FAO
FISHERIES AND
AQUACULTURE
TECHNICAL
PAPER

ISSN 2070-7010

509

Analysis of aquaculture development in Southeast Asia

A policy perspective

Cover photographs:

Clockwise from top left:

Floating market on Lake Inle, Myanmar. Credit: © FAO/22506/L. Lizzi; Filtering water at Ayong Farm (Lampung, Indonesia). Credit: courtesy of A.D. McKinnon © Australian Institute of Marine Science; Fish trap to sink into the water, wait for the fish to gather above and then hoist with the fish inside. Prek Toal, Battambang, Cambodia. Credit: © FAO/24414/J. Thompson; The use of soy as a feedstock in the aquaculture industry. Credit: courtesy of Ohio Soybean Council.

Analysis of aquaculture development in Southeast Asia

A policy perspective

FAO
FISHERIES AND
AQUACULTURE
TECHNICAL
PAPER

509

by

Nathanael Hishamunda
Fishery Planning Officer
Fisheries and Aquaculture Economics and Policy Division
FAO Fisheries and Aquaculture Department
Rome, Italy

Pedro B. Bueno
Advisor
Network of Aquaculture Centres in Asia-Pacific (NACA)
Bangkok, Thailand

Neil Ridler
FAO Visiting Expert, Professor of Economics
University of New Brunswick
Saint John, Canada

and

Wilfredo G. Yap
Aquaculture-Based countryside Development Enterprises Foundation Inc.
Pasig City, Metro Manila, the Philippines

FOOD AND AGRICULTURE ORGANIZATION OF THE UNITED NATIONS
Rome, 2009

ISBN 978-92-5-106339-2

Preparation of this document

This report was prepared in the framework of the ongoing efforts of the FAO Fisheries and Aquaculture Department to reduce food insecurity and poverty by promoting aquaculture as a sustainable economic activity through, inter alia, collecting and disseminating success and failure stories from different parts of the world. Southeast Asia has a long history of aquaculture, but rapid expansion did not start until after the mid-1970s, with output of food fish exceeding five million tonnes in 2005 and the region producing a significant proportion of the world aquaculture output in terms of volume and value. In addition, the sector continues its expansion. However, there has been no uniform pattern of aquaculture development across countries in the region. Thus, because of its contribution to food security, rural livelihoods and foreign exchange in the region, it is important to understand why and how aquaculture developed to a commercial level in some countries and failed to do so in others, and to ascertain whether this growth is likely to continue in the future. In a region that has experienced such a rapid expansion of aquaculture output and where aquaculture development is uneven, there are successes and failures. Both of these can provide invaluable lessons from which countries within and outside the region can learn. The study aims at achieving these two goals: identifying how commercial aquaculture developed and learning from experience in individual countries. Information reported in this document comes from reports which were commissioned in each of the seven countries studied. These reports, which resulted from analysis of existing documentation and interviews with some of the major players in the sector including policy-makers/government officials, farm managers, domestic sellers of aquaculture products, processors of aquaculture products, exporters of aquaculture products and consumers, were headed by national experts, either in academia or in government. Workshops were later organized to analyse and compare results.

Abstract

This paper aims to understand the factors which have enabled aquaculture to reach a commercial level in many countries in Southeast Asia and constrained it in others. While aquaculture has had a long history in Southeast Asia, its rapid expansion began in response to market demand, both domestic and international. In most countries, aquaculture developed because entrepreneurs were able to benefit from these profit opportunities; government involvement was minimal. Aquaculture was endorsed by governments as a source of livelihood or of export earnings but not promoted with the generous incentives that other countries in the region now offer. The most recent expansion of aquaculture in the region has still been driven by the profit incentive but this time it has been accompanied by government involvement. In some cases, governments have been pro-active, deliberately promoting the sector with incentives, motivated by the sector's contribution to economic development, food security and the balance of payments. In other instances, governments maintain an enabling role but, having learned from earlier mistakes in the region, they intervene with regulations to limit laisser-faire excesses. Although further development could be limited by the unavailability of land and fresh water, shortage and price of good quality feed, adequate energy supply and its rising cost, pollution and environmental degradation problems and limited expertise among government officials, aquaculture is likely to remain important in Southeast Asia for many more years ahead

Hishamunda, N.; Bueno, P.B.; Ridler, N.; Yap, W.G.
Analysis of aquaculture development in Southeast Asia: a policy perspective.
FAO Fisheries and Aquaculture Technical Paper. No. 509. Rome, FAO. 2009. 69p.

Contents

Figures

Foreword

Availability and access to information are one of the key factors to development. This paper aims at sharing positive and negative experiences, especially in terms of development policies, in aquaculture in Southeast Asia – a region where aquaculture produces more than 10 percent of the world's volume of farmed fish, maintains 12 percent of the world aquaculture value (and 25 percent without China), employs millions of people, contributes up to 5 percent of some countries' gross domestic product and supplies significant quantities of fish as food to a region that relies heavily on fish for food and protein. The report was prepared by Dr Nathanael Hishamunda of the Development and Planning Service of the FAO Fisheries and Aquaculture Economics and Policy Division, assisted by Pedro B. Bueno of the Network of Aquaculture Centres in Asia-Pacific (NACA), Professor Neil Ridler, a visiting scientist from the University of New Brunswick, Saint John, Canada and Wilfredo G. Yap of the Aquaculture-Based Countryside Development Enterprises Foundation Inc., Pasig City Metro Manila, Philippines. I would like to recognize them for achieving this outstanding job. The information contained in this report draws heavily upon a compilation and analysis of national reports which were prepared by Srun Lim Song, Chin Da and Jennifer O'Brien of the Inland Fisheries Research and Development Institute, Ministry of Agriculture, Forestry and Fisheries, for Cambodia; Kisto Mintardjo of the Indonesia Directorate of Aquaculture, for Indonesia; Nik Abdul Wahab Mat Diah, Senior Fisheries Officer, for Malaysia; Win Latt, for Myanmar; Jose O. Paclibare of the Philippines Bureau of Fisheries and Aquatic Resources, for the Philippines; Kamchai Lawonyawut, Senior Research Officer at the Thai Directorate of Fisheries, for Thailand; and Nguyen Xuan Cuong, researcher at the Research Institute for Aquaculture (RIA) No. 1 Aquaculture Development Planning for Watershed Areas of Thai Nguyen province, for Viet Nam. Françoise Schatto-Terribile (FAO Fisheries and Aquaculture Information and Statistics Service) and Olivia Liberatori and Diego Valderrama (Development and Planning Service of the FAO Fisheries and Aquaculture Economics and Policy Division) contributed valuable editorial work to the manuscript. It is my belief that the information included in this report will be of significant importance to countries within and outside Southeast Asia as they strive to develop aquaculture.

Jean François Pulvenis de Séligny
Director, Fisheries and Aquaculture Economics and Policy Division
FAO Fisheries and Aquaculture Department

1. Introduction

1.1 RATIONALE AND OBJECTIVES

Aquaculture output has been increasing rapidly in Southeast Asia, especially in the most recent 15 years or so. Total aquaculture output (which includes aquatic plants) increased from less than two million tonnes in 1990 to more than seven million tonnes in 2005. Moreover, the region's pace of expansion has accelerated. From 2000 to 2006, annual average growth rates in output more than doubled those from 1990 to 2000.

Of the seven countries in Southeast Asia included in this study, namely Cambodia, Indonesia, Malaysia, Myanmar, the Philippines, Thailand and Viet Nam, all but Cambodia, with its productive inland fisheries, ranked among the top twenty five countries in terms of aquaculture volume (FAO, 2007a). Excluding aquatic plants, in 2005 Viet Nam alone accounted for 3 percent of world tonnage, and Indonesia and Thailand each about 2.5 percent. Together, the seven countries accounted for more than 10 percent of the world output of fish where "fish" includes all output except aquatic plants. Over the last ten years, their combined output has doubled. In terms of aquatic plants, five of the seven are among the top dozen producing countries, with the Philippines accounting for 9.1 percent of world volume and Indonesia 6.2 percent. Output of aquatic plants from the seven countries combined has also doubled over the last decade.

The importance of aquaculture in the region goes beyond its relatively high contribution to world aquaculture output. Fish products are important in the diet of much of Southeast Asia. The population generally has a high per capita consumption of fish. Fish is also a major source of animal protein in a region where levels of animal protein are below the world average. The capture fisheries have shown increased output (at about 2.8 percent annually since 1990), but growth rates are slowing. Maintaining present levels of per capita consumption of fish among the seven countries, whose average population is projected to grow by 16 percent by 2015, requires continued expansion of aquaculture. Most aquaculture takes place in fresh water environments and most of the cultured species are consumed domestically. Hence, aquaculture offers the potential to provide food fish to the growing population. Farmed species such as carp, milkfish and tilapia, are already important sources of animal protein in the region. Presently, aquaculture accounts for a quarter of all food fish produced among the seven countries as a region.

Aquaculture also provides rural employment and income. More than half a million people are employed in aquaculture in Viet Nam; capture fisheries do not employ as many people. For Vietnamese policy-makers, with plans to double aquaculture output by 2010 (to two million tonnes), aquaculture is a tool for rural diversification – providing jobs and an alternative to urban migration. By 2010, projections are that three million people (at least 50 percent of them women) will be employed in aquaculture. It is also a sector with promising export potential. Viet Nam forecasts that the value of aquaculture exports will increase and earn US$3 billion by 2010. In terms of the value of their aquaculture production, the seven countries combined earned almost US$10 billion in 2005, only a small proportion of which (2.7 percent) came from aquatic plants (FAO, 2007a).

This short discussion shows that, because of its contribution to food security, rural livelihoods and foreign exchange, aquaculture is an important sector in Southeast Asia. It also indicates that it is a growing sector. However, there has been no uniform pattern of aquaculture development in the region. Thus, the sector merits study.

More specifically, there is a need to understand why and how aquaculture developed to a commercial level in some countries and failed to develop so rapidly in others. In other words, questions arise as to what were the main enabling and/or disabling factors of aquaculture development across the region. It is equally useful to know if this growth is likely to continue in the future.

This report attempts, therefore, to answer these questions. In a region that has experienced such a rapid expansion of output and where aquaculture development is uneven, successes and failures can provide lessons from which to learn. This paper seeks to uncover these lessons, which may be useful not only to countries in the region, but also to other countries elsewhere that Endeavour to develop aquaculture.

1.2 METHODOLOGICAL APPROACH

To obtain the information contained in this document, a report was commissioned in each of the seven countries studied. These reports were headed by national experts, either in academia or in government. Workshops were later organized to analyse and compare results.

At the national level, the research was completed by adopting a commodity-by-commodity approach where possible; otherwise a sector[1] approach was used.

For each commodity, information/data was obtained through existing documentation and through interviews with some of the major players in the sector. These included policy- makers/government officials, farm managers, domestic sellers, processors and exporters of aquaculture products and consumers. Authors of the national reports also used other sources of information and their own knowledge of the sector/commodity. Hence, unless otherwise indicated, all the information contained in this report is a result of synthesis of the seven national reports, which will not be referenced herein.

1.3 ORGANIZATION OF THE REPORT

After the introductory chapter, this paper presents a historical perspective of aquaculture in the region, discusses the physical importance of the sector, analyses its socio-economic performance and explores the governance of the sector in terms of policies, laws and regulations, ending with a summary and conclusions. It is in this last section that the future of aquaculture in the region is discussed and lessons learned are presented.

Throughout this report, two terms will be used that need clarification. The first is the term "commercial aquaculture". For the purposes of this document, commercial aquaculture is defined as aquaculture that is business-oriented, the goal being to maximize profit (Ridler and Hishamunda, 2001). The second is the term "region". This term will be used synonymously with the seven countries that are included in the study (Cambodia, Indonesia, Malaysia, Myanmar, the Philippines, Thailand and Viet Nam). Three countries from Southeast Asia, namely Brunei Darussalam, the Lao People's Democratic Republic and the Republic of Singapore, were omitted from this study because they have not developed significant commercial aquaculture industries. It is worth noting that the seven countries covered by the study dominate Southeast Asia's aquaculture production, where they represent more than 98 percent of the (aquaculture) output. They also account for about as much of Southeast Asia's population. Thus, for the purposes of this report, the seven countries represent the Southeast Asia "region" reasonably well.

[1] In this context, commodity refers to species; sector means aquaculture.

2. Historical development

There is a lack of documentary evidence to indicate how, when or where, aquaculture started in the region.

For the continental part of Southeast Asia, which includes Cambodia, Lao People's Democratic Republic, Myanmar, Thailand and Viet Nam, aquaculture probably had its start inland, most likely as part or an extension of the rice paddies, as it happened in China. This would explain why fresh water aquaculture is an important, or even the dominant, type of aquaculture. It would also explain why brackishwater aquaculture had a relatively late start in these countries. In fact, real development of brackishwater aquaculture in the region came only in response to the shrimp fever, which gripped the region in the 1980s in the case of Thailand (and China), and only in the mid-1990s in Viet Nam.

On the one hand, aquaculture may have started in Thailand as early as 1691 (Tarnchalanukit, 1974). However, the earliest reference to rice-fish farming in the region, in the form of an inscription on a stone tablet from the Sukhothai[2] period which says "There were rice in the fields, fish in the water" (MacKay, 1992), may be an indication that aquaculture started earlier than 1691. In fact, it would be safe to hazard that harvesting fish from the rice fields is as old as rice farming in puddle fields and that what is now known as rice-fish farming was the norm rather than the exception during the pre-pesticide and pre-HYV (high yielding varieties) days. It is very plausible that harvesting fish from rice fields, or what is termed by Coche (1967) as "captural system of rice-fish farming", could have developed into deliberate stocking of fingerlings in rice fields. The stocking started probably with wild-caught stock and eventually progressed to hatchery-bred fingerlings once breeding technology became available. It may never be known with certainty whether fresh water fish culture in Southeast Asia developed independently from that of, or was introduced from, China where both archaeological and documentary evidence indicate that rice-fish farming was already practiced 1 700 years ago (Li, 1992; Cai, Ni and Wang, 1995). Ali (1992), citing Tamura (1961), wrote that rice-fish culture was introduced to Southeast Asia from India some 1 500 years ago.

