drug residues in shrimp is a result of indiscriminate antibiotic usage (Ariyawansa *et al*, 1999: 22). Treating shrimp diseases at farm level is not practical, but chemicals could be used to induce molting. The soft shell syndrome could be managed by adequate nutrition, and use of quality soil and water. Low temperature, low oxygen level, salinity shock, overcrowding and severe gill fouling are considered reasons for muscle necrosis (Ahmed and Kumara, 2005: 117-118). The application of probiotics in culture ponds has a greater value in terms of reducing luminous vibriosis (Narayana *et al*, 2003: 15-22). Some farmers use sugar to control luminous vibriosis. Probiotics are used indiscriminately without proper technical guidance. The maintenance of water quality using probiotics has not shown the expected results (Corea, 2003: 8).

Best management practices have been introduced to chemical suppliers and importers for the shrimp industry. They include the registration and inspection of all suppliers, importers, and manufacturers under DAPH. Labelling must be done in all three languages. Proper guidelines must be clearly indicated — with the purpose of use, dosage, prior protection instructions, withdrawal period, active ingredients (common name and scientific name), country of origin and manufacture, batch number, stock number, date of manufacture, and date of expiry. A separate logo should be used to indicate that the product is for shrimp industry and to keep away from children. The chemicals must be stored under specified conditions with enough space, light and ventilation. All products must be stored separately without affecting the environment and without harm by fire and pests. These chemicals should not be stored with shrimp feed. The package should be water resistant. Storage conditions should be maintained during transportation and chemicals should not be transported with shrimp feed. Correct instructions should be given for proper handling and safety use.

Record keeping of chemical usage should be maintained in shrimp farms for inspection (Chandraratne, 2007: 2-5).

The total harvest has fallen to grade 2 in Sri Lanka as a result of poor post-handling and bad management practices at farm level (Ariyawansa *et al*, 1999: 22). Use of antibiotics, disinfectants and other chemicals are restricted. One meal for shrimp is stopped prior to harvest. Water change in ponds one week before — would stimulate molting at harvest. The harvesting is carried out in the morning or evening with minimum sunlight and heat to prevent dehydration. The duration of harvesting is less than 6 hours, with minimal physical damages by not keeping shrimp in nets or on pond bottom for a longer duration and maintaining general hygiene practices. Domestic animals such as dogs and cats should be allowed into the harvest site. Shrimps should be immersed in a solution of ice, water and salt immediately after harvest. Then shrimps should be kept in a 0.2-0.5 percent sodium meta-bysulphate solution according to the requirement of the purchaser. Finally, packing should be done in plastic containers with ice at a ratio of 2:1 ice and shrimp (Chandraratne, 2007: 2-5).

Health certificates are essential for export of fish and fishery products and the competent laboratories registered with the Ministry of Fisheries issue certificates. The total quantity of seafood exported under health certificates has declined by 8.8 percent in 2006 (NARA, 2006). The bacteriological quality of farmed shrimp is essential in assessing the standard of shrimp exports. During shrimp processing, the core body temperature should be maintained below 40C (Chandraratne, 2008: 2-5). International Commission on Microbiology Specification prohibits the contamination of shrimps with *E.coli and Salmonella spp* for Foods (Kumarasinghe *et al*, 1994: 56-57). The Post Harvest Technology Division of NARA has established a semi-quantitative ELISA technique to detect chloramphenicol in shrimp (Edirisinghe, 2005: 14). NARA should be armed with GC-MS (Gel chromatography–Massspectrometry) or LC-MS (Liquid chromatography-Mass spectrometry) facilities to detect drug residues of chloramphenicol and nitrofurans as well as their metabolites accurately in order to meet European standards. The European Union was the major market for fish and fishery products followed by Japan. Fresh fish is the major product exported under health certificates to specified countries (NARA, 2006).

The permissible standards of Central Environmental Authority (CEA) for water quality parameters should be in the favourable range of aquatic organisms for sustainable shrimp farming and minimising the environmental impacts (Wijesekera *et al*, 1998: 17). Rapid expansion of unauthorised small and medium-scale farms was the major reason for the deterioration of pond environmental and water quality of the major water bodies. The Dutch Canal was self-polluted and the water quality parameters were close to maximum tolerable level of *Penaeus monodon* (Corea *et al*, 1993: 423-427). The pollution of the Batticaloa lagoon by agricultural and industrial wastes resulted in hyper eutrophication (Arulananthan, 2005: 4). The unfavourable water condition of major water bodies seems to be the reason for the poor growth rate and disease conditions reported at farm level. Since, the beginning of the industry there was no proper zoning and more than 80 percent of shrimp farms are located in state-owned lands located in the inter-tidal zone.

Lack of proper zoning led to social problems such as reduced grazing land for domestic animals, seawater intrusions to the paddy fields and domestic wells, loss of groundwater and loss of traditional fishing grounds (Jayasinghe, 1995: 357-376). The destruction of ecologically sensitive mangroves areas and eradication of small mammals led to loss of biodiversity (Jayasinghe, 1995: 357-376). About 1,200 ha of mangrove land was destroyed in the north-western province as a result of shrimp farming activity (FAO, 2003). The effluent water from shrimp farms disturbed sea grass beds due to algal proliferation. These sea grass beds are important for sediment stabilisation and serve as nursery grounds for many aquatic fauna in the fisheries industry (Pahalawattaarachchi and Siriwardena, 2003a: 11). The environmental degradation related to shrimp culture was not quantified in terms of ecological importance and values

(Wijegoonawardena and Siriwardena, 1996: 127-139). The budget of 2005 had allocated funds for immediate infrastructure reconstruction and environmental protection of shrimp farming activities in 2005 (Central Bank of Sri Lanka Annual Report, 2004: 45). But, this effort has not shown the expected results.

The present strategies of shrimp farming are related to minimising the risk of devastating diseases. Avoiding problem soil areas, better pond preparation, techniques for testing post larval quality for diseases especially SEMBV using PCR (Polymerace Chain Reaction), change from intensive rearing practices to semi-intensive levels, improving the water supply systems using water treatment methods (chemical and biological), introducing closed recycle systems, use of sedimentation tanks for incoming water and wastewater are important to reduce disease outbreaks (Jayasinghe, 1997b: 1-9).

The Dutch Canal has not been maintained for the past 50 years and has become very narrow and heavily silted. Therefore, the restoration of the canal is of utmost importance (Corea *et al*, 1993: 423-427). Other than that, appropriate sterilisation of affected ponds, development of captive bred brood stock with high health standards, use of probiotics instead of antibiotics, farming of *Litopenaeus vannamei* rather than *Penaeus monodon* have been suggested to overcome present crisis in shrimp farming (Maguire, 2005: 28). A laboratory was established in Buttaluoya of the Puttalam district for water quality analysis in shrimp farming (Central Bank of Sri Lanka Annual Report,2007: 38).

A community-based management system established in the shrimp culture area would strengthen the unity of the farming community to work as a group - to control disease outbreaks. The Shrimp Farm Monitoring and Extension Unit of NAQDA, Zonal Shrimp Farm Association and adjacent shrimp farmers should be informed of disease ponds prior to harvesting. Young shrimps should be destroyed using chemicals under supervision of the relevant authorities. Large shrimps could be harvested using nets or by discharging water to empty ponds on the same farm. The movement of animal should be restricted to prevent the spread of dead shrimp containing pathogens. Water from disease ponds, water used for washing of dead shrimps, all utensils and workers should be disinfected with appropriate chemicals (Chandraratne, 2007: 2-5). NAQDA has established a cultivation calendar for shrimp farming in order to reduce diseases outbreaks (Central Bank Annual Report, 2007: 38).

Monitoring of environmental quality in the estuarine system and protecting its biodiversity is essential for eco-friendly shrimp farming. The help of several associations actively involved in the shrimp industry viz prawn farmers and exporters associations, shrimp breeders associations and small-scale shrimp farmers associations should be obtained to find solutions for current problems in shrimp culture. The Dutch Canal, being an artificial, unscientific construction, which converted freshwater from the Mundal Lake, is not a resource that can be sustainably maintained under the present situation. Therefore, the only way of having a sustainable shrimp industry is to have additional laws against the operation of illegal farms in the inter-tidal zone and allow closed farms only.

8.1.4 Aquatic Plant Culture

Some anthropogenic effects have threatened the aquatic plant biodiversity viz deforestation, sand mining, industrial waste, eutrophication, spread of exotic species and collection from the wild for commercial activities. The current regulations have banned wild collection of aquatic plants for commercial purposes. The lengthy procedures to get export permits, cause shortage of supply for export demand. Time-consuming enforcement methods and lack of skilled manpower to identify species are some major constraints (Corea and Jayasekara, 2003: 13). The exportation of potted aquatic plants, use of tissue culture methods for propagation (Jonathan, 1993; 37-38), increase in the growth rate, control of pests, genetic improvement

and development of new strains are useful to upgrade the industry (Corea, 2005: 9). A tissue culture laboratory was established in the Rambodagalle area for aquatic plant breeding (Central Bank of Sri Lanka Annual Report, 2007: 38). Sustainable harvesting from natural resources under rational management is the correct methodology.

8.1.5 Ornamental Fish Culture

Development of breeding and hatchery technology, genetic improvement and domestication are key factors to get good quality fish larvae (Jonathan, 1993: 4-17). Unavailability of good quality brood stocks is one constraint on ornamental fish culture. Some of the fish species develop less resistance to diseases and show deformations due to inbreeding. The breeding techniques used by Sri Lankan fish breeders are still in a primary stage (Haputanthri *et al*, 2001: 5-12). Most of them practise simple natural spawning methods. Still, fish breeders do not succeed in breeding valuable fish species such as Arowana (*Scleropages formosus*).

The reason may be the lack of training programmes in modern technology and knowledge, minimum facilities and the lack of research on fish breeding. Fish diversity is not enough to meet present demand in international trade (Jonathan, 1993: 4-17). New fish strains could be developed through cross breeding. For example — common carp and different varieties of goldfish (Edirisinghe and Vallipuram, 1996: 81). Most growers practise the monoculture system while only a few people have experience on more profitable poly culture systems, which maximise the use of pond resources with a few compatible species.

Generally, a feed carries 60–70 percent of the total production cost (Gunawardane and Edirisinghe, 1995: 149-150). Microencapsulated fatty acid boosters are recommended to enhance the nutritive value of live feeds fed to juvenile fish in order to improve general quality and growth (Jonathan, 1993: 4-17). Most of the artemia used in fish farms are very expensive and imported from foreign countries. Though, hatchability is comparatively low in the artemia produced locally, it is gradually getting popular. Artemia feeding has an effect on increasing the survival rate of fish species (Sumith Kumara *et al*, 2005: 45-52). Moina, Daphnia, Paramecium and micro worm are cheap live feeds used for larval feeding. Micro worm is a cheap feed with satisfactory performance (Parameshwaran *et al*, 2002: 62-67). It is used as a feed up to 20 days for goldfish and after that they could be cultured in waters fertilised with chicken manure (Parameshwaran *et al*, 2002: 60-71).

Chicken manure and cow dung used in a 1:1 ratio and artemia results in a significantly high growth rate in goldfish post-larvae at 150 PL/m3 stocking density (Sumith Kumara *et al*, 2005: 45-52). Chicken manure promotes plankton growth more than cow dung due to superior nutrient content. Chicken manure or cow dung could be used effectively at 1000 kg/ha as basal fertiliser on dry matter basis in outdoor concrete tanks without deteriorating water quality (Kumara *et al*, 2003: 242-253). Goldfish fry could be cultured successfully using chicken manure instead of formulated feed. It is very much cheaper to use chicken manure than conventional standard formulated feed in outdoor goldfish fry culture (Kumara *et al*, 2003: 242-253). Self-mixed feed at farm level is cheap but nutritionally unbalanced and low water stability. Feed binders are needed to increase water stability. Feed analysis and adjustment should be done timely to maintain nutritional quality. Preparation of feed for ornamental fish with tilapia fishmeal as the main protein supplement will benefit in terms of the economics of feeding (Gunawardane and Edirisinghe, 1995:149-150).

Expensive cod liver oil could be replaced using coconut oil or soya bean oil without causing significant growth reduction in guppy larvae (Parameshwaran *et al*, 2002: 62-67). Goldfish fry could be cultured in paddy plots using chicken manure, paddy straw and paddy husk charcoal as the only fertiliser for both fish and paddy. The marketable size fish could be produced in 8 weeks starting with 4 week-old fry by supplementing with chicken manure at 400 kg/ha

fortnightly. A high percentage of bright coloured goldfish and increased paddy yield could be obtained using this environmental friendly culture system (Jayaweera *et al*, 2007: 290-300).

Most small-scale farmers are unaware of water quality parameters and equipment used to measure water quality. Therefore, ornamental fish species are grown in suboptimal water conditions (Jonathan, 1993: 4-17). Water quality parameters should be in the favourable range for healthy growth and resistance to disease. At least, regional laboratories should be armed with water quality testing equipment. Colorimetric water testing kits are cheap and easy to use at farm level. Better harvesting, handling and packing techniques are required to minimise damages for producing best quality export fish (Jonathan, 1993: 4-17). Special attention should be paid to the volume of water, fish density and dissolved oxygen concentration.

Sri Lanka has to change its marketing strategies and packing methods for a healthy market share and to compete with Singapore in international trade (Central Bank of Sri Lanka Annual Report, 2001: 85). Two companies handle 50 percent of export volume (Ekarathne 2000: 3-8). Small-scale farmers have to comply with monopolistic terms and conditions. Low level of consumer awareness about the Sri Lankan product is the major constraint. Sri Lankan ornamental fish has little or no consumer market perception. Follow-up communication with international buyers and development of a Sri Lankan cultured ornamental fish "brand" should be used to maintain a healthy market share (Jonathan, 1993: 4-17). The introduction of ornamental fish at international exhibitions and media campaigns would be able to generate international recognition and interest.

Recently, the ornamental fish industry is experiencing disease outbreaks of bacterial, viral, parasitic and fungal origin. Most of the time, bacterial pathogens are causing infections, which are associated with viruses and fungi. Bacterial diseases caused by basically gram-negative bacteria include *Aeromonas* (Chandrakanthi *et al*, 2000: 29-42), *Vibrio* (Vasantha *et al*, 1995: 272-274), *Flexibacter* (Hettiarachchi and Hettiarachchi, 2002:116) and *Pseudomonas*. Although not confirmed, there is evidence on several fish viral diseases in the country. At present, Koi Herpes Virus (KHV) is spreading in the Asian region. It is an OIE (World Organisation for Animal Health) listed fish disease (OIE listed diseases, 2007). So, there is a potential threat to the industry (Balasuriya, 2006:4-6). The protozoan parasitic diseases include Trichodiniasis, Chilodoneliasis, Ichthyopthiriasis, Tetrahymenosis, Ichthyobodosis, Oodinium infestation and Hexamita infestation (Thilakaratne *et al*, 2003: 157-162). The metazoan parasitic diseases are Monogenean infestations (*Gyrodactylosis* and *Dactylogyrosis)*, Digenian infestations (*Centrocestus spp*), Nematode infestations (*Capillaria spp*), Cestode infestations and Copepod infestations (Argulosis and Lernaeasis) (Thilakaratne *et al*, 2003: 157-162).

Parasitic infections are common in fish farms located in the north- central province. Terahymina has become an outbreak in 1998 causing heavy losses in ornamental fish farming (Hettiarachchi and Hettiarachchi, 2003: 41-49). After that, there were sporadic outbreaks. The digenian trematodes have an indirect life cycle and are abundant in fish reared in mud ponds. Parasitism is the greatest threat in mud ponds as opposed to cement tanks. Treatment of diseases in the mud pond environment is rather difficult since it contains a significant amount of organic matter.

Fungi are opportunistic pathogens and sporadically cause problems. Saprolegniasis and Branchiomycosis are the main fungal diseases are found among ornamental fish species (Ahmed and Kumara, 2005: 28-31). The Epizootic Ulcerative Syndrome (EUS) is a fungal disease caused by *Aphanomyces invadans*. It was first reported in the late 1980s and many fish species were affected causing heavy production losses (Pathiratne and Rajapakshe, 1998: 203-211). After that, there were several disease outbreaks but of low virulence. EUS is the only OIE listed fish disease present in Sri Lanka (OIE listed diseases, 2007). The miscellaneous diseases of fish are non-infectious in origin. Deficiency diseases, deformities, gas bubble disease, neoplasm,etc,

could be considered miscellaneous disease (Ahmed and Kumara, 2005: 47- 53). Carp sleeping sickness is spreading in the Polonnaruwa area and has affected other areas as well (Hettiarachchi, 2004: 74). The causative agent is still unclear.

Most of the fish breeders and growers are not aware of fish diseases. They use their naked eye to diagnose fish disease of different origin and use chemotherapeutics blindly (Jonathan, 1993: 4-17). The widely used antibiotics are tetracycline, oxytetracyclin, chloramphenacol, sulphonamides (Subsainghe, 1992: 547-553) and amoxycillin. Indiscriminate usage of oxytetracycline and chloramphenacol are hazardous for fish immunity and haeamopoiesis (Kasagala, 2005: 70-76). Indiscriminate antibiotic usage is the main reason for development of resistant bacteria. Formalin, sodium chloride, copper sulphate, potassium permanganate and triple mixture (formalin, malachite green and methline blue) are the widely used anti-parasitic drugs. Trichlorphon (organophosphate) used to treat copepod infestations are now banned in aquaculture. Malachite green, copper sulphate formalin, potassium permanganate and methline blue are used to control fungal infections (Ahmed and Kumara, 2005: 28-33).

Fish disease diagnostic facilities have not been widely spread in the country and should be extended to the regional level through Veterinary Research Institute (VRI) and veterinary investigation centres (VICs) of the Department of Animal Production and Health (DAPH). VIC is a regional laboratory for animal disease diagnosis. The government has planned to establish VICs in all districts. It has direct contact with VRI and could establish a network on fish health. Inland Aquatic Resources and Aquaculture Division (IARAD) of NARA and NAQDA provides technical service and training to fish farmers on fish disease diagnosis, water quality management and fish nutrition. Presently, the Rambodagalle Centre of NAQDA is involved in ornamental fish breeding and conducts training programmes for fish farmers. NAQDA has extensive network of aquaculture extension officers.

The production loss due to predation is a disadvantage in mud pond fish culture. The harvest could be reduced up to 20 percent due to natural predation (Jonathan, 1993: 4-17). Birds, frogs, water snakes, wild carnivores and wild fish are the common predators. These predators could carry certain bacteria and parasites pathogens to culturing fish species. Therefore, additional cost has to be met for ultra-violet stabilised bird mesh netting, frog walls and nets to filter incoming water.

Many exotic fish species are introduced to the country as ornamental fish species. Sri Lanka has never practised a scientific quarantine procedure in the importation of exotic fish to the country (Edirisinghe, 1999: 63-70). Some of the exotic ornamental fish species spread to the natural environment and started self-recruitment. Knife fish (*Chitala ornata*) is a top predator inhabiting the Bolgoda Lake. The scavengers (Sucker mouth Catfish, *Hypostomus plecostomus*) are abundant in the Polgolla, Victoria, Parakrma Samudraya and in many other reservoirs. The threat is high due to spread of this alien fish in all Mahaweli ecosystems. Presently two carnivorous fish species viz Piranha and Catfish (*Clarias batrachus*) were imported to Sri Lanka as ornamental fish (Bambaradeniya, 2000: 25-32). Natural enemies are not present for these exotic fish species. Guppy is a prolific breeder and distributed in all aquatic ecosystems. It is a threat to most of the endemic fish species (Jayawardena *et al,* 2000: 308-315). Introduction of exotic species is a significant threat to fish biodiversity and necessary steps should be taken to prevent exotic fish from entering Sri Lanka ecosystems.