On the other hand, Indonesia and the Philippines always had a well-developed brackishwater aquaculture industry, centuries before there was a strong demand for marine shrimps (Rabanal, 2000). In fact, in terms of quantity, milkfish was and continues to be the major species cultured in coastal ponds in both countries. Fresh water aquaculture in Indonesia is also large and robust and may likely have a long history. Nevertheless, no documentary evidence can be found to indicate whether it preceded or followed brackishwater aquaculture.

It is generally believed that brackishwater fishponds had their origins in the island of Madura or in East Java. It is equally assumed that the practice spread to what is now the Philippines which, after all, was part of the Madjapahit Empire which was centered in Java. Herre and Mendoza (1929) cited the Dutch author C. Th. van Deventer as having recorded that a Javanese law codified in 1400 A.D. already provided punishment for "him who steals from a *tambak*." They noted that the ancient style of fishponds continued until 1921 in Mactan Island, Philippines.

In the Philippines, aquaculture was definitely for a very long time synonymous with milkfish culture in brackishwater fishponds. Aquaculture in inland waters is a very

[2] A Thai kingdom which flourished 700 years ago.

recent development. Early Philippine literature on fisheries prior to the 1950s does not have any mention of fresh water aquaculture (Rabanal, 2000). The first exotic foodfish with potential for aquaculture was the common carp (*Cyprinus carpio)* which was introduced in 1915 from Hong Kong, now China, Hong Kong Special Administrative Region (China, Hong Kong SAR) (Villaluz, 1953), but the specimens introduced were stocked in the swamps and fresh water lakes of Mindanao in 1916 and 1918. Thus, fresh water aquaculture development in the Philippines appeared to have its real start with the introduction of the Mozambique tilapia (*Oreochromis mossambicus*) from Indonesia in 1950 (Villaluz, 1953). A decade later, there were no more than 14 531 ha of fresh water fishponds in the Philippines compared to about 239 320 ha of brackishwater fishponds (BFAR, 2001). A significant upsurge in fresh water aquaculture production came only with the introduction of fish pens in the mid-1970s (Delmendo and Gedney, 1974) and of fish cages very soon thereafter.

Up to the middle twentieth century, aquaculture in Southeast Asia was limited to the common carp (*C. carpio*) and other cyprinids, the silver barb (*Puntius gonionotus*), the climbing perch (*Anabas testudineus*) and the giant guorami or sepat Siam (*Trichogaster pectoralis*) in fresh water farms; milkfish (*Chanos chanos*) in brackishwater farms; and oysters in marine waters. The green mussel (*Perna viridis*) used to be considered a nuisance in Philippine oyster farms until its value as a crop in itself was realized in 1955 by staff of the then Bureau of Fisheries (Yap, 1999). It was probably already cultured in Thailand in the 1960s since there was also an attempt to bring Thai mussel stock into the Philippines in the late 1960s.

While the Mozambique tilapia (*O. mossambicus*) has been in Indonesia for some time, the Nile tilapia (*Oreochromis niloticus*) came to Southeast Asia only in the 1960s. Until the resurgent post-war Japanese economy boosted market demand for shrimps, the jumbo tiger shrimp (*Penaeus monodon*) had always been an incidental harvest in the Philippine Punong and Indonesian tambaks.[3] In turn, starting in the late 1960s, this demand fuelled the development of the technology to produce *P. monodon* fry in hatcheries and to raise it as a primary crop. Work on all the other species now being cultured such as the grouper (*Epinephenus* sp.), seabass (*Lates calcarifer*) and the mangrove snapper (*Lutjanus argentimaculatus*), soon followed. There is no coincidence in the timing. It seems the infrastructure and human resources developed to build the technology for shrimp culture went into work on many other important marine species as well. Expanding to other species was merely a logical development and served to optimize the use of the research and development infrastructure which was established due to the high demand for marine shrimps.

[3] Brackishwater ponds used for rearing herbivorous fishes in Indonesia.

3. Analysis of aquaculture supply

3.1 CONTRIBUTION OF AQUACULTURE TO REGIONAL AND NATIONAL TOTAL FISH SUPPLY

3.1.1 Contribution to the region's fish supply

Aquaculture's contribution to the region's fish[4] supply and its growing role as a source of food are illustrated in Figure 1.

As Figure 1 shows, capture fisheries are the major source of fish production, and output from the capture fisheries doubled from 1980 to 2005. From a much smaller base, fish aquaculture output increased seven fold from 1980 to 2005, and tripled from 1990 to 2005. Its annual average rate of growth accelerated to reach 14 percent from 2000 to 2005. Thus, in spite of large absolute increases from the capture fisheries, the share of aquaculture in total production has grown. From about 10 percent of the region's total fisheries production in 1980, aquaculture's share increased to about 13 percent in 1990, 17 percent in 2000, and 26 percent in 2005. By 2005, therefore, more than a quarter of total production of foodfish came from aquaculture.

3.1.2 Contribution to national fish supplies

Table 1 illustrates the relative importance of aquaculture among the seven countries in the region in 2000 and 2005.

Not all seven countries in the region are equally dependent on aquaculture. Cambodia and Malaysia have a small aquaculture sector relative to other countries and also to their capture fisheries. The share of aquaculture in total fish production in Cambodia is the lowest at 6.3 percent, even though its capture fisheries are small. Yet, the importance of aquaculture has increased. From 2000 to 2005 aquaculture output almost doubled and that is reflected in its share of total production. Aquaculture, however, is important in Indonesia, Myanmar, the Philippines, Thailand and Viet Nam. Myanmar and Viet Nam in particular, but also Thailand, saw large increases in the share of aquaculture in total production from 2000 to 2005. Indonesia's aquaculture sector is larger than that of Myanmar, but so is its capture fisheries; hence their share of fish production is approximately equal. Viet Nam's aquaculture output, excluding aquatic plants, is the largest and is reflected in the share. Almost half of Viet Nam's fish production comes from aquaculture, and this has also increased sharply.

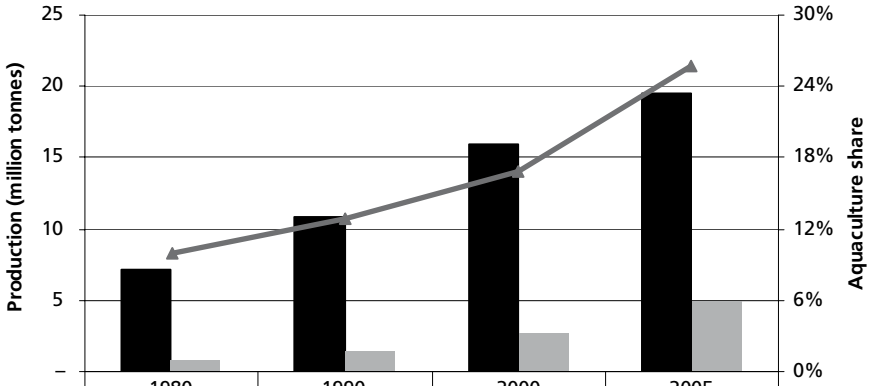
There is no single explanation for this expansion; nor have all countries experienced the same growth. Cambodia's aquaculture output is small and its aquaculture remains a marginal sector. This is partly topographical, but also a reflection of past political upheavals and an unwillingness to encourage the private sector because of ideology. The country also has a well established inland capture fishery, which has reduced the need to promote aquaculture.

Aquaculture is neither a priority in Myanmar, where the sector is subordinate to agriculture in land use conflicts. Over the last ten years, Myanmar's aquaculture output has increased five-fold but the sector is better characterized as subsistence rather than commercial. Only since 1989 have private investment and the market system been encouraged.

Simultaneously, a parallel conversion to the market system occurred in Viet Nam. However, unlike Myanmar, Viet Nam has placed a high priority on aquaculture because

[4] Here, fish refers to all output except that of aquatic plants.

FIGURE 1
Contribution of aquaculture to the region's total fish supply from 1980 to 2005



	1980	1990	2000	2005
Capture and aquaculture (T)	7 100 732	10 829 827	15 958 099	19 533 077
Aquaculture production (T)	704 789	1 397 965	2 684 150	5 028 363
Aquaculture share (%)	9.9%	12.9%	16.8%	25.7%

Source: Adapted from FAO (2007a).

TABLE 1
Relative importance of aquaculture in fish production by country, 2000 and 2005

Country	Total fish production (tonnes)		Aquaculture (tonnes)		Share of aquaculture in total food fish production (%)	
	2000	2005	2000	2005	2000	2005
Cambodia	298 798	410 000	14 430	26 000	4.8	6.3
Indonesia	4 872 079	5 594 767	788 500	1 213 457	16.2	21.7
Malaysia	1 445 098	1 394 097	151 773	175 834	10.8	12.6
Myanmar	1 192 112	2 217 466	98 912	474 510	8.3	21.4
Philippines	2 292 905	2 806 149	393 863	557 251	17.2	19.9
Thailand	3 735 279	3 743 398	738 155	1 144 011	19.8	30.6
Viet Nam	2 121 829	3 367 200	498 517	1 437 300	23.5	42.7
TOTAL	15 958 099	19 533 077	2 684 150	5 028 363	16.8	25.7

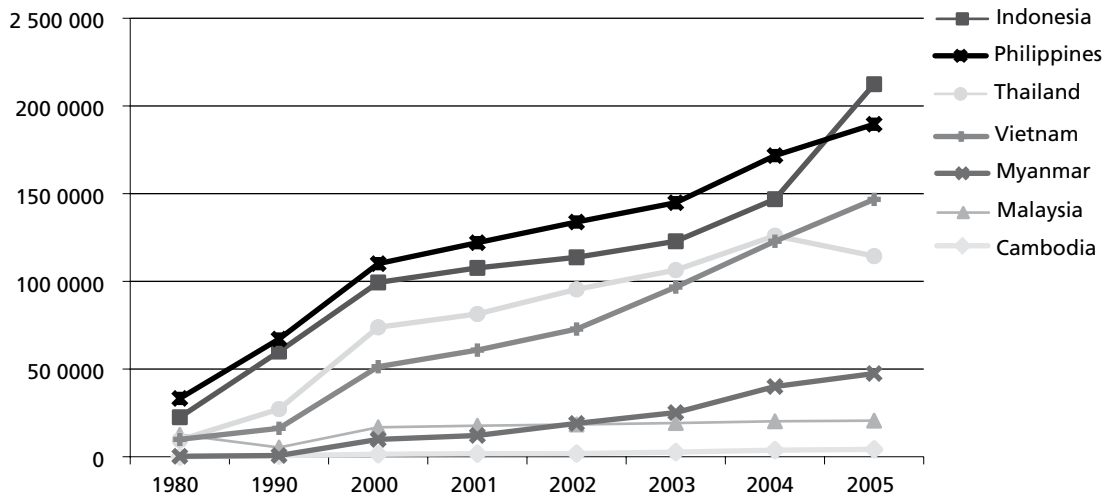
Source: FAO (2007a).

of its perceived benefits in terms of employment and foreign exchange. It also encourages the private sector, welcoming investment from both domestic and foreign sources.

Malaysia is another country that has a relatively small output. However, the quantity and value of its aquaculture output has, on the average, increased by more than 10 percent annually from 1990–2002, which is a higher rate than that of the gross domestic product (GDP) of this rapidly industrializing country.

In contrast to Cambodia, the Philippines and Indonesia have a long-established commercial aquaculture industry and were early movers in brackishwater cultivation. The farming of milkfish in the Philippines and shrimp in Indonesia was encouraged by governments for food security and foreign exchange. However, environmental impacts, particularly the destruction of mangroves, prompted officials in these two countries to reconsider the merits of unconstrained expansion and placed moratoriums on farm development. Thus, both countries experienced slower growth in aquaculture output from 2000 until 2003. However, as Figure 2 illustrates, with the two top curves representing the Philippines and Indonesia, rates of growth appear to have resumed since 2003 in the Philippines (and also in Indonesia). Both countries combined had a 30 percent increase in production of aquatic plants from 2003 to 2005; marine cage culture of milkfish in the Philippines also increased.

FIGURE 2
Evolution of aquaculture output (including aquatic plants) by country from 1980 to 2005



Source: Adapted from FAO (2007a).

TABLE 2
Relative importance of aquatic plants and fish production to aquaculture output in 2005 by country

	Aquaculture output *('000 tonnes)*			Share of the regional output *(%)*		
	Aquatic plants	Fish	Aquaculture	Aquatic plants	Fish	Aquaculture
Cambodia	16.0	26.0	42.0	0.6	0.5	0.6
Indonesia	910.6	1 213.4	2 124.1	39.2	24.1	28.9
Malaysia	30.0	175.8	205.8	1.3	3.5	2.8
Myanmar	0.0	475.5	474.5	0.0	9.5	6.4
Philippines	1 338.6	557.3	1 895.8	57.6	11.1	25.8
Thailand	0.0	1 144.0	1 144.0	0.0	22.7	15.5
Viet Nam	30.0	1 437.3	1 467.3	1.3	28.6	20.0
Total	2 325.2	5 028.4	7 353.6	100.0	100.0	100.0

Note: Rounding up the tonnage resulted in minor discrepancies.
Source: FAO (2007a).

It is important to note that Figure 2 includes aquatic plants. Aquatic plant production can be important in some countries, sometimes surpassing that of fish, and insignificant in others. In the Philippines, for example, the tonnage of aquatic plants more than doubles that of non-aquatic-plant organisms. Indonesia is also a significant producer of aquatic plants. Cambodia, Malaysia and Viet Nam, on the other hand, have only a small output; Myanmar and Thailand produce no aquatic plants. Table 2 shows the weight of aquatic plants in total output among the seven countries. Once aquatic plants are excluded, Indonesia, Thailand and Viet Nam exceed the Philippines in aquaculture output.