Nutrient and organic enriched wastewater from fish farms, which result in build-up of anoxic sediments, lead to changes in benthic communities and eutrophication of common water bodies. They are some of the negative environmental impacts related to ornamental fish culture. The exploitation of wild fish resources for export is a threat to biodiversity. Chemical pollution of water from agriculture and industries, urbanisation and environmental degradation from deforestation are the potential threats to ornamental fish industry.

The higher fish biodiversity, breeding endemic fish species, international reputation for quality ornamental fish exports and favourable government policies are supportive factors for ornamental fish culture (Wijesekara and Yakupitiyage, 2001: 241-252). Ornamental Fish Breeders and Exporters Association is the largest organisation in Sri Lanka that constitutes different stakeholders in the ornamental fish sector. At present, the formation of provincial level cooperative societies of ornamental fisheries is a favourable trend for the development of the industry.

8.1.6 Reservoir Fisheries

The former inland fisheries division did a significant contribution to the development of inland aquaculture through introducing exotic species, production of fish seeds and introducing community-based aquaculture in seasonal village tanks and perennial reservoirs. These key activities increased the inland fish production from 6000 mt in the mid seventies to 39,000 mt in 1990 (NACA, 2005: 4). The World Bank estimated that in 1990 the inland fisheries and aquaculture sector was contributing U$S 24 million per year to the rural economy of the country (FAO, 2003). However, the government withdrew state patronage for inland fisheries and aquaculture in 1990 and handed over the entire operation to the private sector. During that period, fishery stations were closed and some stations started ornamental fish farming.

The local fisheries organisations and government administration set-up in perennial tanks did not exist. As such the activity diminished and fishermen were engaged in over-fishing. Most of experts of the inland fisheries division left the field. It was a very dark period for inland aquaculture and fisheries sector. As a result, the annual inland fish production 40,000 mt in 1989 declined to 12,000 mt in 1994 (Athukorala and Amarasinghe, 2005: 5). However, state support was again given in 1994 and NAQDA was established in 1999 - to continue inland aquaculture and fisheries activities (Amarasinghe and de Silva, 1999: 87-399).

The annual seed requirement was 30 million fingerlings, but the present production is 3 percent of the demand (World Fish Centre, 2001). Scarcity of fingerlings is one of the major problems in inland aquaculture. It is necessary to strengthen the private sector participation in fingerling production to meet this demand. But, many of the fingerling producers stressed that there is no proper market channel for their products. However, only the solution to this would be the production of carp fingerlings post larvae in reservoir coves (Edirisinghe, 2008: 76). NAQDA has planned to establish 50 mini-hatcheries in most of the districts involved in food fish culture in order to resolve the scarcity of fingerlings. 21 mini-hatcheries were established in the mid 2007 (NAQDA, 2007).

Rainbow trout was introduced to Sri Lanka during the colonial period for sport fishery. Now it is found in the cold streams of Horton Plains National Park. Rainbow trout is considered a threat to endemic shrimps and endemic crabs in the area (Bambaradeniya, 2000: 25-32). The food fish species that are introduced to Sri Lanka — are not carnivorous. But, there would be competition with endemic fish species (Wijeyarathne, 1993: 61-73). Tilapia (*Oreochromis mossambicas*) was introduced to Sri Lanka without practising scientific quarantine procedure in 1951. Tilapia is a prolific breeder. *Oreochromis mossambicas* breeds the year around and spread all over the country due to its euryhaline nature (Edirisinghe, 1999: 63-70). Tilapia has a negative impact on the indigenous species on limited food availability (Wijeyarathne, 1993: 61-73). The recent declining of indigenous Tabalaya (Orange finned labeo, *Labeo porcellus*) population has a link with introduction of Rohu (Labeo rohita) (Wijeyarathne, 1993: 61-73). Improper introduction of exotics would lead to inter and intra species competition, especially in perennial reservoirs (Edirisinghe, 1983: 36-37).

These unscientific introductions have led to many alien pathogens entering the country (Edirisinghe, 1999: 63-70). The Epizootic Ulcerative Syndrome (EUS) was introduced to Sri Lanka

in the late 1980s and spread in major reservoirs causing death to millions of fish. The inland aquaculture and fisheries were affected adversely and caused severe environmental and social problems (Balasuriya, 2006: 4-6).

8.1.7 Aquaculture-base integrated farming system

It could be evident that for the development of the rural sector of Sri Lanka, a significant contribution should come from aquaculture mainly due to resource availability, accessibility and compatibility. It is unfortunate that these advantages of aquaculture are not reaped in a sustainable and rational manner. Therefore, it is of utmost importance to identify appropriate management strategies and develop an aquaculture-base integrated farming system specific to the particular rural community so as to alleviate poverty in Sri Lanka.

8.2 Key Recommendations

1. Resource availability, suitability for small-scale production and unmet demand are major advantages Sri Lanka has for further development of aquaculture. Though the consumption of mussels and oysters are not popular except amongst the foreign tourists, such habits could be popularised amongst the local people too through awareness programmes. It is unfortunate that these advantages of aquaculture are not reaped in a sustainable and rational manner. There is also the compelling need for diversifying and improving rural and smallholder farming sector incomes where aquaculture can play a significant role. Therefore, it is of utmost importance to identify appropriate management strategies and develop an aquaculture-base integrated farming systems appropriate for rural communities and localities to alleviate poverty.

2. Shrimp farming is highly profitable but capital intensive. However, this sub-sector has the potential for contributing to GDP significantly. High feed cost is a critical factor determining the profitability of shrimp farming and it presents a great obstacle for developing small-scale operations. Though a few companies are producing shrimp feed locally, the most popular feed brands in the market are imported from Thailand, Taiwan and India. As already noted, research has revealed that manufactured feeds using locally available raw material are equally effective in providing required nourishment for culturing shrimps at relatively a lower cost.

3. Monitoring of environmental quality in the estuarine system and protecting its biodiversity is essential for eco-friendly shrimp farming. For example, the Dutch Canal, being an artificial and unscientific construction that converts freshwater from the Mundal Lake is not a resource that can be sustainably maintained under the present condition. Therefore, the only method of having a sustainable shrimp industry is to introduce additional laws to prevent the operation of illegal farms in the inter-tidal zone — and to have closed farms.

4. The breeding techniques used by Sri Lankan fish breeders are still in a primary stage. The reason for this may be the lack of training programmes in modern technology and distribution of knowledge, minimum facilities and lack of research on fish breeding. Export fish diversity in Sri Lanka cannot meet present demand in international trade. Therefore, new fish strains should be developed through cross breeding.

5. Consumer awareness about the Sri Lankan product is low and communication with international buyers and development of a Sri Lankan cultured ornamental fish "brand" is advocated to maintain a healthy market share. The introduction of ornamental fish at international exhibitions and media campaigns should be launched to generate international interest.

6. Most of the fish breeders and growers are not aware of fish diseases. They use their naked eye to diagnose fish disease of different origin and use chemotherapeutics hastily. Fish disease diagnostic facilities are not widely spread in the country and should be extended to the regional level through VRI and VICs. The latter being the regional laboratories for animal diseases diagnosis, the government has planned to establish branches in all districts. They have direct contact with VRI and could establish a network on fish health.

7. The thréat to freshwater fish production is high due to the spread of alien fish in Sri Lankan ecosystems such as scavengers (Hypostomus plecastomus) in the Mahaweli eco-system. Other than that two carnivorous fish species viz Piranha and Catfish (Clarias batrachus) were imported to Sri Lanka as ornamental fish. Natural enemies are not present for these exotic fish species. Guppy is a prolific breeder and distributed in all aquatic ecosystems and is a threat to most of the endemic fish species. Necessary steps should be taken to prevent exotic fish from entering Sri Lanka ecosystems.

8. Nutrient and organic enriched wastewater from shrimp fish farms, which result in the build-up of anoxic sediments, lead to changes in benthic communities and eutrophication of common water bodies. These are some of the negative environmental impacts on shrimp and ornamental fish culture. The exploitation of wild fish resources for export is a threat to biodiversity. Chemical pollution of water from agriculture and industries, urbanisation and environmental degradation from deforestation are the potential threats to aquaculture industry.

9. Scarcity of fingerlings is one of the major problems in inland aquaculture. It is necessary to strengthen the private sector participation in fingerling production to meet the demand.

10. To increase the participation of the poor in aquaculture production, the government should launch programmes to develop methods and strategies suitable for local conditions such as poor people's resource conditions and their credit, extension, storage and marketing needs.

References

Ahmed, K and Kumara, W A G S ed. (2005), *Handbook on Fish and Crustacean Diseases in SAARC Region*, SAARC Agricultural Information Centre (SAIC).

Amarasinghe, U S and De Silva S S (1999), *'Sri Lankan Reservoirs: A Case for Introduction of Co-management Strategy', Fisheries Management and Ecology*, (6): 387-399.

Amarasinghe, O (1991), *'Some Economic Aspects of Integrated Livestock-Fish Farming in Sri Lanka,* Proceedings of the FAO/IPT Workshop on Integrated Livestock-Fish Production Systems', Institute of Advanced Studies, University of Malaya, Kuala Lumpur, Malaysia. www.fao.org.

Animal Disease Act No 59 of 1992, Democratic Socialist Republic of Sri Lanka.

Animal Disease (Control and Prevention) Regulations (1998), Democratic Socialist Republic of Sri Lanka.

Aquaculture Management (Disease Control) Regulations (2000), Democratic Socialist Republic of Sri Lanka.

Aquaculture (Monitoring of Residues) Regulations (2002), Democratic Socialist Republic of Sri Lanka.

Ariyarathne, M H S and De Silva P K (2003), *'Appropriate Technology for Rural Aquaculture Development in Sri Lanka through Community Participation'*, Proceedings of the First Scientific Session on Inland Aquatic Resources and Aquaculture, National Aquatic Research Development Agency, Colombo 15, Sri Lanka.

Ariyawansa, K W S Jayasinghe, J M P K Wijendra, N D and Hettiarachchi, K (1999), *'Antibiotic Sensitivity of Bacterial Isolates from Penaeus Monodon Cultured in Semi Intensive Systems'*, Proceedings of the 5th Annual Session Sri Lanka Association for Fisheries and Aquatic Resources.

Arulananthan, K (2005), 'Anthropogenic Effects on the Dynamics of Coastal Ecosystems in Sri Lanka', *Proceedings of the International Workshop on Fisheries and Aquatic Research in Sri Lanka,* National Aquatic Research Development Agency, Colombo 15, Sri Lanka.

Athukorala, D A and U S Amarasinghe, (2005), *'Introduction of Co-management Strategies for the Reservoir Fishery of Sri Lanka: Case Studies on Two Reservoirs'*, Proceedings of the international workshop on fisheries and aquatic research in Sri Lanka, National Aquatic Research Development Agency, Colombo 15, Sri Lanka.

Balasuriya, K (2006), *' The Major Challenge for Aquaculture in Sri Lanka'*, Aquaculture News, Ministry of Fisheries and Aquatic Resources, National Aquaculture Development Authority, Sri Lanka, (3): 4-6.

Bambaradeniya, C N B (2000), *'Alien Invasive Fauna in Natural Ecosystems of Sri Lanka'*, Proceedings of the symposium Alien Invasive Species of Sri Lanka: Impact on Eco system Management (B Marambe, ed) Ministry of Forestry and Environment and NASSL.

Bay of Bengal Programme (1989), *Seaweed Production and Utilisation around the Bay of Bengal,* Bay of Bengal News, Chennai, India.

Billard, R ed. (1999), *Carp Biology and Culture,* Springer-Praxis series in Aquaculture and Fisheries.

Board of Investment (BOI) Act (2002), Democratic Socialist Republic of Sri Lanka.

Central Bank of Sri Lanka (2007), *Annual Report,* Ministry of Finance, Colombo, Sri Lanka.
Central Bank of Sri Lanka (2005), *Annual Report,* Ministry of Finance, Colombo, Sri Lanka.

Central Bank of Sri Lanka (2004), *Annual Report,* Ministry of Finance, Colombo, Sri Lanka.

Central Bank of Sri Lanka (2003), *Annual Report,* Ministry of Finance, Colombo, Sri Lanka.

Central Bank of Sri Lanka (2001), *Annual Report,* Ministry of Finance, Colombo, Sri Lanka.

Chandrasoma, J (1988), *'Observation on Marketing of Fish Produced in Seasonal Tanks'*, Journal of Inland Fisheries, (4): 63-67.

Chandraratne, N (2007), *'Best Management Practices for Shrimp Culture'*, Aquaculture News, Ministry of Fisheries and Aquatic Resources, National Aquaculture Development Authority, Sri Lanka, (4): 2-5.

Chandrakanthi, W H S Pathiratne, A and Widanapathirana, S. (2000), *'Characteristics and Virulence of Aeromonas Hydrophila Isolates from Freshwater Fish with Epizootic Ulcerative Syndrome (EUS)'*, Journal of National Science Foundation of Sri Lanka, 28 (1): 29-42.

Chin How Cheong and Amandakoon, H P (1991), *'Statues, Constrains and Potential of Mud Crab Fishery and Culture in Sri Lanka'*, Report of the Seminar on the Mud Crab Culture and Trade, Swat Thani, Thailand.

Coast Conservation Act (1981), Democratic Socialist Republic of Sri Lanka.

Coast Conservation Act (1981, as amended in 1988), Democratic Socialist Republic of Sri Lanka.

Coast Conservation Regulations (1982), Democratic Socialist Republic of Sri Lanka.

Corea, A S L E Jayasinghe, J M P K Ekaratne, S U K and Johnstone, R (1995), *'Environment Impact on Prawn Farming on Dutch Canal: The Main Water Source for the Prawn Culture Industry in Sri Lanka'*, Ambio, No.7-8: 423-427.

Corea, A S L E Jayasekara, M S S Cooray (2003), *'Problem Encountered in Aquatic Animal Plant Trade,'* Proceedings of the First Scientific Session on Inland Aquatic Resources and Aquaculture, National Aquatic Research Development Agency, Colombo 15, Sri Lanka.

Corea, A S L E Jayasekara, M S S Cooray, N N E and Gunasinghe, P G (2003), *'Ornamental Plant Culture as a Cottage Industry,'* Proceedings of the First Scientific Session on Inland Aquatic Resources and Aquaculture, National Aquatic Research Development Agency, Colombo 15, Sri Lanka.

Corea, A S L E (2003), *'Recent Trends in Disease Management in Sri Lankan Shrimp Farming Industry'*, Proceedings of the First Scientific Session on Inland Aquatic Resources and Aquaculture, National Aquatic Research Development Agency, Colombo 15, Sri Lanka.

Corea, A S L E (2005), *'Overview of Aquatic Plant Industry and Future Needs'*, Proceedings of the International Workshop on Fisheries and Aquatic Research in Sri Lanka, National Aquatic Research Development Agency, Colombo 15, Sri Lanka.

Corea, A S L E and Jayasinghe, J M P K (2005), *'Future Strategies for Development of Shrimp Culture Industry'*, Proceedings of the International Workshop on Fisheries and Aquatic Research in Sri Lanka, National Aquatic Research Development Agency, Colombo 15, Sri Lanka.

Cosmetics, Devices and Drug Act (1980), Democratic Socialist Republic of Sri Lanka.

Cruz, C R (1990), *'The Pond Refuge in Rice-fish System'*; Aquabyte, 3 (2): 6-7.

De Alwis, A (1992), *'Aquatic Ornamental Plants of Sri Lanka'*; Viduruwa, 14 (2): 4-18.

Department of Primary Industries and Fisheries (DPIF) (2006), *Australian Prawn Farming Manuel*, The state of Queensland, Australia.

Department of Censes and Statistic (2007), Democratic Socialist Republic of Sri Lanka, official website, www.statistics.gov.lk.

De Silva S S John, M, Benedict, S, Devin, Band Rohana, S. (2003), *Inland Fisheries and Aquaculture: A Synergy for Sustainable Food Fish Production*, FAO Fisheries Circular No. 886 (Revision 2), FAO United Nations, Rome.

De Silva, K H G M (1992), *'Limnology and Fisheries of Three Recently Impounded Reservoirs in Sri Lanka'*, Proceedings of 2nd Asian Reservoir Fisheries Workshop, Hangzhou, People's Republic of China.

De Silva S Sena, Anderson A Trevor (1995), *Fish Nutrition in Aquaculture*, Chapman & Hall, London.

Dissanayake, B C S Jayasinghe, J M P K and Edirisinghe, U (1998), *'Impact on Water Management on Shrimp Health in Complete Recirculation and Semi Enclosed Systems'*, Proceedings of Anual Student Research Sessions, Faculty of Agriculture, University of Peradeniya.

Dissanayake, W A D C P, Hettiarachchi, M and Iqubal, M C M (2003), *'Tissue Culture Propagation of Ornamental Aquatic Plants, Cryptocorin Wendtii (wendi brown) and Echinodorous Cordifoious (marble queen)'*, Proceedings of Annual Research Symposium, Faculty of Graduate Studies.

Edirisinghe, U Weerasooriya, A C and Nathanael, S (2003) *'A Case Study: Managing Risk of Earth Fluctuation by Fisherman in a Small Perennial Reservoir (Ibbankatuwa) at Dambulla'*, Peradeniya University Research Sessions.

Edirisinghe, R (2005), *'Contamination Problems in Aquaculture Products- Chemotherapeutic Drugs,'* Proceedings of the International Workshop on Fisheries and Aquatic Research in Sri Lanka, National Aquatic Research Development Agency, Colombo 15, Sri Lanka.

Edirisinghe, U (1983), *'Is the Inland Fishery in Sri Lanka in Danger'*, The Postgraduate Agricultural Journal, (1): 36-37.

Edirisinghe, U and Vallipuram, T (1996), *'Cross Breeding Common Carp (Cyprinus carpio) and Goldfish (Carassius auratus L) by Hypophsation'*, SLAAS, 52 (1): 81

Edirisinghe, U Jayasinghe, J M P K and Wannigama, J P (1997), *'Evaluation of Presently Practised Water Exchange Rates on the Performance of Penaeus Monodon and on the Water Quality in Semi-intensive Culture Systems'*, Sri Lanka journal of Aquatic Science, 2: 55 –59.

Edirisinghe, U (1999), *'Ornamental Fish Culture as a Livelihood for Costal Region'*, Proceedings of the Workshop on Costal Resource Management in Sri Lanka, PGIA, University of Peradeniya, Sri Lanka.

Edirisinghe, U (2003), *'Sustainable Aquaculture Resource Management in the 21th century: Some Important Issues'*, Tropical Agricultural Research and Extension, (6): 122-127).

Edirisinghe, U (2008), *'Importance of Establishing a Carp-based Fishery with Co-management in Miner–perennial Reservoirs in Sri Lanka'*, 8th Asian Fisheries Forum Book of Abstracts, Kochi, India.

Ekarathne, S U K (2000), *A Review of the State and Trends of Exported Ornamental Fish Resources and their Habitats in Sri Lanka*, Bay of Bengal Programme, Chennai, India.

Fernando, C.H. (2000), *'A View of the Inland Fisheries of Sri Lanka: Past, Present and Future'*, Journal of aquatic science (5): 1-26.

Fisheries and Aquatic Resource Act No 2 of 1996, Democratic Socialist Republic of Sri Lanka.

Fish Product (Export) Regulations (1998), Democratic Socialist Republic of Sri Lanka.

Food and Agriculture Organisation of the United Nations (2003), *National Aquaculture Sector Overview - Sri Lanka, Department of Fisheries and Aquaculture*, Official web site, www.fao.org.