3.2 MAJOR SPECIES FARMED AND THEIR CONTRIBUTION TO FISH SUPPLY

As Figure 3 shows, by volume, the two main groups of fish species cultivated in the region are shrimp and miscellaneous fresh water fishes. They account for 41 percent of the 2005 total non-plant aquaculture output. Also important are catfish, milkfish, carps and tilapia, which contributed 45 percent of this total. Catfish output has increased rapidly largely due to Viet Nam, which accounted for more than half the regional total in 2005. Its output has quadrupled since 2000.

3.2.1 Contribution of fresh water species

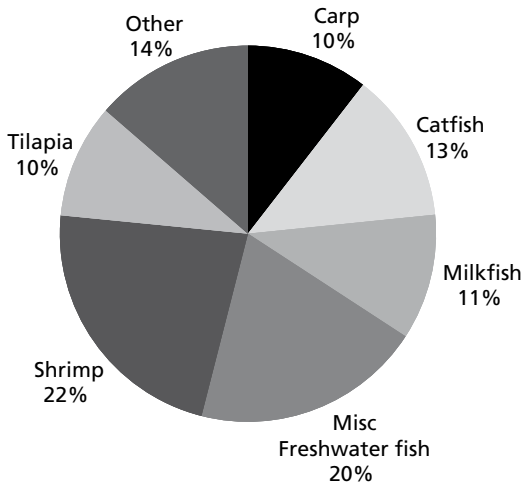
The fresh water environment is the most important in terms of tonnage, accounting for half the total volume cultured in the seven Southeast Asian countries (51 percent). As can be inferred from Figure 3, there were almost a million tonnes of cultured fresh water fish classified as miscellaneous in 2005. Viet Nam supplies more than half of this total and its output of miscellaneous fresh water fish has doubled since 2000.

The major identified fresh water species (other than miscellaneous fresh water species) are catfish and cyprinids (carps and barbells). They account for about half of all cultured fresh water output in the region although there are considerable differences among countries.

Virtually all carp produced in the region (85 percent) are farmed. Indonesia is the major producer, accounting for almost half of the region's output, but production has stagnated in recent years. In 2005, it was much the same as in 1996. Its most common species is the common carp. Cambodia and Myanmar are smaller producers of carp, but are more dependent on it. Carp accounts for more than 40 percent of their total aquaculture output. Cambodia's principal species are the Thai silver barb (*Barbonymus gonionotus*), the common carp and the silver carp (*Hypophthalmichthys molitrix*). Myanmar's output of carp and roho labeo (*Labeo rohita*) in 2005 was 163 000, tonnes with the ruho and common carp being the major species. The country produced another 260 000 tonnes of undesignated fresh water fish. The Philippines produced only about 17 000 tonnes of carp in 2005, which is less than 8 percent of its fresh water output. Carp was promoted in the Philippines as a source of low cost protein, but it did not meet immediate market acceptance because consumers were not familiar with the species. However, the bighead carp (*Aristischthys nobilis*), which used to be grown with milkfish in Laguna Lake fish pens, has now become the predominant species there because of poor growing conditions for milkfish. Over time, the low price of carp has increased the quantity demanded by consumers, and output has been growing.

Overall, the region's output of carp has increased, but more slowly since 2000. For the seven countries as a whole between 1990 and 2000, carp output more than doubled. However, expansion has slowed since then. From 9 percent between 1990 and 2000, the annual average growth rate fell to 6 percent between 2000 and 2005. In the Philippines, the increase in output has been small. In Malaysia, output actually fell.

FIGURE 3
Major fish species cultivated and their share of the region's fish aquaculture output in 2005 (Total output = 5 028 363 tonnes)



Note: The data used to produce this figure are presented in Tables 3 and 4.

TABLE 3
Farmed fresh water species and their share of the region's aquaculture output, 2005

Species	Region's output (tonnes)	Share of fresh water aquaculture output *(%)*	Share of total aquaculture fish output *(%)*	Share of total fish output *(%)*
Carp	525 782	20.3	10.4	2.7
Catfish	646 518	25.0	12.9	3.3
Tilapia	458 845	17.7	9.1	2.3
Other	953 181	37.9	18.9	4.9
Total fresh water aquaculture	2 584 326	100.0	51.4	13.2
Total aquaculture fish	5 028 363		100.0	25.7
Total fish capture and aquaculture	19 533 077			100.0

Source: FAO (2007a).

Tilapia output, on the other hand, has grown at twice the rate of carp since 2000; by 2005 farmed output almost equaled that of carp in the region. As with carp, almost all tilapia produced (78 percent) is farmed. The Philippines, Indonesia and Thailand are the main producers; their joint output accounts for more than 90 percent of farmed tilapia in the region. Most tilapia is farmed in fresh water; since 1987, output of tilapia in brackishwater has largely stagnated at about 30 000 tonnes. From 154 120 tonnes in 1990, output of tilapia increased to 279 180 tonnes in 2000 and 493 351 tonnes in 2005 (458 845 tonnes from fresh water).

The two main species of tilapia are the Mozambique and the Nile tilapia. The great majority (90 percent) of Mozambique tilapia is grown in Indonesia where it is cultivated in both fresh and brackishwaters. The Mozambique tilapia is still the predominant tilapia species cultivated in Malaysia. In other countries, its output has been dwarfed by that of Nile tilapia. While Indonesia is the region's main producer of Mozambique tilapia, its output has largely stagnated since 1990, and its output of Nile tilapia more than doubled from 2000 to 2005; it is now twice that of Mozambique tilapia.

As the previous discussion hints, the Nile tilapia is increasingly becoming the region's main tilapia species cultivated. In 2005, Nile tilapia accounted for 79 percent of total farmed tilapia in the region, compared with only 20 percent in 1990. In absolute volume, output of Nile tilapia in 2005 was nine times more than that of Mozambique tilapia.

In addition to Indonesia, other countries that have expanded their Nile tilapia production are the Philippines, Thailand and Viet Nam. From 50 000 tonnes in 1990, the Philippines increased production to 76 000 tonnes in 2000 and 126 563 tonnes by 2005, or an increase of 66.5 percent in five years. Similarly, in Thailand, Nile tilapia output grew from just 23 000 tonnes in 1990 to 109,701 tonnes by 2005. A primary reason for the success of Nile tilapia is the breeding of improved strains such as the Genetically Improved Farmed Tilapia (GIFT), which was developed in the Philippines with the assistance of university researchers, and was introduced in Indonesia in 1989 and in Viet Nam in 1994.

Catfish production has also been growing rapidly in some countries. Output has grown sharply, almost tripling from 2000 to 2005. The main producer is Viet Nam, with an output of 376 000 tonnes of Pangas (*Pangasius* sp.): it accounted for about a half of total output, while Thailand and Indonesia each accounted for about a sixth. Thailand's output has quadrupled since 1990. Of the 130 784 tonnes produced by Thailand in 2005, the predominant strain is the hybrid catfish, with the output of striped catfish (*Pangasius* sp.) reaching a plateau since 1990. Indonesia produced 102 090 tonnes of catfish in 2005, predominantly torpedo shaped catfish (*Clarias* sp.), but also Pangas (*Pangasius* sp.). Catfish can be grown in ponds or cages. In Cambodia, where data indicates that yields per hectare are more than ten times higher in cages than in ponds, cage culture is the predominant form of cultivation. This information is summarized in Table 3.

3.2.2 Contribution of brackishwater species

The importance of brackishwater species in terms of their contribution to fish supply in the region is summarized in Table 4.

The two main species cultivated in brackishwater are shrimp and milkfish (*C. chanos*). Both have seen their output increase since 1980. However, the relative weight of individual countries has changed. In 1980, the Philippines accounted for 70 percent of the world milkfish aquaculture. By 2005, its share had dropped to 44 percent. This declining share reflects, on the one hand, the stagnating output at home. By 2005, aquaculture output of milkfish in the Philippines was lower than in 1983. On the other hand, it reflects the growing production from other countries. With output almost doubling since 1990, Indonesia has sharply increased its production of farmed milkfish, and at 254 018 tonnes in 2005, its output exceeded that of the Philippines.

While in the Philippines output of milkfish in brackishwater was actually lower in 2005 than in 1983, its output of milkfish grown in marine waters has increased. During 1991–1993, output of milkfish in brackishwater declined nearly 50 percent in the Philippines due to the impact of volcanic eruptions. Since then, it has slowly increased to match output levels of 220 000 tonnes which were achieved in the early 1990s. Milkfish culture in marine cages, which only started in the mid-1990s, produced about 44 000 tonnes in 2005, accounting for 15 percent of all milkfish production (capture and aquaculture) in the country. Deep-water sea cages measuring no more than 20 m in diameter produce at least 30 tonnes per cage per year. This yield compares with production of about one tonne per hectare per year in most land-based brackishwater farms, and perhaps with as high as 12 tonnes in a few farms that stock up to 25 000 fingerlings per hectare (Cruz, 2002).

Total farmed milkfish output of Indonesia and the Philippines are approximately equal (nearly 250 000 tonnes). For all the seven countries combined, output of milkfish cultivated in brackishwater approximates a third of all the region's total tonnage (aquaculture and capture) obtained from that environment. However, by total weight, it is half that of shrimp; by value, it is only one-sixth.

The principal species by volume (and value) in brackishwater is shrimp. As Table 4 shows, farmed shrimp accounts for about 61 percent of all brackishwater output, and almost a quarter of all aquaculture production (excluding aquatic plants). In terms of value, the role of crustaceans in the region is even more important, accounting for 47 percent of total value (excluding aquatic plants).[5]

Globally, total shrimp production, which includes both aquaculture and capture fisheries, has almost doubled each decade since the 1980s. Within the region, it more than tripled from 1980 to 2005. Shrimp farming accounts for a growing share. From 2.6 percent of total world production in 1980, shrimp aquaculture's contribution to total shrimp output grew to 60.1 percent by 2005. For farmers, shrimp culture was attractive because of potential profits. Returns were higher relative to other species. For example, in 1992, Thai shrimp farmers' income was more than three times higher than that of snakehead farmers, the next best aquaculture species in terms of income earnings (Appendix 1). For governments, shrimp aquaculture was encouraged because of its export potential.

The overall expansion of shrimp aquaculture in the region has varied, from early movers such as the Philippines and Thailand, to late-comers such as Myanmar and Viet Nam. Thailand and Viet Nam have expanded production rapidly. They had minimal output of crustaceans in 1980 but had outputs of 405 320 tonnes and 327 200 tonnes, respectively, by 2005. Because of diseases, Thailand's output stagnated in the late 1990s. However, the country has had a rapid surge in output since 2002 and, by 2005, accounted for 12.7 percent of farmed shrimp output in the world. Indonesia, whose

[5] Not in Table 4.

TABLE 4
Farmed brackishwater species and their share of the region's aquaculture output, 2005

Species	Region's output *(tonnes)*	Share of brackishwater aquaculture output *(%)*	Share of total aquaculture fish *output (%)*	Share of total fish output *(%)*
Shrimp	1 055 331	60.9	21.0	5.4
Milkfish*	473 924	27.3	9.4	2.4
Miscellaneous	202 454	11.8	4.0	1.0
Total brackishwater aquaculture	1 731 709	100.0	34.4	8.9
Total aquaculture fish	5 028 363		100.0	25.7
Total fish capture and aquaculture	19 533 077			100.0

* Milkfish is cultivated in both brackishwater and marine environments; this quantity represents the tonnage from brackishwater production only.
Source: FAO (2007a).

output in 1980 exceeded that of Thailand and Viet Nam combined, had an output of 280 548 tonnes by 2005. Indonesia, Thailand and Viet Nam combined accounted for more than 30 percent of world farmed shrimp in 2005.

However, the seven countries as a whole have seen their share of the world shrimp output fall since 1990, reaching 22.3 percent of world total (aquaculture and capture) production in 2005. This decline reflects their declining role in shrimp aquaculture. From more than 50 percent in 2000, the regions' share of the world shrimp aquaculture output had fallen to 36.6 percent by 2005.

Diseases and environmental degradation were the reasons for the decline in the region's share of shrimp aquaculture output. A relatively small producer of shrimp, the Philippines expanded production after 1995, but has been hampered by disease. Initially, in the Philippines, shrimp was an incidental harvest in ponds with milkfish, but sugar farmers diversified into shrimp which they saw as a more economically attractive alternative to the depressed sugar market. Taiwan assisted shrimp farming development by providing technology, feeds and machinery. The role of the San Miguel Company was also critical. The Company introduced integrated operations and provided free technical assistance and feed to small-scale growers, in return for an option to buy the grower's shrimp. Shrimp became the Philippine's top marine product export, earning about US$300 million at its peak in 1992. However, since the mid-1990s, both tonnage and value of farmed shrimp have declined. Thailand has also had disease problems. Thailand's 2005 output of giant tiger shrimp (*P. monodon*) was only a quarter of its 2000 level. For the seven countries combined, farm output of giant tiger shrimp peaked in 2001 and has declined since then.

The decline in tiger shrimp production has been due to a shift into whiteleg shrimp (*Penaeus vannamei*) production. In all the seven countries but Thailand, the predominant species is the tiger prawn. However, from zero recorded output in 2001, the seven countries produced more than 502 875 tonnes of whiteleg shrimp by 2005, exceeding the output of giant tiger shrimp. Thailand is the major producer of whiteleg shrimp with 60 percent of the region's total. Its current output exceeds that of tiger prawn by nearly three times. Nevertheless, Indonesia and Viet Nam are also producing significant amounts. Indonesia's output of whiteleg shrimp accounted for more than a quarter of its total shrimp output, and the trend towards whiteleg shrimp appears likely to continue.