Food and Agriculture Organisation of the United Nations (2006), *The Statues of World Aquaculture and Fisheries*, Department of Fisheries and Aquaculture, Official web site, www.fao.org.

Food and Agriculture Organisation of the United Nations (2008), *Glossary*, Department of Fisheries and Aquaculture, Official web site, w.ww.fao.org/fi/glossary.

Food Act No 26 of 1980, Democratic Socialist Republic of Sri Lanka.

Funge, S S (1999), *'Small-scale Rural Aquaculture in LAO PDR (Part 11)'*, FAN Aquaculture Newsletter (22): 17-21.

Gunawardane, I M P K and Edirisinghe, U (1995), *'Potential uses of Locally Available Row Material for the Formulation of Ornamental Fish and Ornamental Fish Feed for Fingerling Culture'*, SLAAS, 51 (1): 149 –150.

Gunawardena, I M P K and Edirisinghe, U (1996), *'Investigation on Possibility of Using Wheat Flour as a Binder in Shrimp Feeds'*, SLAAS, 52 (1): 82.

Haputantri, S Perera, P A T C and Vidanage, S P (2001), *Development of Ornamental Fish Production and Culture for Increased Export Earnings and Employment Opportunities*, Socio- economic Market Research Division, NARA, Crow Island, Colombo 15, Sri Lanka.

Hernroth, B Allard, A Nenonen, N and Kronkvist, B (2005), *'Accumulation of Human Enteric Pathogen in Bivalves'*, Proceedings of the International Workshop on Fisheries and Aquatic Research in Sri Lanka, National Aquatic Research Development Agency, Colombo 15, Sri Lanka.

Hettiarachichi, D C and Hettiarachichi, M (2003), *'Some Growth Characteristics of Tetrahymena spp, A Parasite of Guppy, Poecilia Reticulate and the Effect of a Mixture of Two Commonly*

Used Protozoacides on its Population Density', Sri Lanka Journal Aquatic Science, (8): 41-49.

Hettiarachchi, M and Hettiarachchi, D C (2002), *'A Study on Columnaris Disease in Guppy, Poecilia reticulate'*, Proceedings of the 5th symposium on Diseases in Asian Aquaculture.

Hettiarachchi, M (2004), *'A Preliminary Study on the Sleeping Sickness in Ornamental Carp, Cyprinus Carpio'*, Proceedings of Annual Research Symposium, Faculty of Graduate Studies, University of Kelaniya.

Jayasinghe, J M P K (1993), *'Shrimp Culture in Sri Lanka; Immediate Profits or Sustainable Development'*, Annual Scientific Session, NARA, Crow Island, Colombo 15, Sri Lanka.

Jayasinghe, J M P K and Jayasekara, A M (1999), *'Aquaculture Research Needs and Priorities and Capacities in Sri Lanka'* Sri Lanka Journal of Aquatic Science, (4): 1-11.

Jayasinghe, J M P K and Macintosh, D J (1993), *'Disease Outbreak in the Shrimp Culture Grow Out Systems of Sri Lanka'*, Tropical Agricultural Research, (5): 336-346.

Jayasinghe, J M P K Sunil, W and Edirisinghe, U (1994) *'Economies and Performance of Shrimp Hatcheries'*, SLAAS, 50(1): 278-279.

Jayasinghe, J M P K (1995), *Report on Regional Study and Workshop on the Environment Assessment and Management of Aquaculture Development*, Food and Agricultural Organisation and Network on Aquaculture Centres in Asia-Pacific.

Jayasinghe, J M P K Perera, M D S De Alwis, P and Edirisinghe, U (1995), *'Utilisation of Ground Water Resources for Shrimp Culture: Assessment of Water Quality in Deep and Shallow Tube Well in Mahawawa Arachchikattuwa and Puttalam in the North Western Province of Sri Lanka'*, SLAAS,51(1):150-151.

Jayasinghe, J M P K (1997a) *'Shrimp Farm Performance and Financial Commitments Related to Disease Outbreaks, Sri Lankan Case'*, Economic Review, 23(6): 21-25.

Jayasinghe, J M P K (1997b), *Treatment System for Shrimp Culture*, National Aquatic Resources Research and Development Agency, Colombo 15, Sri Lanka.

Jayathilaka, P S Edirisinghe, U and De Silva, D D N (2003), *'Use of Clove Oil to Anaesthetise Female Wild Guppy (Poecilia reticulata) for Short Duration'*, Tropical Agricultural Research, (15): 235-241.

Jayawardena, J M C K Edirisinghe, U and Silva, L P (2000), *'Morphology Biology and Predatory Efficiency of Poecilla Reticulate for Mosquito Larvae'*, Tropical Agricultural Research, (12): 308-315.

Jayaweera, B P A Edirisinghe, U and Ranaweera, B (2007), *'Integration of Goldfish Culture with Organic Rice Farming,'* Tropical Agricultural Research and Extension, (19): 290–300.

Jonathan, K L Mee (1993), *An Overview of the Ornamental Aquatic Sector in Sri Lanka*, The Agro-Enterprise Development project Colombo Sri Lanka.

Kasagala, K H D T (2002), *Shrimp Industry in Sri Lanka, Environmental Technological Socio-Economic and Health Aspects*, BVSc. Undergraduate Thesis, Faculty of Veterinary Medicine, University of Peradeniya, Sri Lanka.

Kasagala, K H D T (2005), *Assessment of the Influence of Chloramphenicol and Oxytetracycline on HaemoPoiesis of Koi Carp, Cyprinus Carpio,* MSc. Thesis, University of Kelaniya, Sri Lanka.

Kithsiri, H M P Siriwardene, P P G S N and Hemalee Rupila, G R (2003), *'Captive Breeding of Some Endemic Ornamental Fish Species in Sri Lanka'*, Sri Lanka Journal of Aquatic Science, (8): 85-93.

Kumara, A G A S Edirisinghe, U and Dematawewa, C M B (2003), *'Effect of Chicken Manuer and Cow Dung on Water Quality,Pond Productivity, and Growth and Survival of Goldfish (Carassius auratus) Fry'*, Tropical Agricultural Research, 15: 242-255.

Kumarasinghe, L S Fonseka, T S G and Edirisinghe, U (1994), *'Some Microbiological Characteristics of Farmed Shrimp (Penaeus monodon) at Harvesting and Processing'*, SLAAS, 50(1): 56-57.

Kumari, H P C Jayasinghe, J M P K and Edirisinghe, U (1998), *'Shrimp Farm Performance in Different Agro-Climate Zones and Financial Constraints related to White Spot Disease Outbreak'*, Proceedings of the Annual Student Research Sessions, Faculty of Agriculture University of Peradeniya.

Kuruppu, M (1987), *Manuel on Artemia*, National Aquatic Research Development Agency, Colombo 15, Sri Lanka.

Kuruppu, M and Ekaratne, S U K (1995), *'Characterisation of Brine Shrimp Artemia from Sri Lanka'*, J Natn Coun, Sri Lanka 23 (4): 153-160.

Luu, T L (2001),*'Sustainable Aquaculture for Poverty Elevation (SAPA): A New Rural Development Strategy for Viet-Nam-part 1'*,FAN Aquaculture Newsletter (27): 12-17.

Maguire, B G (2005), *'Sustainable Marine Shrimp Farming'*, Proceedings of the International Workshop on Fisheries and Aquatic Research in Sri Lanka, National Aquatic Research Development Agency, Colombo 15, Sri Lanka.

Ministry of Environment and Natural Resources (2003), *Caring for Environment 2003-2007 Path to Sustainable Development*, Ministry of Environment and Natural Resource, Sri Lanka.

Ministry of Fisheries and Aquatic Resource of Sri Lanka (MFOR) (2006), The National Fisheries and Aquatic Resource Policy plan. www.priu.gov.lk.

Narayana, N M N K and Edirisinghe, U (1998), *'Evaluation of Bacterial Profiles of Shrimp Farm Treatment Systems and the Impact of the Use of Probiota Epicin on Shrimp Health and Farm Performance,'* Proceedings of the Annual Student Research Sessions, Faculty of Agriculture, University of Peradeniya.

Narayana, N M N K Jayasinghe, J M P K and Edirisinghe, U (2003) *'Evaluation of Bacterial Profiles of Farm Treatment Systems and the Impact of the Use of Probioties on Shrimp Health and Farm Performance'*, Sri Lanka Journal of Animal Production, 2: 15-22.

National Aquatic Resources Research Development Agency (2001) *Sri Lanka Fisheries Year Book*, Ministry of Fisheries, Colombo.

National Aquatic Resources Research Development Agency (2006) *Sri Lanka Fisheries Year Book*, Ministry of Fisheries, Colombo.

National Aquatic Resources Research Development Agency Act (Act No 54 of 1981), Democratic Socialist Republic of Sri Lanka.

National Aquaculture Development Authority (2007), Official web site. www.naqda.gov.lk.

National Aquaculture Development Authority Act (No 53 of 1998), Democratic Socialist Republic of Sri Lanka.

National Aquaculture Development Authority (2007), *Development of Freshwater Fisheries and Aquaculture*, Aquaculture News, NAQDA news letter (4): 1-8.

National Environmental Act No 47 of 1980, Democratic Socialist Republic of Sri Lanka.

National Environmental (Protection and Quality) Regulations (1990), Democratic Socialist Republic of Sri Lanka.

National Environmental (Impact Assessment) Regulations (1992), Democratic Socialist Republic of Sri Lanka.

National Environmental Regulations (1993), Democratic Socialist Republic of Sri Lanka.

National Environmental (Procedure for Approval of Project) Regulations (1993), Democratic Socialist Republic of Sri Lanka.

Network of Aquaculture Centres in Asia-Pacific (2005), Stream Country Paper, Sri Lanka, Bangkok, Thailand.