The level of technology and production intensity in shrimp farming varies from country to country. On one hand, 85 percent of shrimp farms in Thailand were intensive (with stocking densities above 100 000 fry per hectare) in 1994. This compared to only 15 percent, 10 percent and 5 percent for the Philippines, Indonesia and Viet Nam, respectively. On the other hand, extensive farms (50 000 fry or less per hectare) represented 80 percent of Vietnamese farms, 45 percent of Indonesian farms and 35 percent of farms in the Philippines, compared to only 5 percent in Thailand (Rosenberry, 1995).

3.2.3 Contribution of marine species

Table 5 shows the most important farmed marine species in terms of their share of marine aquaculture production, total aquaculture output and total fish production from both capture and aquaculture sources. Aquatic plants are excluded from the analysis.

Molluscs account for about 84 percent of the total mariculture output in the seven countries combined (excluding aquatic plants).

The green mussel (*Perna viridis*) accounts for almost half of the total output of farmed molluscs. This species used to have no perceived value; it only became a cultured species in the 1950s. Its fisheries and aquaculture combined output grew from 43 709 tonnes in 1980 to 277 309 tonnes in 2005. Almost all the 2005 output came from aquaculture compared to 70 percent in 1980. The major expansion has come since 2000 and particularly between 2001 and 2002. The largest producer is Thailand, which accounts for 90 percent of the region's cultivated output. From 88 759 tonnes in 2000, its output of green mussels grew to 249 620 tonnes in 2005 (down from 291 023 in 2002). Other countries producing green mussels include Malaysia and the Philippines. It should be noted that Viet Nam's output of (unspecified) marine molluscs was 143 800 tonnes in 2005.

Other molluscs farmed in the region include the blood cockle (*Anadara granosa*) and oyster, with blood cockle being the second most important, in terms of tonnage, after mussels. Total farmed output of blood cockle was 129 971 tonnes in 2005, about the same as in 1999. Thailand is the principal producer, barely ahead of Malaysia. Another major aquaculture species by weight is the cupped oyster (*Crassostrea gigas*), where again Thailand is the dominant producer. Production of all oysters in 2005 was more than 44 000 tonnes, almost all it coming from aquaculture. Thailand accounted for almost two-thirds of the cultured output, with the Philippines and Malaysia producing the remainder.

Although marine finfish output has also increased since 2000, output is still small. Moreover, most of this increase, from almost three million tonnes in 1980 to seven million in 2005 in the seven countries, came from the capture fisheries, and output from aquaculture remains marginal: a mere 51 477 tonnes in 2005 or less than 1 percent of total marine fish production. The bulk (85 percent) of the cultured marine fish was milkfish from the Philippines. From a very small output in 1997, milkfish cultivation in marine waters in the Philippines reached 43 970 tonnes in 2005.

Other marine species in the region include king fish (*Rachrycentron canadum*), red snapper (*Lujanus* sp.), grouper (*Epinephelus* sp.) and seabass (*Lates* sp.). The main

TABLE 5
Farmed marine species and their share of the region's aquaculture and total fish output, 2005

Species farmed	Region's output (tonnes)	Share of mollusc output (%)	Share of mariculture output (%)	Share of total aquaculture fish output (%)	Share of total fish output (%)
Molluscs	595 628	100.0	83.6	11.8	3.0
Blood cockle	129 971	21.8	18.2	2.6	0.7
Mussels	277 309	46.5	38.9	5.5	1.4
Oysters	44 545	7.5	6.3	0.9	0.5
Other molluscs	143 800	24.1	1.9	2.8	0.7
Milkfish*	44 019		6.2	0.9	0.5
Others	72 681		10.2	1.4	0.2
Total mariculture fish	712 328		100.0	14.2	3.6
Total aquaculture fish	5 028 363			100.0	25.7
Total fish capture and aquaculture	19 533 077				100.0

* Milkfish is cultivated in both brackishwater and marine environments; this quantity represents the tonnage from brackishwater production only.
Source: FAO (2007a).

finfish cultivated in marine waters after milkfish is grouper; groupers from Indonesia account for 30 percent of all farmed marine fish. In all seven countries, the total tonnage in 2005 was about 9 436 tonnes, with two-thirds coming from Indonesia where culture of grouper has increased although erratically. With its extensive marine area, the potential for farming grouper in Indonesia is considerable, and the National Marine Development Centres in Bali and Lampung have promoted the technology.

In Cambodia, grouper is stocked for fattening, but use is made of cyanide poisoning for their capture with damaging environmental effects on coral. Other major constraints to grouper farming include the erratic availability of seed in many places and the use of fish (trash fish) for feed. In the Philippines, grouper culture is likely to expand because of its profitability. A high demand (for live fish) is reflected in grouper's retail price, both in export and local markets, particularly in upper-scale Chinese restaurants. Thailand also produced more than 2 000 tonnes of grouper (in brackishwater) in 2005 with output almost doubling since 2000. Viet Nam is also planning to expand farmed grouper production. In fact, it imported grouper (and seabass) broodstock from Taiwan Province of China, but expansion has been limited by a shortage of seed. Despite investments on hatchery research, the country is dependent on wild seed. This dependence has resulted in a shortage of seed which, in turn, has led to under-stocking of cages, thereby affecting cage productivity and farm profitability. Productivity is very low (about a quarter of normal). Moreover, the seasonality of wild seed adversely affects farmers' ability to plan. A temporary solution to the shortage of wild seed locally has been to import seed from neighboring countries.

Seabass culture is also undertaken in Indonesia, Malaysia and Thailand. Because the retail price is only half of the price of grouper, farmers in the Philippines are reluctant to grow seabass even though the technology is available. The low retail price is a reflection of consumer preferences and not of production costs, which are similar to grouper. Farming seabass, therefore, is not as profitable as farming grouper.

In short, most countries see considerable potential for marine finfish culture. There are often considerable coastlines where high-value species can be grown for export. Grouper is particularly attractive where market demand is present. Because of its market potential, Viet Nam imported marine fish broodstock from China, Hong Kong Special Administrative Region and Taiwan Province of China from 1990 to 2000. However, attempts to rear fingerlings from larvae have not been successful as mortality rates exceed 90 percent. As long as this issue is not resolved, marine fish farming will not reach its full potential.

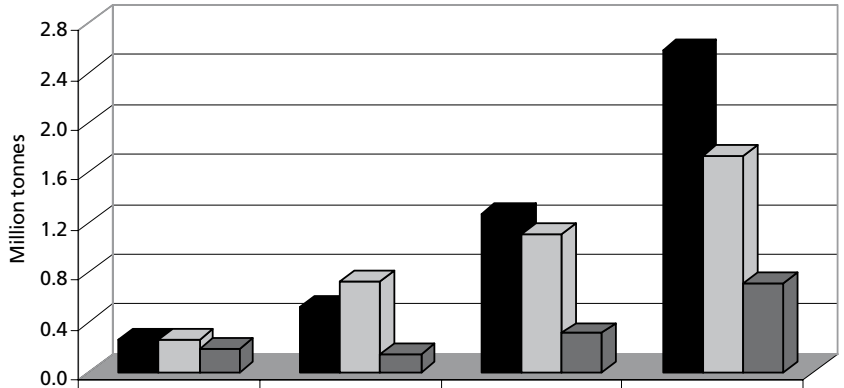
3.3 CONTRIBUTION OF FARMING ENVIRONMENTS TO AQUACULTURE OUTPUT OVER TIME

Figure 4 summarizes the changing importance of the three aquaculture environments between 1980 and 2005.

In aggregate for the seven countries, the share of aquaculture output (excluding aquatic plants) was approximately the same among the three environments (fresh water, brackishwater and marine) in 1980. From then until 1990, output from brackishwater grew rapidly compared to the fresh water and mariculture environments. However, between 1990 and 2005, output from fresh water, and more recently from mariculture, has experienced faster growth rates. In marine waters, output doubled between 1990 and 2000, and then again from 2000 to 2005. The principal reason has been increased mollusc production. Total production of molluscs in the region reached 659 909 tonnes in 2004.

Extrapolating into the future, it is likely that marine output will continue its rapid expansion in the region. This regional expansion coincides with a global trend in which mariculture output is increasing faster than either fresh or brackishwater culture.

FIGURE 4
Evolution of fish aquaculture output by environment from 1980 to 2005



	1980	1990	2000	2005
Fresh water (T)	258 256	526 727	1 269 811	2 584 326
Brackishwater (T)	260 206	723 624	1 102 724	1 731 709
Mariculture (T)	186 327	147 615	311 615	712 328

Source: Adapted from FAO (2007a).

While in 1980 the share of regional aquaculture output in each of the three environments (excluding aquatic plants) was approximately equal, individual countries had major differences; and some still persist. For example, Cambodia and Indonesia had no output from the marine environment and output was still zero or negligible by 2004. At the other extreme, Malaysia's output from mariculture in 1980 accounted for 98 percent of total national output. While an unusually large harvest of blood cockles in 1980 may have distorted somewhat the statistics, Malaysia continued to rely almost exclusively on mariculture throughout the 1980s. In 1980, Myanmar had no output from brackishwaters and that situation still persists.

With the development of shrimp (particularly *P. monodon*), output from brackishwater farms increased sharply, exceeding the combined output from fresh water and mariculture in 1990. However, environmental issues such as mangrove loss hampered the expansion of milkfish in the region; diseases impeded that of shrimp. Thus, the 2004 output of giant tiger prawn in the Philippines was barely a third of the total in the mid-1990s. Nevertheless, some countries such as Indonesia, Thailand and Viet Nam have continued to experience increased output from brackishwater operations.

4. Economic and social importance, markets and trade in aquaculture

4.1 DIRECT CONTRIBUTION OF AQUACULTURE TO REGIONAL AND NATIONAL ECONOMIES

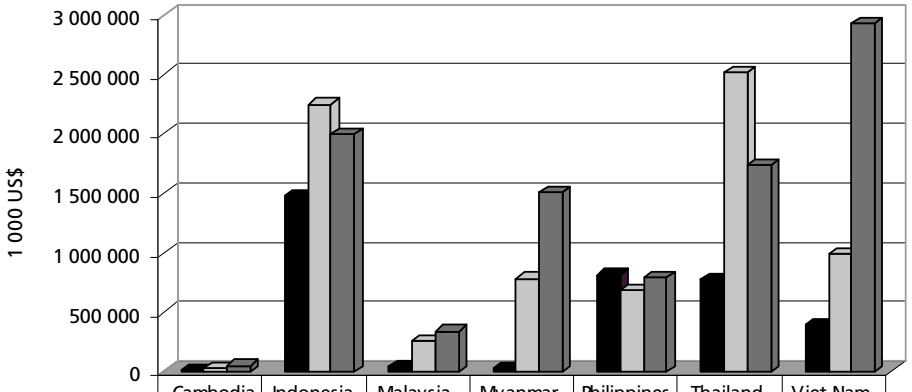
4.1.1 Overall contribution of aquaculture

Whereas the combined output from aquaculture from the seven countries has consistently increased, the value of output has seen more variability. In 2003, the value of aquaculture output, even with the inclusion of aquatic plants, was approximately the same as in the mid-1990s. There was some improvement by 2005, but the seven countries' share of world aquaculture value has declined; particularly since 2000. The world value of aquaculture output reached US$78 billion in 2005; the share of the seven countries was 12.4 percent of the world total and 25 percent of the world without China total. In 2000, the respective shares were 13.9 percent and 27.9 percent.

The reason for the overall variability has been the declining value of aquaculture output in some countries, which was not always offset by increasing values in others. The value of aquaculture output from the Philippines was less in 2005 than in 1990 and almost half of its peak value in 1994 (with or without aquatic plants). Indonesia and especially Thailand have also seen revenue declines; both had fewer revenues in 2005 than in 2000. As in the Philippines, a major explanation for declines in aquaculture value was the collapse in revenue (and production) of shrimp due to diseases. Figure 5 illustrates the changes in aquaculture values between 1990 and 2005.

On the other hand, other countries have seen sharp increases in aquaculture revenues. By 2005, Viet Nam ranked first in the region in the value of aquaculture output whereas in 2000 it was only third, and fourth in 1990. Viet Nam earned almost

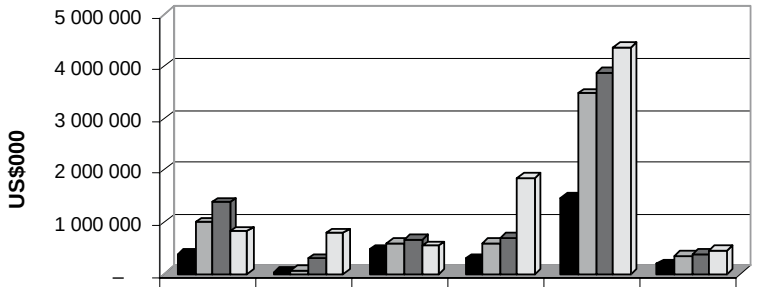
FIGURE 5
Evolution of the value of farmed fish by country from 1990 to 2005 (US$000)



	Cambodia	Indonesia	Malaysia	Myanmar	Philippines	Thailand	Viet Nam
1990	13 943	1 477 269	45 657	27 970	812 976	775 799	395 352
2000	28 275	2 245 695	254 150	781 368	680 728	2 513 846	991 318
2005	50 400	1 999 246	339 166	1 504 450	793 580	1 739 760	2 930 650

Source: FAO (2007a).

FIGURE 6
Evolution of the value of aquaculture output by species from 1989 to 2005 (US$000)



	Carp	Catfish	Milkfish	Misc. freshwater fish	Shrimp	Tilapia
1989	383 091	29 761	467 504	293 443	1 470 241	192 671
1994	988 809	70 163	588 037	599 895	3 488 410	347 635
2000	1 380 124	290 095	660 489	701 079	3 886 964	372 964
2005	812 017	788 465	547 870	1 845 747	4 371 592	453 438

Source: FAO (2007a).

three billion dollars from aquaculture in 2005 compared with less than a billion dollars in 2000. Another country that has experienced a sharp increase in the value of aquaculture output is Myanmar.

One indicator of a sector's economic importance is its contribution to the economy's overall output or GDP. Only rarely is the contribution of aquaculture to GDP estimated, either because it is a marginal sector, or because it is a new sector. Even when there are estimates, results depend not only on the absolute importance of aquaculture, but also the level of development of each country. This is reflected in Cambodia and Malaysia where the contribution of aquaculture to GDP is minimal. In Cambodia, estimates of the contribution of the fisheries as a whole vary widely (from 2 percent to 10 percent of GDP). But, as illustrated above, it has such a small aquaculture sector (with only 10 percent of the volume of total fishery production coming from aquaculture) that aquaculture's contribution to GDP can be assumed to be insignificant. Malaysia, on the other hand, has a much larger aquaculture sector than Cambodia (about ten times larger by value), but it also has a considerably larger GDP (more than twenty times larger). Aquaculture's contribution to GDP, therefore, is low (estimated at less than 0.3 percent, a fifth of that of fisheries, 1.6 percent). One estimate of aquaculture's contribution to GDP in 1998 gave an average of 1.24 percent for all of Southeast Asia, with 1.0 percent for Cambodia and 0.26 percent for Malaysia.

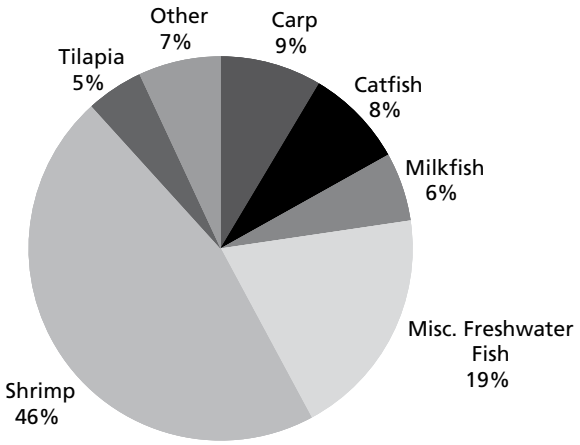
With aquaculture adding 4.96 percent to GDP in 1998, Viet Nam has the highest contribution of aquaculture to economy in the region (and probably the world). Since then, the value of Viet Nam's aquaculture output has been increasing exponentially, at an annual average rate of more than 22 percent, approaching US$3.0 billion in 2005 (FAO, 2007a). It also has a relatively small GDP, measured in US dollars, compared to Indonesia, Malaysia, the Philippines and Thailand. Thus, the contribution of aquaculture to GDP in Viet Nam could approximate 5 percent in 2005.

The changes in value of aquaculture output by species cultivated in the region are shown in Figure 6.

4.1.2 Contribution by species

The relative importance of species in terms of their contribution to the region's economy is illustrated in Figure 7.

FIGURE 7
Share of total value of farmed fish by species en 2005
Total value in 2005 = US$9.48 billion



Source: FAO (2007a).

Unlike volume where the fresh water environment dominates, brackishwater produces the most valuable farmed species (shrimp and milkfish) and constitutes the principal source of aquaculture revenues, although its absolute and relative weight has fallen because of declining values of shrimp and milkfish. Shrimp is the main species in the region. In 2005, it accounted for 81 percent of the value of all brackishwater aquaculture output and 46 percent of the value of all aquaculture output (excluding aquatic plants).

However, as it can be seen from Figure 6, the value of shrimp in the region has fluctuated according to the prevalence of diseases, and by 2005 it was barely higher than in 2000. The value of milkfish has also fluctuated. In Indonesia the value of farmed milkfish halved in 2002 compared with 2000. At the same time, in the Philippines, the falling value of milkfish cultured in brackishwater has been offset by the rising value of milkfish cultured in marine waters. Overall, the value of milkfish in the region was lower in 2005 than in 2000, and not much higher than in 1990. The shares of the value of aquaculture output by species cultivated in 2005 are presented in Figure 7.

Fresh water species are the second source of fish aquaculture revenues after brackishwater species: 41 percent compared with over 52 percent for brackishwater fish (shrimp, milkfish and some species in "other" category). As noted previously on a per weight basis, the most important category by value of fresh water species is miscellaneous fresh water fish (19 percent of total value). With a 9 percent share of total value, carps dominated among the identified fresh water species followed by catfish (8 percent) and tilapia (5 percent).

Revenues from carps have fluctuated, reaching less than half the 2000 total in 2002. This sharp decline must have been caused by falling carp prices, because during that period carp volumes increased. Referring to Figure 6, it can be seen that in 2005 the value of carps continued to decline after a rebound in 2004, and was only two-thirds that of 2000. The major producers of carp by value are Myanmar and Indonesia. The two countries account for 60 and 28 percent of the total value of carp, respectively. Cambodia, however, is the most dependent on carp, with almost half of the total value of its aquaculture output coming from carp farming in 2005.

The value of farmed tilapia has shown an increase over 1990, but it was about half the value of carps in 2005. As with carps, prices must have fallen because the value of tilapia has declined since the late 1990s while quantities have consistently increased. The third group, catfish, has seen rising values from 1990 to 2004. However, certain species must have experienced price declines. The torpedo shaped catfish, which accounts for about a third of all catfish farmed in terms of quantity, has seen its revenues more than halved since 2002. Yet, quantities have fallen far less.

Although increasing rapidly, more than quadrupling in absolute dollars since 2000, the value of marine aquaculture output remains small. When aquatic plants are excluded, the marine environment accounted for 7 percent of the value of all aquaculture output in 2005. While small, its contribution has increased from less than 2 percent in 2000.

Worth about US$194 million in 2005, pearl oyster from Indonesia is the most valuable marine species. However, marine fish, particularly grouper from Indonesia, have seen a ten-fold increase in value since 2000 and their value reached almost US$80 million in 2003 before falling to US$47 million in 2004 and US$15 million in 2005. The value of green mussel has been growing, particularly since 2000 and was worth about US$26 million in 2005, which was approximately twice the value of oysters.

In addition, aquatic plants have also shown an increase and were worth approximately US$250 million in the region. About two thirds of this value comes from the Philippines where the predominant strain is the Zanzibar weed. The value of red seaweed from Indonesia is about a third of the Philippines total.

4.2 DIRECT CONTRIBUTION OF AQUACULTURE TO EMPLOYMENT AND INCOME GENERATION

Employment data in aquaculture are often sketchy, but only in the major producing countries is the contribution significant at a national level. An example is Cambodia where fisheries and aquaculture employs more than two million people. Estimates of employment suggest that almost 20 000 were employed in aquaculture by 2005. However, this is a mere 1 percent of fisheries employment. The reason for the relatively low employment in aquaculture may lie in income data, which indicate that those involved in aquaculture earn less than half the income earned in the fisheries. At the other extreme is Viet Nam where employment in aquaculture is larger than the number involved in the fisheries. In 2001, some 580 000 people were directly or indirectly employed in aquaculture, a number that doubled since 1991. By 2005, it is likely that employment exceeded one million, given that aquaculture output doubled from 2001 to 2004. Aquaculture is promoted by Vietnamese policy-makers because it provides rural employment, thereby diversifying rural economies and discouraging rural-urban migration. Aquaculture is also a sector for the poor, who have few alternatives and no resources. In Viet Nam, aquaculture does not typically attract the wealthy, who perceive aquaculture risks as high and financing difficult. The wealthy prefer offshore fishing and trading. Aquaculture therefore is attractive to policy-makers because it absorbs the poor.

Aquaculture employment in Indonesia is also important; it was estimated at 2.13 million jobs in 1996. The majority of aquaculture households in Indonesia make their living in fresh water farming. At about 470 000, the number of households engaged in fresh water farming more than doubled that of households in paddy field farming, and was four times higher than the number involved in brackishwater aquaculture, where the 287 000 shrimp farmers received about US$160 million in remuneration.

In the Philippines, shrimp farms employed some 42 000 people in the 1990s. Shrimp account for about 20 percent of all 239 323 ha of brackishwater ponds with the remainder used for milkfish, usually in extensive culture. A conservative estimate is that one employee covers five hectares of extensive milkfish ponds. Thus, milkfish farming would generate another 38 292 jobs. The 16 000 fresh water ponds are generally smaller

than brackishwater ponds, and their management would require at least one employee per two hectares. In addition, there are cage and pen operations as well as shellfish farms. This is an indication that direct employment in aquaculture (excluding aquatic plants) is probably well over 100 000. If indirect jobs in linked activities are included then total employment generated by aquaculture would be larger still. This is small relative to the total labour force of more than 27 million, but the regional impacts are considerable. In the municipality of Lake Sebu Mindanao, aquaculture contributes more than half the annual municipal income and employs 10 percent of the labour force.

In some cases, employment estimates can be derived from production data. For example, Table 6 shows estimated employment in shrimp farming according to different farming intensities in six of the seven countries in the region.

Table 6 shows that employment in shrimp farming increases with intensity, although the variation among countries is considerable. For example, Thailand employs twice as many people per hectare in intensive operations as Malaysia. For extensive operations, the differences were even greater, with Viet Nam employing five times more people per hectare than the Philippines. Throughout Asia, extensive shrimp farming is estimated to provide an average of 6.4 person-months/ha/year compared to 18.6 person-months/ha/year for semi-intensive and intensive farms (ADB/NACA, 1996). These figures compare with 6 to 8 person-months/ha/year in rice farming, which indicates the higher potential contribution of shrimp farming in generating employment opportunities in coastal areas (ADB/NACA, 1996).

Thailand's shrimp farming is predominantly small-scale with about 80 percent of the farms less than 2 hectares. As Table 7 shows, in 1992 shrimp farming in Thailand, which then had an output of 184 884 tonnes, was estimated to employ 63 445 persons. Assuming the same labour productivity, output of farming in 2004 would suggest that employment in shrimp farming has doubled to 130 000 jobs.

Even more significant is the employment in fresh water fish farming. In 1992, Thailand's employment in fresh water aquaculture was estimated at 239 684. Since 1992, output of fresh water fish in Thailand has almost tripled, so employment has probably increased too. A conservative estimate would suggest that at least 500 000 people are currently employed in fresh water aquaculture, with 600 000 employed in total. Data on household income imply that aquaculture was a lucrative activity. In 1992, except for carp culture, households earned on average more than US$1 000 growing fresh water fish. Shrimp farming was even more lucrative with household incomes approaching US$12 000 (Appendix 1).

Table 8 disaggregates carp employment by gender. It shows the role of women in carp farming varies by country.

Vietnamese women play a predominant role as hired workers in semi-intensive operations. For all species, about 80 percent of workers involved in aquaculture processing are women (not in Table 8). This is similar in Thailand where hired labour

TABLE 6
Estimated employment generated per hectare per year by the shrimp culture industry in selected countries in Southeast Asia, 2001

Country	Production intensity and employment/ha/year		
	Extensive	Semi-intensive	Intensive
Indonesia	175	478	809
Malaysia	n.d.	534	428
Myanmar	147	n.d.	n.d.
Philippines	90	531	631
Thailand	n.d.	n.d.	946
Viet Nam	492	771	n.d.

Source: Leung and Sharma (2001)

TABLE 7
Estimated employment in aquaculture by farming environment and species in Thailand, 1992

Farming environment and species	Number of households	Workers per household	Total number of workers	Contribution to total employment (%)
Fresh water	119 842	2.00	239 684	76.56
Brackishwater	23 170		69 436	22.18
Shrimp	*19 402*	*3.27*	*63 445*	*20.27*
Seabass/Grouper	*3 768*	*1.59*	*5 991*	*1.91*
Mariculture	2 146		3 941	1.26
Oyster	*1 597*	*1.93*	*3 082*	*0.98*
Mussel	*250*	*1.15*	*288*	*0.09*
Blood cockle	*245*	*2.11*	*517*	*0.17*
Others	*54*	*1.00*	*54*	*0.02*
Total	145 158		313 061	100.00

Source: Adapted from Virapat (2005).

TABLE 8
Estimated employment in carp farming in selected countries of Southeast Asia by gender, 1992

Culture system and country	Family labour			Hired labour			Total	
	Men	Women	Percentage of women	Men	Women	Percentage of women	Labour	Percentage of women
Semi-intensive								
Cambodia	0.3	0.1	25.0	n.a.	n.a.	n.a.	0.4	25.0
Indonesia	0.5	0.1	16.7	0.3	0.1	25.0	1.0	20.0
Malaysia	1.0	0.2	16.7	n.a.	n.a.	n.a.	1.2	16.7
Myanmar	0.4	0.1	20.0	2.6	0.1	3.7	3.2	6.3
Thailand	2.1	0.9	30.0	1.0	0.6	37.5	4.6	32.6
Viet Nam	1.9	0.5	20.8	2.3	5.0	68.5	9.7	56.7
Extensive								
Malaysia	0.7	0.1	12.5	n.a.	n.a.	n.a.	0.8	12.5
Philippines	0.1	0.0	0.0	n.a.	n.a.	n.a.	0.1	0.0
Thailand	1.4	1.1	44.0	0.0	0.2	100.0	2.7	48.1
Viet Nam	1.6	0.4	20.0	0.6	0.0	0.0	2.6	15.4
Pen/cage culture								
Philippines	0.7	0.0	0.0	0.2	0.0	0.0	0.9	0.0
Viet Nam	1.3	0.5	27.8	n.a.	n.a.	n.a.	1.8	27.8

n.a. = not applicable.
Source: Adapted from ADB/NACA (1996).

in extensive systems consists exclusively of women. Women also represent a sizable portion of family labour in both semi-intensive and extensive systems where they account for 30 and 44 percent, respectively. In Indonesia, there are few female managers of aquaculture enterprises, but women are actively involved as hired workers. A survey conducted in 1993 found that women managed fewer than 10 percent of fresh water and brackishwater ponds and about 16 percent of mariculture enterprises. Yet, about 45 percent of workers employed in fresh water aquaculture and cage culture were women. For brackishwater aquaculture, the proportion of female employment was 34 percent, and 69 percent in mariculture. Women's participation is low in Malaysia, and negligible in Myanmar.