Network of Aquaculture Centres in Asia-Pacific (2008), Strengthening Capacity of Smallholder ASEAN Aquaculture Farmers for Competitive and Sustainable Aquaculture, Official web site, www.enaca.org.

NACA/FAO (Network of Aquaculture Centres in Asia-Pacific/Food and Agriculture Organisation of the United Nations) (2001), *'Aquaculture in the Third Millennium'*, Technical Proceedings of the Conference on Aquaculture in the Third Millennium, Bangkok, Thailand

North-eastern Regional Aquaculture Centre (1993), *An Introduction to Water Chemistry in Freshwater Aquaculture*, Massachusetts, Dartmouth, North Dartmouth, Massachusetts 02747.

North Western Province Environmental Statue, No 12 of 1990, Democratic Socialist Republic of Sri Lanka.

Pahalawattaarachchi, V and Siriwardana, P P G S N (2003 a), *'Effect of Shrimp Farm Effluents on Sea Grass Beds in Negombo Lagoon'*, Proceedings of the First Scientific Session on Inland Aquatic Resources and Aquaculture, National Aquatic Research Development Agency, Colombo 15, Sri Lanka.

Pahalawattaarachchi, V and Siriwardana, P P G S N (2003 b), *'Gracilaria edulis Farming as a Household Aquaculture Option for Costal Communities'*, Proceedings of the First Scientific Session on Inland Aquatic Resources and Aquaculture, National Aquatic Research Development Agency, Colombo 15, Sri Lanka.

Parameshwaran, K, Edirisinghe, U and Dematawewa, C M B and Nandasena, K G (2001), *'Effect of Live and Formulated Feed on Larval Growth and Survival of Guppy (Poecilia reticulata) in Indoor Tanks'*, Tropical Agricultural Research 13:421-430.

Parameshwaran, K, Edirisinghe, U and Dematawewa, C M B (2002), *'Replacement of Cod Liver Oil with Soybean or Coconut Oil Diets of Larval Goldfish, Carassius auratus L'*, Tropical Agricultural Research and Extension, 5 (1&2): 62 - 67.

Pathmi, A W S, Jayamanne, S C, Siriwardena, P P G S N, and Hirimuthugoda,Y (2003), *'Impact of Crab Fattening on the Lagoon Environment and the Livelihood of Fisheries in Negombo Lagoon'*, Proceedings of the First Scientific Session on Inland Aquatic Resources and Aquaculture, National Aquatic Research Development Agency, Colombo 15, Sri Lanka.

Pathiratene, A and Rajapakshe, W (1998), *'Haematological Changes Associated with Epizootic Ulcerative Syndrome in the Asian Cichlid Fish, Etroplus suratensis'*, Asian Fisheries Science, (11): 203-211.

Perera, N, Ehambram, S and Edirisinghe, U (1995), *'Evaluation of Different Acid Treatments and Fermentation Duration on Fish Waste'*, SLAAS, 50(1): 159-160.

Premarathne, S, Muthukuda, A and Edirisinghe, U (1995),*'Use of Shrimp Waste (Panaeusmondon) in Improving the Quality of Grass (Brachiaria brizantha) silage'*, SLAAS, 51(1): 155-157.

Priyanjith, S K D, Fonseka, T S G, Edirisinghe, U and Cyril, H W, (1995), *'Some Bio-chemical Characteristics of Vibrios Isolates from Diseased Shrimp (Penaeus monodon)'*, SLAAS, 51(1):172-173.

Samaranayake, R A D B (1986), *'States and Prospects for Brackish Water Aquaculture in Sri Lanka'*, Journal of Inland Fisheries, (3): 88-90.

Samarasinghe, R P, Fernando, DY and De Silva, O S S C (1991), *'Pond Culture of Mud Crab in Sri Lanka'*, Report of the Seminar on the Mud Crab Culture and Trade, Swat Thani, Thailand.

Siriwardene, P P G S N, Alwis De A, and Dias, K U (1988), *'Shrimp Farming in Sri Lanka: Present State and Future Strategies'*, Journal of Inland Fisheries ,(4): 123-145.

Siriwardene, P P G S N (1999), *Shrimp Culture in Sri Lanka: The Benefits, Problems and Constraints Associated with the Development and Management and Responses to Address Problems*, FAO Technical Consultation on Policies for Sustainable Shrimp Culture, Bangkok, Thailand.

Subasinghe, R P (1992), *'The Use of Chemotherapeutic Agent in Aquaculture Sri Lanka,' Proceeding of the Symposium on Disease in Asian Aquaculture, Fish Health Section*, Asian Fisheries Society, Manila.

Sugunan, V V (1997), *Fisheries Management of Small Water Bodies in Several Countries in Africa, Asia and Latin America*, FAO Fisheries Circular No 933FIRI/C 933 FAO, United Nations, Rome.

Sumith Kumara, A G L A, Edirisinghe, U, Dematawewa, C M B and Perera, K A (2002), *'Determination of Compensatory Growth in Goldfish (Carassius auratus) fry'*, Tropical Agricultural Research, (14): 60-71.

Sumith Kumara, A G L A, Edirisinghe, U and Dematawewa, C M B (2005), *'Effect of Stocking Density and Application of Chicken Manure and Cow Dung on the Growth of Goldfish (Carassius auratus) Post Larvae'*, Tropical Agricultural Research and Extension, (8): 45-52.

Sundarabarathy, T V, Edirisinghe, U and Dematawewa, C M B (2004), *'Captive Breeding and Rearing of Fry and Juveniles of Cherry Barb (Puntius titteya Deraniyagala), a Highly Threatened Endemic Fish Species in Sri Lanka'*, Tropical Agricultural Research, (16): 137-149.

Thayaparan, K (1982), *'The Role of Seasonal Tank in the Development of Freshwater Fisheries in Sri Lanka'*, Journal of Island Fisheries, (1): 133-167.

Thenmoli, V S, Edirisinghe, U and Dematawewa, C M B (2005), *'Breeding and Larval Rearing of Threatened Endemic Fish Stonesucker, Garra Ceylonesis (Bleeker)'*, Journal of Aquatic Research, (36): 196-201.

Tennakoon, K S B, Sirisena, K K G and Seneveiratne, P R P (1988), *'Some Observations on the Seasonality of Production of Seeds of Chinese and Major Carps in Sri Lanka'*, Journal of Inland Fisheries, (4): 43-61.

Thilakaratne, I D, Rajapaksha, G, Hewakopara, A, Rajapakse, R P and Faizal, A C (2003), *'Parasitic Infections in Freshwater Ornamental Fish in Sri Lanka'*, Diseases in Aquatic Organisms, (2): 157-162.

Vasantha, G K H and Hettiarachchi, M (1995), *'The Pathogeneticity of Freshwater Vibrio spp on Ornamental Fish, Pterophyllum Scalarae (angelfish),'* Proceedings of the 51 th Annual Sessions of the Sri Lanka Association for the Advancement of Science.

Vincke, M M J (1991), *'Integrated Farming of Fish and Livestock: Present and Future Development, Proceedings of the FAO/IPT Workshop on Integrated Livestock-Fish Production Systems'*, Institute of Advanced Studies, University of Malaya, Kuala Lumpur, Malaysia. www.fao.org.

Wanninayake, W M T B (1998), *Raft Culture of Brown Mussel, Perna Perna in the Rumassala Bay, Galle, Sri Lanka,* National Aquaculture Research Development Agency, Crow Island, Colombo 15, Sri Lanka.

Wen Young Tseng (1987), *Shrimp Mariculture: A Practical Manuel,* Department Fisheries, the University of Papua New Guinea, Port Monesby, Papua New Guinea.

Wijesekera, R G S, Jayasinghe, J M P K and Edirisinghe, U (1994), *'Effect of Water Exchange Rate on Benthos, Planktons and Soil Quality in Giant Tiger Prawn (Penaeus mondon) Cultured in Outdoor Ponds'*, SLAAS, 50(1) 52.

Wijesekara, R G S, Jayasinghe, J M P K, Dassanayake, S, and Edirisinghe, U (1998), *'Water Quality Conditions in Main Water Sources and Eeffluent for Shrimp Culture: Need for Revision with the Central Environmental Authority (CEA) Standards'*, Proceedings of the First Annual Session of the Sri Lanka Association of Animal Production.

Wijesekara, R G S, Yakupitiyage, A (2001), *'Ornamental Fish Industry in Sri Lanka: Present State and Future Trends'*, Aquarium Science and Conservation, (3): 241-252.

Wijeyarathne, M J S (1993), *Conservation of Freshwater Fish Biodiversity in Sri Lanka, Conservation and Sustainable Development*, School of Natural Resources and Environment, University of Michigan.

Wijegoonnawardena, P K M and Siriwardena, P P G S N (1996), *'Shrimp Farming in Sri Lanka: Health Management and Environmental Considerations,* Proceedings of the Regional

Expert Consultation on Aquaculture Health Management in Asia and the Pacific.

Wijenayake, W M H K, Jayasinghe,U A D, Amarasinghe,U S, Athula, J A , Pushalatha, K B C and De Silva, S S (2005), *'Culture-based Fisheries in Non-perennial Reservoirs in Sri Lanka: Production and Relative Performance of Stocked Species'*, Fisheries Management Ecology, (12):249-258.

World Fish Centre (2001), *Sustaining Fisheries and Aquaculture Production to benefit poor household in Asia,* ICLARM, Penany, Malaysia., www.worldfishcenter.org.

World Organisation of Animal Health (2007), Official web site, www.oie.int

Annex 01

The Fisheries and Aquatic Resources Act No 2 of 1996 - Related Sections to the Study

AS ACT TO PROVIDE FOR THE MANAGEMENT, REGULATION, CONSERVATION AND DEVELOPMENT OF FISHERIES AND AQUATIC RESOURCES IN SRI LANKA; TO REPEAL THE FISHERIES ORDINANCE (CHAPTER 212), THE CHANK FISHERIES ACT (CHAPTER 213), THE PEARL FISHERIES ORDINANCE (CHAPTER 214) AND THE WHALING ORDINANCE (CHAPTER 215) ; AND TO PROVIDE FOR MATTERS CONNECTED THEREWITH OR INCIDENTAL THERETO.