4.3 COMPETITIVENESS OF MAJOR SELECTED SPECIES AND WELFARE IMPLICATIONS FOR THE POOR

Most farmed species are sold domestically. Therefore, their competitive position depends on preferences, and the relative prices of substitutes, including fish from the capture fisheries. However, shrimp is largely exported with prices determined globally. For potential investors, the attractiveness of aquaculture depends on profits and risks relative to other sectors. In Malaysia, aquaculture is considered more profitable than agriculture with domestic and international markets likely to increase. Table 9 indicates the profitability level of some species in Indonesia.

TABLE 9
Investment, production costs, revenues and profits of aquaculture in mangrove areas in Indonesian silvo-fish culture (in Rp. 1 000)

	Milkfish	Seabass	Tilapia	Shrimp	Crabs
Investment	540	873	523	873	46
Production cost/crop	1 356	2 036	1 882	2 077	320
Revenue/crop	1 852	4 320	2 800	4 950	331
Profit/crop	496	2 284	918	2 873	11
Profit/year	1 488	4 568	2 754	5 746	99

TABLE 10
Comparative investment profile for milkfish and grouper in the Philippines

Item	Milkfish	Grouper
Profit margin (US$/kg)	0.20	2.0
Production required to earn US$2 000/yr (kg)	10 000	1 000
Number of production cycles per year	2	1
Number of fish needed per year	30 000	2 000
Total investment needed (US$)	5 600	2 800

For all species but crabs, which were raised in a $2.5 \times 1.2 \times 1.5$-m^3 bamboo cage, cultivation was conducted in a 1-ha pond. As the bottom row of Table 9 indicates, profitability is highest with shrimp, followed by seabass, tilapia, milkfish (in brackishwater ponds) and crabs. These returns partially explain the increased output of shrimp and the decline in output of milkfish in brackishwater in Indonesia (and also perhaps in the Philippines). Table 9 also shows that capital and operating costs are not necessarily directly correlated with profitability. That is, high costs do not always diminish profits themselves; they do so if they are not more than offset by high revenues.

One of the inferences that can be made from these results (Table 9) is that, provided poor farmers can be given access to credit for investment and operating costs, one policy to reduce poverty might be to encourage the poor to farm high-value species. While there are concerns about the use of low-value/trash fish in farming high-value species, the culture of such species offers a means of raising living standards of the poor. The annual profit from farming seabass is three times higher than milkfish. Shrimp farming yields a profit to Indonesian farmers almost four times higher than that of milkfish.

The argument that poor farmers could be better off by farming high-value species if they are given the opportunity is illustrated by results of the analysis of investment profiles for milkfish and grouper in the Philippines (Table 10). To earn US$2 000 a year, a farmer needs 30 000 milkfish but only 2 000 grouper. With 2 000 grouper a year, the return to farmers is equal to the return on growing 30 000 milkfish. Moreover, the total investment in grouper farming is half the investment required to farm groupers.

Future markets for farmed foodfish appear promising, implying high expectations on their competitiveness capacity. The main determinants of demand for foodfish include relative prices, income and urbanization, which are on the rise. Estimates of price and income elasticity coefficients by the WorldFish Center (formerly the International Center for Living Aquatic Resources Management [ICLARM]) suggest that carp, tilapia, and shrimp have strong market potential (ICLARM, 1998). As one would expect, expenditure elasticity coefficients were high for crustaceans, but they were also high for carp. The higher coefficient of carp compared to tilapia is counter-intuitive because tilapia is commonly perceived as a generally preferred fish. This preference for tilapia is reflected in relative prices. In Viet Nam, for example, the price of a 200 g tilapia is about the same as a 500 g carp. The high expenditure coefficient

TABLE 11
Resource cost ratio indices of shrimp farming in selected Asian countries by farming intensity and export market

	Farming intensity and market											
	Intensive system			Semi-intensive			Extensive			Average by market		
	EU	Japan	United States of America	EU	Japan	USA	EU	Japan	United States of America	EU	Japan	United States of America
Bangladesh	0.89	0.42	1.02	1.15	1.09	0.97	0.51	0.48	0.43	0.83	0.79	0.70
China	–	–	–	0.34	0.17	0.38	0.37	0.18	0.42	0.53	0.26	0.61
India	0.74	0.33	0.69	0.78	0.35	0.72	0.73	0.32	0.67	0.75	0.33	0.69
Indonesia	0.33	0.25	0.34	0.27	0.21	0.29	0.43	0.33	0.45	0.34	0.26	0.36
Malaysia	0.49	0.21	0.49	0.63	0.27	0.64	–	–	–	0.56	0.24	0.64
Philippines	n.a.	0.44	0.47	n.a.	0.17	0.18	n.a.	0.22	0.24	–	0.28	0.30
Sri Lanka	n.a.	0.18	0.19	n.a.	0.19	0.18	n.a.	0.26	0.27	–	0.21	0.21
Taiwan, PC	0.92	0.47	0.77	–	–	–	–	–	–	0.92	0.47	0.77
Thailand	0.31	0.19	0.22	–	–	–	0.23	0.14	0.17	0.27	0.17	0.20
Viet Nam	–	–	–	0.87	0.66	0.35	0.98	0.74	0.39	0.93	0.70	0.37

n.a. = not applicable.
Sources: Shang, Leung and Ling (1998); Leung and Sharma (2001).

for carp may therefore indicate a preference for quantity rather than quality. A policy implication of this finding at the farm level would be to encourage farmers to refrain from producing larger fish; they would be better off by cutting production cycles and supplying more fish per volume. Cross-elasticity estimates show that carp and tilapia have positive coefficients, meaning that consumers regard the two species as substitutes. Therefore, all other factors held constant, they will buy whichever species is cheaper.

Estimates of own-price elasticity in Viet Nam indicate that crustaceans and carp are more price elastic than tilapia, with the latter's coefficient being almost unity. High price elasticity is welcome to farmers because it suggests that output of all three species can increase without negative repercussions on farm incomes; quite to the contrary, it would result in more revenues to farmers.

Besides competing among each other, farmed species must also compete with the wild fisheries. This competition is reflected in prices. When production from the capture fisheries is high, fish prices will fall and so will demand for farmed fish. This is well understood by milkfish and tilapia farmers in the Philippines who prefer to harvest at full moon when catches from the wild fisheries decline. Similarly, during typhoon season, when the dangers associated with fishing increase, farmers can expect to obtain higher prices. Due to improved transport infrastructure, imported mackerels, squid and scads are also entering the wet market in urban areas of the Philippines, further threatening local markets.

For species traded internationally, production and transport costs are critical, but so are exchange rates. The most definitive studies of comparative advantage among producing countries of shrimp in Asia were published by Shang, Leung, and Ling in 1998 and by Leung and Sharma in 2001. In these studies, the domestic resource cost of the shrimp was divided by the nominal exchange rate to obtain an index of comparative advantage (Table 11). The index was estimated for different farming techniques and by export destination. Thus, production costs and exchange rates were included. On average, Thailand had the largest comparative advantage of all the countries analysed in all three export markets (Europe, Japan and the United States of America), and Viet Nam was the least competitive in Europe and Japan. Thailand's comparative advantage was present in both extensive and intensive systems, while Indonesia was particularly competitive with semi-intensive systems. Given the exchange rates prevailing at the time, Indonesia's most competitive market was Japan.

TABLE 12
Prospects for some commercial species in the region

Country	Species	Prospects	Constraints	Advantages
Cambodia	Catfish	Not good	Low value fish	Feed available
	Snakehead	Not good	Seasonality of feed	
Indonesia	Common carp	Not good	Low value fish	
	Tilapia	Very good		Omnivorous
				High demand
	Shrimp	Good	Mangrove depletion	International demand
				Large coast
	Milkfish	Fair	Medium demand	Large coast
	Groupers	Very good	Seed availability	High value
			Feed	Strong Demand
Malaysia	Catfish	Not good	Low value fish	Feed available
	Tilapia	Good	Comparative advantage	High demand
	Shrimp	Not good	Comparative advantage	International demand
	Blood cockle	Fair	Low value	Demand exists
	Green mussel	Fair	Low value	Demand exists
Myanmar	Carp	Not good	Low value fish	Feed available
	Shrimp	Good	Mangrove depletion	International demand
Philippines	Tilapia	Very good	Lack of extension	High demand
	Milkfish	Good	Commercialize hatchery technology	Potential for yield increases
	Carp	Good	Consumer acceptance	Fast growing
				Known technology
	Shrimp	Good	Mangrove depletion	International demand
Thailand	Catfish	Good		High demand
	Tilapia	Very good		High demand
	Shrimp	Very good	Disease risks	Experience/ Size
	Blood cockle	Good	Environmental	Demand exists
	Oysters	Good	Environmental	Demand exists
	Green mussel	Good	Environmental	Demand exists
Viet Nam	Catfish	Very good	Tariff barriers	International demand
	Shrimp	Very good	Market competitiveness	International demand
	Molluscs	Good		Demand exists
	Marine fish	Very good	Seed availability	High value

Source: National reports; FAO (2007b).

Table 12 indicates the prospects for some commercial species by country in the region. It will be important to assess the comparative advantage of the most promising species.

4.4 IMPACT OF AQUACULTURE ON COMMUNITIES

To analyse the impact of aquaculture on social structures, it is useful to distinguish between traditional farming activities and highly capital intensive operations. On the one hand, traditional farming would include carp culture in most countries and also perhaps shrimp. Most aquaculture operations in Southeast Asia are small-scale. Cambodia and Myanmar have few aquaculture ventures, and those that exist tend to be small-scale. In the Philippines, almost half of all brackishwater ponds are less than 5 ha and two-thirds are less than 10 ha. These proportions are even higher in ponds under the Fishpond Lease agreement. Only 20 percent are more than 20 ha, although these account for more than half the area (ADB/NACA, 1996). Even in Thailand, one of the largest shrimp producers in the world, most shrimp farms are of medium size, i.e., less than 2 ha (Yap, 1999). Traditional activities either engage in growing low-value species or high-value species at very low levels of production intensity. Farmers are typically

among the poorest in the community and the impact of such activities on the economy or social fabric is minimal.

On the other hand, capital intensive operations can transform communities. The best example of such transformations in Southeast Asia occurred with intensive shrimp farming. Where the location was suitable, roads were constructed and electricity delivered. Schools and clinics were provided in Indonesia, where nucleus-estate farms collaborated with thousands of shrimp farmers in Lampung and Palembang. Employment and income contributed to the economic development of whole communities. A lesser example has occurred in the Philippines in Lake Luzon municipality, with cage and pen farming of carp. About half of the tax revenue of the municipality comes from carp aquaculture.

Not all the impacts of these capital intensive operations are positive. There may be environment degradation such as mangrove destruction and the loss of that habitat to traditional users, and salinization of land that reduces agricultural productivity. This has occurred in the Philippines and elsewhere. There can also be damage from toxic chemicals and pesticides. Negative impacts may also be caused by social discontent. Conflicts may arise with traditional users of the land and water, or because of income inequalities and increasing resentment. Such social disruption may manifest itself in lawsuits, protests or poaching, and be costly to farmers and communities.

4.5. CONTRIBUTION TO NATIONAL FOOD SECURITY

Food security is a concept that has both supply (availability) and demand (accessibility) components. It also encompasses the utilization aspect. On the supply side, commercial aquaculture increases the availability of food fish. It produces food fish for farm households, who consume their own fish, and for domestic buyers who consume purchased fish as well. Commercial aquaculture may also earn foreign exchange from exports that can be used to pay food import bills.

The contribution of aquaculture to total fish food supply by country was shown earlier in Table 1. Almost a quarter of total fish production among the seven countries now comes from aquaculture with Viet Nam's contribution exceeding a third. By tonnage, most of the fish cultured is marketed domestically.

In some countries such as Viet Nam, aquaculture tends to absorb the poorer sections of the population, who consume much of what they produce. Most of aquaculture's output, therefore, provides protein directly to the poor. In Cambodia, where aquaculture's share of fisheries production is low, one third of the population is below the poverty line and 90 percent of these live in rural areas (mostly employed in agriculture). With an increasing population and declining commercial fisheries, aquaculture offers a way for the poor to acquire protein. In Indonesia, a country with a large commercial fisheries sector, policy-makers see aquaculture as complementary to the fisheries, a means of raising per capita consumption of fish, and a source of foreign exchange. The tonnage of total fishery exports declined from 1987 to 2001 and their value stagnated, while the value of aquaculture's contribution to export earnings by 2001 had grown to about 80 percent that of the capture fisheries.

On the demand side, commercial aquaculture provides incomes in terms of wages/salaries and farm revenues with which other staple foods can be purchased. It therefore enables the poor to access food. In addition to these direct demand effects from employment income, there are also indirect effects through employment generated in linked industries, and induced effects through consumer spending.