Be it enacted by Parliament of the Democratic Socialist Republic of Sri Lanka as follows : -

Act Nos,
2 of 1996 [11th January , 1996]
4 of 2000 [14th February , 2000]
4 of 2004 [21st January , 2004]
[11th January , 1996]

Short title

1. This Act may be cited as the Fisheries and Aquatic Resources Act No 2 of 1996.

PART I
ADMINISTRATION

Appointment of Director-General and other officers . [2,4 of 2000]

2.

(1) There shall be appointed-

(a) a person, by name or by office, to be or to act as the Director-General of Fisheries and Aquatic Resources (hereinafter referred to as the "Director - General") ;

(b) one or more persons, by name or office, to be or to act as Director of Fisheries and Aquatic Resources: and (c)such other officers as may from rime to time be required for the purpose of this Act.

(2) The Director-General shall be responsible for the administration and giving effect to the provisions of this Act.

(3) Any person appointed under sub-section (1) to be or to act as a Director of Fisheries and Aquatic Resources may, subject to the control of the Director - General, exercise ail or any of the powers conferred upon the Director- General by or under this Act.

(4) All officers appointed under this section shall on deemed to be public servants within the meaning of the Penal Code.

(5) All officers (not below the rank of Preventive Sergeant) appointed under this section shall be deemed to be peace officers within the meaning and for the purposes of the Code of Criminal Procedure Act, No 15 of 1979.

Establishment of Fisheries and Aquatle Resources Advisory Council .

3.

(1) There shall be a Fisheries and Aquatic Resources Advisory Council (hereinafter referred to as the "Council") which shall consist of-

(a) the Secretary to the Ministry of the Minister appointed under Article 44 of the Constitution to whom the subject

of Fisheries and Aquatic Resources has been assigned, who shall be the Chairman of the Council ;

(b) the Director;

(c) the Director of Fisheries of each Province;

(d) the Director in charge of the National Institute of Fisheries Training ;

(e) the Director in charge of planning of the Ministry of the Minister who shall be the Secretary of the Council ;

(f) the Chairman of the National Aquatic Resources Research and Development Agency ;

(g) the Chairman of the Ceylon Fisheries Corporation established under the State Industrial Corporations Act ;

(h) the Chairman of the Ceylon Fishery Harbours Corporation established under the State Industrial Corporations Act;

(i) the Chairman of the Central Environmental Authority established by the National Environment Act No 47 of 1980 ;

(j) the Director of Coast Conservation ;

(k) the Chairman of the Sri Lanka National Federation of Fisheries Co-operative Societies Ltd ;

(l) two persons engaged in fishing nominated by the Sri Lanka National Federation of Fisheries Co-operative Societies Ltd.;

(m) the President of the Fishery Products Exporters Association ;

(n) the Chairman of the Association of Live Ornamental Fish Exporters of Sri Lanka ;

(o) two representatives of women engaged in fishing ;

(p) six other members appointed by the Minister herein after referred to as " appointed members" from among persons who shall have special knowledge and experience in matters relating to the fisheries industry or other scientific disciplines.

(2) The Council may invite such other persons as it may think fit to attend its meetings as observers.

(3) A person shall be disqualified from being appointed or continuing as an appointed member of the Council-

(a) if he is, or becomes, a Member of Parliament ; or

(b) if he is not, or ceases to be, a citizen of Sri Lanka

(4) Every appointed member of the Council shall, unless he vacates office earlier or is removed from office by the Minister under subsection (5), hold office for a period of three years and shall be eligible for reappointment.

(5)The Minister may remove from office any appointed member of the Council without assigning any reason therefore.

(6) In the event of the vacation of office of any appointed member, or his removal from office under the provisions of subsection (5), the Minister shall appoint another person to hold such office for the unexpired period of the term of office of his predecessor.

(7) If any appointed member is temporarily unable to discharge the duties of his office due to ill-health or absence from Sri Lanka or for any other cause, the Minister shall appoint some other person to act in his place.

(8) Subject to the provisions of this Act, the Council shall make rules regulating the procedure in regard to its meetings and the transaction of business at such meetings.

(9) No act or proceeding of the Council shall be invalid by reason only of the existence of a vacancy in the Council, or any defect in the appointment of a member of the Council.

Functions and responsibilities of the Council

4. Subject to the provisions of this Act, the functions and responsibilities of the Council shall be-
(a) to advise the Minister on all matters relating to the management, regulation, conservation and development of fisheries and aquatic resources in Sri Lanka waters;
(b) to consider, and advise the Minister on, such other matters as the Minister may refer to the Council for advice; and
(c) to advise the Director on all such matters relating to the administra tion of this Act, as he may refer to the Council for advice.

Fisheries management and development plan.

5. The Secretary to the Ministry of the Minister shall, in consultation with the Council, cause to be prepared from time to time a plan for the management, regulation, conservation and development of is heries and aquatic resources in Sri Lanka.

PART IV

PROTECTION OF FISH AND OTHER AQUATIC RESOURCES

Prohibition against the use or possession of poisonous of explosive substances.
[2, 4 of 2004]

27.

(1) No person shall -

(a) use or attempt to use any poisonous, explosive or stupefying substance (including dynamic) or other noxious or harmful mater or substance in Sri Lanka Waters for the purpose of poisoning, killing, stunning or disabling any fish or other aquatic resources;
(b) carry, or have in his possession any poisonous, explosive or stupefying substance (including dynamite) or other noxious or harmful material (not being a fishing net) or any substance for any purpose referred to in paragraph (a)
(2) No person shall land, sell, buy, receive, possess or transport any fish or other aquatic resources knowing of having reasonable cause to believe that such fish or other aquatic resources have been taken by the us of any poisonous, explosive or stupefying substance (in - cluding dynamite) or other noxious or harmful material or substance.
(3) No person shall place, deposit, dump or cause the escape of, poisonous, explosive or stupefying substance (including dynamite) or other noxious or harmful mate- rial or substance in Sri Lanka Waters

Prohibited fishing gear water engage method.
Catching and possession

28. No person shall use or possess, or have on board any local fishing boat, any prohibited fishing gear or en- gage many any prohibited fishing method in any area

prohibited fishing & of Sri Lanka Waters.

c. Presumption. 29. No person shall catch, land, transport, sell buy, receive or have in his possession, such species of prohibited fish, or other aquatic resources as may be prescribed,

[3, 4 of 2004] 29A. In any prosecution for an offence referred to in section 27, it shall be presumed, unless the contrary is proved, that such poisonous, explosive or stupefying substance (including dynamite) or other noxious or harmful material or substance was used, carried or possessed for any of the purposes referred to in section 27.

Prohibition or regulation of export and import of fishing. 30.

(1) The Minister may in consultation with the Minister in charge of the subject of Trade, by Order published in Gazette, and having regard to the need to protect the aquatic resources of Sri Lanka, prohibit or regulate the export from, or import into, Sri Lanka of any species of fish including live fish or any eggs, roe or spawn or any products prepared from such fish, eggs, roe or spawn at other aquatic resources for such period of time as may be specified in the Order.
(2) This section shall have effect as though it formed part of the Customs Ordinance, and the provisions of that Ordinance shall apply accordingly.

Fishers Management area 31.

(1) The Minister May, by Order published Gazette -

(a) designate prescribed areas of Sri Lanka Waters or land adjacent thereto or both such waters and land as fisheries management areas for the purposes of this Act;
(b) designate the fisheries committee established section 32 in respect of any fisheries management area as the fisheries management authority of that area; and
(c) where two or more fisheries committees have been established in respect of any fisheries management area, establish, by Order punished in the Gazette a fisheries management authority for that area consisting of not more than twelve members drawn equally from each of those committees.
(2) A fisheries management authority designated or established by an Order made under subsection (1), may make recommen dations to the Minister on-

(a) the conduct of fishing operations and the use of different types of fishing gear in that fisheries manage ment area ;
(b) the establishment of closed seasons for fishing or closed seasons for the taking of specified species of fish in that fisheries management area; and
(c) the times during which fish may be taken,

Fisheries Committees.

32. (1) Registered fishermen residing or engaged in fishing in each fisheries management area or part thereof, or migrant fishermen may form themselves into a fisheries committee.

(2) The functions of a fisheries committee shall include-

(a) formulating a fisheries programme for its area and implementing that programme ;
(b) assisting its members to obtain boats, gear, and equipment to be used in fishing operations;
(c) carrying out social infrastructure and welfare activities with a view to improving the living standards of the fishing community of that area; and
(d) engaging in such other activities as are approved by the Director as beneficial to the fishing community of the area.

(3) The Director may, on application by any fisheries committee, register such fisheries committee and shall publish in the Gazette a notification of such registration.

(4) From and after the date of registration of a fisheries committee under sub-section (3) such committee shall be a body corporate with perpectual succession and a common seal and may sue and be sued by the name by which it is registered.

(5) Regulations may be made in respect of the election of office hearers of such committee and the procedure for the transaction of business by such committee and the audit of such accounts by the Director or an officer authorised by him in that behalf.

(6) The Director may cancel the registration of any fisheries committee if he is satisfied, after holding such inquiry as he may deem fit, that the fisherie committee has been inactive or has failed to conduct itself in the interests of its members.

(7) The Director shall, where he cancels the registration of a fisheries committee, appoint a person to be liquidator of that fisheries committee who shall have the power to-

(a) take possession of the books, documents and assets of the fisheries committee;
(b) sell the property of the fisheries committee ;
(c) decide any question of priority among the creditors of the fisheries committee;
(d) compromise any claim by or against the fisheries committee with the prior approval of the Director; and
(e) arrange for the distribution of the assets of the fisheries committee in the prescribed man ner.

(8) in the acqisition of any fisheries committee, its funds on applied first to the cost of liquidation and then to the discharge of its liabilities .Any surplus remaining after the closure of the liquidation shall be credited to the Consolidated Fund.