Food utilization is related to more micro dimensions of food security such as nutrition, food preparation and sanitation knowledge, dietary habits and health conditions (Fan, Hazell and Thorat, 1999). Aquaculture contributes to food quality by providing nutritious aquatic food products. It is widely accepted that seafood is an exceptional source of high quality protein, contains various vitamins and minerals and

TABLE 13
Average fish consumption and fish, animal and total protein intake in the region, 2003

	Population	Under-nourished	Fish consumption	Fish protein	Animal protein	Fish/ animal protein	Fish/ total protein
	million	*%*	*kg/person/ year*	*g/person/day*		*%*	
Cambodia	14.1	38	27.1	8.2	14.5	56.5	16.0
Indonesia	219.8	6	20.5	7.0	10.2	68.6	11.1
Malaysia	24.4	< 3	55.9	15.2	39.8	38.2	20.3
Myanmar	49.4	7	18.9	5.3	11.7	45.2	6.6
Philippines	80.0	22	28.8	9.5	24.8	38.3	16.4
Thailand	62.8	19	30.5	9.8	24.1	40.6	17.4
Viet Nam	81.3	19	17.5	4.5	17.4	25.9	6.9
Region	531.8	16.3	28.5	8.5	20.4	44.8	13.5
East & Southeast Asia	611.9	-	26.0	8.0	19.5	41.0	12.1
World	6 198.0	17	16.1	4.4	29.1	15.1	5.8

Sources: FAO (2006); World Bank (2005)

is typically low in saturated fats, carbohydrates and, with the exception of prawns and squid, cholesterol (SFIC, 2006).

The region relies heavily on fish for food and for protein. Table 13 shows average fish consumption and fish protein intake, as well as the contribution of fish to animal and total protein intake.

Of the seven countries in the region, Viet Nam has the lowest fish consumption. However, Viet Nam's per capita fish intake is higher than the world average, which implies that average per capita consumption of fish in all the seven countries is much (77 percent) higher than the world average. Per capita fish consumption in Malaysia is the highest in the region and is more than three times higher than the world average.

Excepting Malaysia, each country in the region consumes less animal protein in absolute quantities than the world average of 29.1 g per day; in some countries (Cambodia, Indonesia and Myanmar), consumption is less than half the average. Yet, whereas fish accounts for 15.1 percent of total animal protein globally, it accounts for significantly more in all seven countries in the region. With the exception of Viet Nam (where it represents 1.7 times), the proportion of fish in animal protein more than doubles the world average in all countries. Consumption in Cambodia and Indonesia is three and four times the world average. This finding reinforces the importance of fish as a source of nutrition in the region. In such a low-protein area, dependence on fish for nutrition becomes particularly important. With the growing share of aquaculture in total fish production (almost a quarter of all fish comes from aquaculture; a greater share is observed in some countries), aquaculture's contribution to animal protein intake is expected to continue increasing.

4.6 MARKETS AND TRADE OF THE REGION'S AQUACULTURE PRODUCTS

4.6.1 Trade balance of aquaculture products

Aquaculture in the region developed as a source of food for the domestic population. Producing fish for domestic consumption is still largely the role of fresh water species. However, the expansion of shrimp farming and improved transport infrastructure has increased the importance of international trade. Foreign exchange earnings are one of the reasons for government support of the industry. Indonesia's Aquaculture Intensification Program is aimed at increasing exports. Species included in the intensification programme are shrimp in seven aquaculture zones, and groupers, Nile tilapia, and seaweed, in five zones. These zones differ by geographical location. This programme comes under the overall umbrella of PROTEKAN (Programme to Increase Exports of Fisheries), which is the strategy to promote fisheries exports (DGF, 1998).

Alternatively, import substitution and the desire to save on foreign exchange may motivate government support. Malaysia has to import a quarter of its food needs, and is a net fish importer. With per capita consumption of fish forecasted to increase, minimizing fish imports is a rationale for government support of aquaculture.

In 2003, the seven countries in aggregate had a small surplus by tonnage in fish seafood trade. The seafood trade deficits of Malaysia and the Philippines were more than offset by large surpluses of Viet Nam and Myanmar. In the future, rising domestic consumption combined with declining output from the capture fisheries may threaten this net surplus. However, with the development of export-oriented aquaculture, particularly in Indonesia and Viet Nam, the fish seafood surplus in the region might continue, and even increase. However, the lack of disaggregation in information gathering makes it impossible to know the contribution of aquaculture to exports.

In Cambodia, all fish exports must go through the state export agency KAMFIMEX (Kampuchea Fish Import and Export Company). Three-quarters of fish exports are shipped directly to Thailand as fresh for re-export; there would be double-counting if they were classified as exports from both Cambodia and Thailand. Another 15 to 20 percent goes to Viet Nam, and a small proportion (0.5 percent) is exported illegally. As is the case in Viet Nam, these data problems are compounded by the lack of disaggregation of output between aquaculture and the capture fisheries. Without data disaggregation, estimating the impact of aquaculture on hard currency earnings is problematic.

4.6.2 Major markets and contribution of major aquaculture species to export earnings

In terms of value, the major aquaculture species exported from the region is shrimp. The ratio of farm-gate price to export price in Indonesia for shrimp is 1:1.6 with export prices about two-thirds higher than producer prices. Nonetheless, except for groupers, shrimp is the producer's highest priced species and earns the farmer about ten times the price per kilogram compared with carp, milkfish, or tilapia. The proportion the region's shrimp output that is exported varies, but it is probably more than 80 percent. With most of the region's output exported, the total value of shrimp exports exceeded four billion dollars in 2005. This total is much the same as in 2000, but considerably higher than in 1990 when the total value of shrimp aquaculture was less than two billion dollars (FAO, 2007a). Indonesia, Thailand and Viet Nam each earned more than one billion dollars, with Viet Nam's output (export) value increasing nearly 800 percent since 1990, from US$147 million to US$1.3 billion (FAO 2007a).

Milkfish exports are much smaller because most production is consumed domestically. Indonesia processes milkfish into a paste, but the majority of exports are fingerlings. Companies exporting fingerlings must obtain approval for the amount they wish to export and for the location of the harvest. The Philippines sends most of its milkfish exports to the United States of America either as whole fish, frozen or smoked. The other main single market is Guam which absorbs fresh, whole and smoked milkfish. For all markets, more than half total exports are in the form of whole fish. Compared to shrimp however, the value of milkfish exports is small (less than 5 percent of the total).

Other species exported include fresh water species, cockles, and marine finfish. Estimates of the proportion exported from Malaysia are 20 percent of fresh water species, 50 percent of cockles, and 60 percent of marine finfish. On average about half of all Malaysian aquaculture output is exported, but the proportion rises to 80 percent for shrimp.

The Philippines is the region's largest producer of seaweed. Thus, shrimp and seaweed together account for almost all aquaculture exports. In 2001, the value of aquaculture exports amounted to almost a quarter billion dollars, of which two-thirds

came from shrimp and the remainder was split between seaweed and milkfish, which accounted for less than 5 percent. Aquaculture exports comprised less than one percent (0.72 percent) of total country exports; almost on par with the exports from capture fisheries.

As with other countries in the region, Viet Nam's main aquaculture export in terms of value is shrimp, which accounts for nearly 50 percent of the total value of production. However, other species such as catfish are exported. Lobster, sea crab, grouper, carp and molluscs also have potential as live exports within Asia. Both total production and exports have soared. Aquaculture exports increased from US$87 million in 1991 to US$800 million in 2000 and US$1 billion in 2001. By value, aquaculture exports were 57 percent of the export value of capture fisheries. The principal market for aquaculture products is Japan, followed by the United States of America; the Taiwanese and Korean markets are also important. Africa, Latin America and the Middle East are also potential market outlets for the US$3.1 billion in total fish exports that Viet Nam forecasts for 2006 (up from US$2.7 billion in 2005) (VASEP, 2006).

5. Policies, laws and regulations

5.1 THE ROLE OF GOVERNMENTS

The government role in a market economy may vary, with some governments designating certain sectors and industries as strategic and worthy of public funding. Alternatively, governments may merely provide an enabling economic environment in which entrepreneurs can compete. Good governance in such an environment would imply that competitive rules are known, and are applied transparently.

In the Philippines where aquaculture is largely left to (partially regulated) market forces, the role of government is more enabling than pro-active. Private entrepreneurship has for many years been the main force behind aquaculture development, with governments adopting a laisser-faire approach and aquaculture development being driven by domestic and foreign demand. A notable exception has been the government-funded support for carp, and the production of seed in the milkfish industry. In Indonesia, Malaysia, Thailand and particularly Viet Nam, on the other hand, governments are more pro-active, promoting the sector through incentives and other policies.

In two countries, Cambodia and Myanmar, aquaculture was long viewed as a minor contributor to food self-sufficiency. It was subordinate either to agriculture or to the capture fisheries. In Myanmar, however, the recent 1998 Aquaculture Law explicitly recognized the role of aquaculture, clarified land tenure to reduce conflicts and reassured private investors. As a consequence, there has been an expansion of registered farms and of aquaculture output.

Indonesian pro-active support for aquaculture is demonstrated by the government's policy. This policy of agriculture intensification is occurring in spite of the availability of large tracts of undeveloped land (Budiono, 2002). Its Aquaculture Intensification Program aims to increase the intensification of commercial species destined for foreign markets such as tilapia (*O. niloticus*), shrimp, seaweed and grouper. Malaysia has a food deficit and actively supports agriculture and aquaculture as a means of strengthening its balance of trade. As mentioned above, Malaysia exports about half of its aquaculture output. Malaysian tax incentives apply as part of an overall agricultural package, even though aquaculture is more profitable than agriculture activities, with strong domestic and international demand.

In Thailand, emphasis is now on sustainability rather than expansion per se. The country, which was an early mover in shrimp aquaculture, has recently adopted a more cautious approach. After rapid expansion of aquaculture, Thailand experienced negative environmental and social externalities in the mid-1990s. It has planed to increase output (to 630 000 tonnes by the end of 2006), but its focus is more on long term sustainability. Means to this end include research, ensuring environmental integrity and producing alternative species such as ornamental fish. However, exports are still a focus of coastal aquaculture, as is the cultivation of ornamental fish.

For Viet Nam, aquaculture development is a national priority for economic development. Government support is partly due to aquaculture's impact on livelihoods, but also to its export potential. Tax incentives, establishing public hatcheries, and offering inducements to foreign investors are among the tools used by policy-makers to promote this strategic sector. This commitment has produced concrete results; aquaculture volumes and values have doubled since 1995. Forecasts are that output will double again by 2010.

5.2 IMPORTANCE OF LAWS AND REGULATIONS

An enabling environment for entrepreneurs means providing law and order. In practice, it may involve drafting a legislative framework, ensuring property rights, administering aquaculture regulations transparently, and processing licences rapidly and equitably.

Law and order are important not only to reassure potential entrepreneurs that their investment will be secure, but also to encourage them to re-invest. Security of property and of water usage provides reassurance to investors. Corruption by officials and poaching are costs of production that either lower profits, or are passed on in higher prices to consumers, thereby reducing competitiveness. More serious forms of violence, including civil unrest, may even force investors to abandon their business. This has occurred in countries which have suffered from civil war.

Legislation can be effective in promoting, regulating and developing aquaculture in an orderly manner. Many countries lack legislation specific to aquaculture. Aquaculture is often administered under a Fisheries Act, as in Thailand. By recognizing aquaculture explicitly as a legitimate activity, Myanmar, with its 1998 Aquaculture Act, encouraged illegal operations to be registered. The aim was to reduce conflicts with agricultural and forestry sectors. In the past, there have been conflicts between agriculture and aquaculture as fish farms expanded to ex-agriculture land and low-lying areas. Governments in Myanmar assumed that conversion of paddy fields to fish farms would cause low rice production, so farms that were operating without a licence were dismantled. This government policy scared existing and potential investors. Farms that continued operated with this uncertainty over land usage. By way of the 1998 Law, the government recognized farms established before 31 March 1990, which increased the number of registered legal farms.

The 1998 Law not only promoted aquaculture in Myanmar by reducing land disputes, but also encouraged more sustainable practices. According to the Law, leases are available for aquaculture only on land designated for that purpose, and only on fallow land. Section 11 of the Law permits the Department of Fisheries to designate land for aquaculture, which could be developed into aquaculture zoning in accordance with integrated coastal management. In addition, earlier laws also encouraged greater sustainability. The Pearl Law of 1995 conserves oyster areas in order to maintain the sustainability of oyster fishing grounds, and the Forest Policy Statement of 1996 fully endorsed the principle of biodiversity and inter-generational equity.

Even without specific legislation, all countries in the region regulate aquaculture. However, the lack of capacity and cost of monitoring limits the effectiveness of regulations. Past attempts to promote aquaculture in Myanmar were handicapped by a lack of regulation, so the 1998 aquaculture legislation, despite deficiencies with respect to the importation of exotic species and genetically modified organisms, controls the amount of effluent and addresses issues of water pollution. Myanmar, however, lacks personnel to monitor the regulations. This lack of capacity has resulted in widespread mangrove conversion to shrimp farming. Prohibiting the use of mangroves for aquaculture, as done in the Philippines and Viet Nam, appears to be ineffective. Similarly, damning flowing water without a permit in the Philippines is prohibited, but monitoring of this regulation is problematic. Thus, the lack of resources for monitoring and enforcement may be as critical as the absence of legislation or regulations.

In Cambodia, the legislative and regulatory framework reflects the underdeveloped nature of aquaculture, but ecological degradation has occurred from other activities. There has been destruction of mangroves, damage to coral reefs by cyanide poisoning in order to capture grouper, and overfishing, particularly of undersized crabs. Cambodia has placed a moratorium on coastal shrimp farming.

Indonesia has regulations regarding aquaculture integrated zones. Only in particular zones can certain species be farmed. The aim is to create a critical mass to obtain economies of scale, and to encourage dissemination of technical knowledge among

farmers growing the same species. There are also regulations for mangrove preservation and environmental protection. In Indonesia, aquaculture has not been responsible for most of mangrove loss (perhaps only 6 percent is due to aquaculture), and land, including mangrove areas, can be leased.

Under the 1985 Fisheries Act, the Minister of Agriculture is responsible for aquaculture regulations in Malaysia. However, except for the 1990 Fisheries (Marine Culture System) regulations that relate to net cages and mollusc culture in the marine environment, there is no aquaculture law to control aquaculture development in Malaysia. There are also voluntary codes of practice.