Register of fishermen.

33. (1) Every fisheries committee shall, in the prescribed manner and form, prepare, revise and maintain a register of fishermen residing or engaged in fishing, within the area of authority of such committee:
Provided, however, that the first register of fishermen residing or engaged in fishing within the area of authority of such committee shall be prepared and certified by the Director.
(2) Regulations may be made in respect of the procedure to be followed in the preparation and revision of the register referred to in subsection (1) Such regulations shall provide-

(a) for any person who claims to be entitled to have his name entered in such register and whose name is not entered therein to apply to the fisheries committee to have his name en tered in such register;
(b) for any person whose name is entered in such register and who objects to the name of any other person appearing therein to apply to the fisheries committee to have that name removed from such register;
(c) the procedure to be followed by the fisheries committee in the determination of such applications; and
(d) for appeals to the Director from the determinations of a fisheries committee on any claims or objections made to such committee.

Minister to declare closed or open season for fishing.

34. (1) The Minister may, by notice published in the Gazette declare a closed season or an open season-

(a) for fishing in such areas and times as may be specified in the notice; and
(b) for taking, in such areas of such species of fish, as may be specified in the notice.

(2) Every notice referred to in sub-section (1) shall be published in Sinhala, Tamil and English in three or more national newspapers and shall be displayed in a conspicuous place or places in the area or areas in respect of which the closed or open season for fishing or the taking of specified species of fish has been declared.
(3) No person shall, during a closed season declared under subsection (1)-

(a) fish to the area or areas specified In the notice; or
(b) take, in such area or areas, any species of fish specified in the notice.

Use of fishing boats for research or scientific purposes.

35.

(1) The Director may give written permission authorising any local fishing boat to be used for research operations, experimental fishing or scientific investigations relating to fish and aquatic resources in Sri Lanka Waters.

(2) The Director may in giving permission under sub-section (1), attach such conditions as he may think fit regarding the conduct of such research operations, experimental fishing or scientific investigations.

(3) Nothing in section 6 shall apply in respect of any local fishing boat operating under the authority of, and in accordance with, the written permission of the Director given under sub-section (1).

(4) Nothing in section 31 or 34 shall apply to any person operating any local fishing boat under the authority given under sub-section (1), or to any person operating any foreign boat under the authority of, and in accordance with the written permission of the Director given under sub-section (1) of section 12 of the Fisheries (Regulation of Foreign fishing Boats) Act No 59 of 1979.

PART VI

AQUACULTURE

Leasing of State lands.

38. Subject to the provisions of the Crown Lands Ordinance there shall be leased, such portions of, State land or the Sri Lanka Waters as the Minister may consider necessary in the interest of the national economy, for the purpose of aquaculture.

Licensing aquaculture enterprises.

39.No person shall set up or operate an aquactiture enterprise except under the authority of a licence granted under section 40.

Application for licence.

40.

(1) Every application for a licence under section 39 shall be made in the prescribed form to a Licensing Officer of the Administrative District in which the aquaculture enterprise is to be operated and shall be accompanied by the prescribed fee.

(2) If there is no Licensing Officer appointed for the Administrative District in which the aquaculture enterprise is proposed to be operated, the application may be made to the Director.

(3) On receipt of an application under subsection (1) or (2) the Licensing Officer or the Director, as the case may be, shall either grant a licence for the operation of the aquaculture enterprise referred to in the application or, for reasons to be recorded by him, refuse to grant a licence for such operation.

Form and duration of the licence.

41. Every licence granted under this Part shall-

(a) be in such form as may be prescribed;
(b) unless it is cancelled earlier, be in force for a period specified in the licence ; and
(c) be subject to such terms and conditions as may be imposed for the protection of the environment.

Renewal of licence. 42. (1) A licence granted under this Part of this Act shall be renewable on application being made to the Licensing Officer or the Director as the case may be, and on payment of the prescribed fee, not less than thirty days before the expiry of the licence.
(2) A licence shall be renewed by the Licensing Officer or the Director as the case may be, only if he is satisfied that-

(a) the licensee has observed the terms and conditions of the licence; and
(b) the continuance of the aquaculture enterprise would not harm the environment.

Cancellation of licence. 43. The Licensing Officer or the Director as the case may be, may cancel a licence granted under this Part if he is licence under this part if he is satisfied.

(a) that the licensee has contravened any of the provisions of this Act or regulations made thereunder or any terms and conditions of such licence ;
(b) that the license has been convicted of an offence under this Act;
(c) that the continuance of the aquaculture enterprise would have the environment.

Settlement of fishing disputes, 44. (1) When any fishing dispute arises or is apprehended, such dispute may be referred by the Director to an Authorised Officer for inquiry.
(2) When a fishing dispute is referred to an Authorised Officer under sub-section (1) he shall summon the parties to the dispute and endeavour to settle the dispute by conciliation.
(3) If the Authorised Officer succeeds in settling a fishing dispute, a memorandum setting out the terms of settlement shall be drawn up by him and shall be signed by the parties to the dispute or by their representatives. Such terms of settlement shall be binding on the parties to the dispute.
(4) If the Authorised Officer fails to effect a settlement, he shall proceed to hear the parties to the dispute and their witnesses and shall determine such dispute.
(5) Any person who is affected by a fishing dispute or by any matter relating to connected with or arising from such dispute, which is the subject matter of an inquiry before as Authorised Officer shall be entitled to be present at such inquiry and to make oral or documentary representations relating to such dispute.
(6) It shall be the duty of the Authorised Officer to prepare a report containing his findings upon the matters inquired into and such recommendations as he may consider necessary in regard to those matters and the rights restrictions or prohibitions which should be conferred or imposed pertaining to the taking of fish in the waters relating to which the dispute arose or is apprehended or any other related matter. Such report shall be read out at the conclusion of the inquiry. The parties to the dispute and any other person who is affected by such report shall be entitled to obtain a copy of such report on payment of the prescribed fee.

(7) The Authorised Officer shall endeavour to conclude the proceedings taken under this section within a period of one month from the date on which the dispute is referred to him where he takes a longer period for such proceedings he shall record

(8) The Minister may make regulations providing for the procedure to be followed at an inquiry held under this section.

(9) Any person who is affected by any fishing dispute into which an inquiry is held under this section, or by any matter relating to, connected with or arising from that dispute may, before the expiration of a period of one month from the date of the report in relation to that dispute, make representations in writing to the Minister on any matter dealt with in the report.

(10) The Minister after considering the report prepared under subsection (8) in respect of any fishing dispute and any representations made to him under subsection (9) with reference to that report, may-

(a) make order canceling the registration of any fishing net or fishing gear and the owner thereof registering in place of such fishing net or fishing gear and the owner thereof any other fishing net or fishing gear and the owner thereof ;

(b) make regulations regarding the subject matter of that dispute or any matter relating thereto or connected therewith or arising there from, including regulations for the purpose of-

(i) prohibiting, restricting or regulating the tabing of fish in any specified part of Sri Lanka Waters by persons not belonging to any specified group or section of persons specified fishing boats, fishing gear and methods; or

(11) Nothing in the preceding provisions of this section shall be deemed or construed to authorise the refer ence there under of any dispute In relation to he subject matter of which any civil action or other civil proceed ing is pending before any court of competent jurisdic tion.

Interim Orders in respect of fishing disputes.

45.

(1) Where the Minister apprehends that any fishing dispute which has been referred for inquiry and report under section 44 is likely to result in a breach of the peace, he may by Order published in the Gazette, make all such provisions in respect of the matters referred to in paragraphs (b) (i) and (ii) of subsection (10) of that section as he may deem necessary to prevent such breach of the peace.

(2) Any Order made by the Minister under subsection (I) in respect of any fishing dispute shall come into force on the date of its publication in the Gazette and shall cease to be in force on the date of the coming into force of regulations, if any, made by the Minister under section 44 (10) in respect of that dispute.

Annex 02

The List of Freshwater Fish Species Prohibited from Export in Live Form

Prohibited from Export in Live Form	
Family	**Fish Species**
Cyprinidae	*Labeo fisheri*
	Labeo porcellus
	Puntius asoka
	Puntius martenstyni
	Puntius srilankensis
	Puntius bandula
	Rasbora wilpita
	Malpulutta kretseri
Gobidae	*Schismatogobius*
	Deraniyagalai
	Sicyopterus halei
	Sicyopus jonklaasi
	Channa orientalis
Cobitidae	*Lepidocephalichthys jonklaasi*

The List of Freshwater Fish Species Restricted from Export in Live Form

Restricted from Export in Live Form	
Family	**Fish Species**
Cyprinidae	*Danio patirana*
	Puntius cumingii
	Puntius nigrofaciatus
	Puntius titteya
	Rasbora vaterifloris
Claridae	*Clarias brachysoma*
Belontidae	*Belontia signata*
Mastacembelidae	*Macrogonthus aral*

Source: Export and Import of Live Fish Regulations of 1998

List of Species of Freshwater Fish Prohibited from Import in Live Form

Family	**Lctaluridae**
	Lctalurus punctatus
	Lctalurus forcatus
	Lctalurus catus
	Lctalurus nebulosus
	Pylodictis olivaris
Family	**Characidae**
	Serrasalmus nattereri
	Serrasalmus hollandi
	Serrasalmus eigenmani
	Serrasalmus notatus
	Serrasalmus striolatus
	Serrasalmus elongates
	Serrasalmus gibbus
	Serrasalmus sanchezi
	Serrasalmus spilopleura
	Serrasalmus antoni
	Serrasalmus rrhombeus
	Serrasalmus serrulatus
	Catoprion mento
Family	**Notopteridae**
	Notopterus notopterus
	Notopterus chitala
	Notopterus afer
	Notopterus blanci
	Chitala blanci
	Chitala ornate

Source: Export and Import of Live Fish Regulations of 1998 and Extraordinary Gazette Notification No 1273/ 6:27/01/2003