In some countries, the national government regulates aquaculture whereas in others responsibility lies with municipality or local governments. In Malaysia, for example, the marine environment is under federal jurisdiction. Thus, cage culture in open water requires a permit from the local office of the national fisheries agency. However, Indonesia and the Philippines (since the Local Government Law of 1991) leave jurisdiction to local government units (Budiono, 2002; Muñoz, 2002). In these two countries, local government units have been given authority over the full extent of what is considered national waters, which is 15 km from the coastline in the Philippines.

5.3 ENVIRONMENTAL AND MANGROVE POLICIES AND REGULATIONS

Preservation of mangroves is an important target of policy in all the countries. The use of mangrove areas for aquaculture probably dates back to the previous century or centuries, particularly in Indonesia and the Philippines. However, development then was not widespread and there is no record of any law regulating such development.

Until the 1980s, governments in Southeast Asia were fairly liberal in granting permits to develop mangrove areas into aquaculture farms. Until the early 1970s, coastal public lands in Thailand, which often means mangrove areas, could either be purchased or leased for up to 30 years on a renewable basis. In order to prevent large-scale speculation by wealthy individuals or by companies, a maximum of 20 rais (about 3 ha) could be leased per applicant. In the early 1970s, the government of Thailand halted the development of mangrove areas and restricted any new development to the supratidal area outside the mangrove zones. Farms already developed within the mangrove areas were allowed to continue operation. However, illegal occupation apparently continued.

Currently, the trend is towards Codes of practice and improved environmental management. This policy was adopted after some major damages caused by brackishwater culture. Prior to the intensification of practices in shrimp farming, aquaculture had been conducted in Asia with benign consequences, but intensive culture techniques caused severe environmental damages. If not conducted properly, aquaculture can have damaging impacts such as loss of habitat due to destruction of mangroves, organic loading and pollution, nutrient enrichment and eutrophication, release of toxic substances during pond construction and pond pest management, irresponsible use of antibiotics, salinization of ground water and land subsidence due to pumping of underground water for salinity management, salinization of agricultural lands due to pumping saltwater, use of trash fish in fish feed, etc. (Pillay and Kutty, 2005).

In fact, most governments are trying to mitigate the worst environmental threats. In Indonesia, public lands, including mangrove areas, can either be leased or purchased from the government, but there is a complete ban on any further development on the island of Java, which hardly has any public land or mangrove forests left intact. The use of coastal areas for shrimp farming is also forbidden on islands of less than 10 000 km^2. Although aquaculture in mangrove areas is allowed on other islands, it must meet two major conditions. The first is to leave a 100-metre belt of mangrove intact along the water line. This Green Belt restriction along the coast is to assist in mangrove preservation. In permitted areas, an Environmental Impact Assessment is

required for farms of at least 50 ha in brackishwater zones, and for larger farms in lakes and in marine waters. A Code of practice with producer organizations is planned. The second requirement is for ventures beyond 50 ha to be developed along the nucleus-estate concept. In this concept, growout ponds are to be distributed to the landless for their eventual ownership under an approved financing plan. The developer is expected to provide support to the farmers in terms of technology, inputs and marketing. No ceiling is set as to the maximum area that can be developed under this rule.

Malaysia has zoning in marine areas, which are under federal jurisdiction. Land and inland waters are under state jurisdiction, so new regulations under discussion are being proposed to state governments for adoption and enforcement. Among the new regulations is the requirement that all aquaculture farmers must obtain a licence and a permit. Previously, only farmers in the marine environment had to obtain a licence.

Myanmar is a newcomer in shrimp culture development. The government still allows the development of mangrove areas beyond a certain distance from the waterline. The lease period is for thirty years and is renewable. There are no bounds on the maximum area that can be applied for, although the area to be approved for release is based on the business plan submitted, and the financial capability of the applicant. Foreign investment is allowed on a joint venture basis, with no limits placed on the extent of foreign involvement. As of 2003, there were about 17 000 ha of shrimp ponds, mainly in mangrove areas.

The Philippines probably has the most elaborate set of laws governing the use of coastal public lands and mangrove forests in the region. The rules and regulations for the use of mangrove forests for fishpond development were promulgated in 1937 when the Philippines were still under United States colonial rule as a commonwealth, and fishery activities were regulated by a Fish and Game Administration. During that period, the maximum area granted for lease was 100 ha for a ten-year period, renewable for another ten years up to a maximum of 50 years.

In 1954, distinction was made between individuals, who were still allowed to hold 100 ha, and corporate applicants who were allowed 200 ha. In 1959, the maximum area for individuals was reduced to 50 ha but that of corporations was increased to 400 ha. During the same year, a set of guiding principles for the issuance of fishpond lease agreements was issued "to implement the Administration's policy of bolstering the fishing industry and at the same time encouraging citizens to take active participation in the economic utilization of our natural resources" (Fisheries Administrative Order No. 14-12). It was during this immediate post-war period that fishpond development was most rapid, with the government actively encouraging brackishwater cultivation of milkfish (Appendix 2). Mangrove swamps could be developed into fishponds under the Fishpond Lease Agreement with large tracts of land available at low cost and long periods. With a US$26 million loan from the International Bank of Reconstruction and Development, the Rehabilitation and Finance Corporation (which later was to become the Development Bank of the Philippines) financed the development of brackishwater fishponds (Villaluz, 1953). Even if covered only by a Fishpond Lease Agreement, the areas to be developed were accepted as collateral. Between 1950 and 1970 the total brackishwater fishpond area more than doubled, from 72 753 ha to 168 118 ha. Most of the mangroves were lost during this period.

In 1979, the 10-year lease period was increased to 25 years. In addition, development plans attempted to address emerging environmental concerns for the first time. Developers were required to leave a 40-m strip along rivers and banks of streams, which should be left forested or, if denuded, should be planted with appropriate species for riverbank protection.

As mentioned above, as a result of a very liberal policy in the granting of fishpond leases and permits, Philippine mangrove forests dwindled even long before the global shrimp fever spread in the 1980s. From an estimated 450 000 ha in 1920, only

139 735 ha were left by 1995. By the time the shrimp boom began in the 1980s, most of the Philippines' mangroves had already disappeared. With growing ecological consciousness and the emergence and growing activism of environmental groups, the Philippine government imposed a complete ban on any further development of remaining mangrove areas. Meanwhile, mangrove reforestation is being encouraged and it is now one of the regular components of coastal resource management activities.

In Thailand, the Fisheries Act prohibits pond construction in public mangroves. Farms already located in mangrove areas can continue operations, but no new leases are available. Farmers are allowed to build ponds on their own property, but only in coastal areas (to prevent saline water leaching to fresh water). Large shrimp farms (8 ha or more) must register and obtain permission before operating. For these farms, there are also plans to require an Environmental Impact Assessment.

In Viet Nam, the government sets no ceiling as to the area of public land that can be applied for and developed. Instead, the area granted is based on an approved business plan and presumably the financial capability of the applicant. Lease period is for as long as 50 years. Foreign investors are allowed up to 70 percent stake in aquaculture ventures. Officially, the government has completely banned any further development of mangrove areas, but the practice reportedly continues unabated on a surreptitious basis. The shrimp fever arrived late to Viet Nam the 1990s, just when interest had already peaked, or even waned, in most other countries in the region.

In conclusion, early movers in coastal farming, such as the Philippines and Thailand, allowed unrestricted development at considerable environmental cost. Both countries are now following a more cautious approach to brackishwater farming, with an emphasis on environmental and social sustainability. The Philippines ban on further encroachment on mangroves and its focus on reforestation is commendable. However, its ability and willingness to monitor and enforce these restrictions is still unknown. Late-comers such as Indonesia, Myanmar and Viet Nam have recognized the dangers of untrammeled development, and have restricted coastal access through zoning, or by setting maximum limits. Here again, capacity may limit enforcement of these regulations. Table 14 summarizes some environmental policies that have been used in the region and their effects.

5.4 AQUACULTURE LEASES, LICENCES AND PERMITS

Property rights provide security to investors and reassurance to lenders. Property rights are well established in the Philippines but there are conflicts in Myanmar because the scarce marine-water and land resources belong to the public domain. Changes in land use regulations in Myanmar permitted rice fields in the seasonally saline areas of the delta to be converted into shrimp farms. This has resulted in a dramatic expansion of shrimp farming in the coastal areas of Rakhine State, Ayeyarwady and Yangon Division.

The length of leases, the transparency and speed of obtaining permits are important for reassuring investors. Twenty years should be a minimum length of a lease, which should also be renewable. Leases can also be transferable, although there is certain risk that this transferability may encourage monopolization of the industry. Monopolization may occur if wealthy segments of society purchase leases from small-scale farmers. Transferable leases can also encourage speculation if the species is successful, which again can lead to monopolization. In addition to leases, governments issue licences or permits. These are usually for short periods and are renewable. The renewal of licences enables the authorities to enforce compliance with regulations.

In Cambodia, where there are few regulations controlling aquaculture, fresh water operations beyond a (small) size, require permits; in coastal areas, licences are required for all operations. These licences are renewable annually. Malaysia has aquaculture development zones, where large farms get a Temporary Ownership of Land which

TABLE 14
Summary of some environmental policies used in the region and their results

Policy goal	Policy measure	Country	Result and comment
Avoid/reduce pollution	Policies based on FAO Code of Conduct	Indonesia	Positive
	Environmental Impact Assessment for brackishwater farms of at least 50 ha	Indonesia Philippines Thailand	Positive
	Environmental Compliance Certificate		
	Plans required for shrimp farms of at least 8 ha.		
	Chemical use and drug quality control	Thailand	Positive
	Board registration, inspection and enforcement		
Coastal planning	Require Green Belt/Aquaculture Integrated Zones	Indonesia	Positive
	Limit areas for shrimp farming	Thailand Philippines	Positive
	Require annual rent	Philippines	Not effective: rent is too low so no need for intensification
	Voluntary codes of practice	Malaysia	Unknown: recent
Protect mangroves	Prohibition of farms in mangroves	Philippines Viet Nam	Little impact: problems of monitoring and enforcement
Ensure water quality	Regulation of maximum discharge	Indonesia	Positive

can be based on a 30-year lease, and is renewed annually. Under present legislation, no licence is required to run a land-based farm although a permit is required for cage culture in marine waters. However, new regulations, if accepted, will require licences for all aquaculture farms, and permissions for construction of facilities.

In Myanmar, fallow land can be leased for 30 years renewable, but other land can be leased for only 10 years. These lease periods are for pond culture only; other forms of aquaculture have a lease period of only three years. This is too brief a period to amortize investment, particularly for capital intensive marine cage culture; so the policy has discouraged investment. However, large-scale farming investors are attracted by the fact that there is no restriction on size and area of land for aquaculture. The lack of restriction on size should enable some farms to obtain economies of scale. Because these leases are non-transferable, monopolization is unlikely. Moreover, since the duration of the lease is decided by the Department of Fisheries, extension is possible; this allows longer operational periods.

There are other onerous restrictions on leases in Myanmar. A lease requires that water culture must occupy at least three-quarters of the leased land. This condition allows limited space for water supply infrastructure, discharge waste disposal and buildings. Together, these entities typically account for almost half the area of a sustainable operation. Moreover, half the lease must be operational in three years and fully operational in five years. This requirement allows no leeway for problems with seed supply or technical assistance, nor does it allow for a learning curve and technology adaptation. In the lease, there is no reference to water quantity and quality, or to the criteria to obtain a lease. This is left to the discretion of the Director General of Fisheries.

The Philippines has used leases as a policy to stimulate aquaculture. Some of the requirements for a lease include a certificate from a bank demonstrating sufficient capital, a payment of a cash bond, a survey plan and an Environmental Compliance Certificate from the Department of Environment and Natural Resources. However, results have been mixed. Under the Fishpond Lease Agreement, mangrove swamps could be converted into fishponds (typically for milkfish) for 25 years renewable. There was a maximum size of 200 ha for a corporation and 50 ha for individuals. This size limit aimed to prevent monopolization. Until 1972, these lands, once developed, were titled and transferable. There was an annual rent, but it was very low. Moreover, the

land in fishponds was exempted from the Comprehensive Agrarian Reform Program designed to redistribute land. Again, this exemption was designed to encourage investment in aquaculture by providing security of tenure.

However, although land was developed, there have been unintended consequences. In the first place, ecological damage caused by destruction of mangroves was poorly understood. Now, there is a complete prohibition on converting mangroves into aquaculture or any other use. In the second place, although often thwarted by having family members apply for adjacent land, the size restriction prevented some farms from becoming sufficiently large to be viable. A third unintended consequence was the lack of intensification attributable to the land rent. The low land rent failed to reflect the opportunity cost of land, and, therefore, provided no incentive for land intensification. Instead, it encouraged farmers to get more land and farm extensively. The government is attempting to increase the land rents by a multiple of twenty, but such an increase will only be gradual due to resistance by owners. A further problem has been the government's inability to monitor and enforce regulations. An example is the sub-leasing of land, which is forbidden for fishponds under the Fishpond Lease Agreement. Such sub-leasing has become common, with rents more than ten times higher than the proposed new land rents opposed by owners. Moreover, the policy that limits natural resource use to Filipinos or to corporations in which Filipinos hold at least 60 percent ownership may have been circumvented by using locals as "fronts".

The lease covered only "surface rights"; it did not allow the licencee to extract timber or minerals from the leased area. Either activity required a different licence. The usual practice then was to first apply for a permit to cut the trees for timber, firewood and charcoal and then obtain a fishpond lease once the trees have been cut. This practice persisted through the 1950s to 1960s. Curiously, the first duty of a lessee was "to take precaution as may be necessary to prevent injury to the public forests and forest lands" (Fish and Game Administrative Order No.14.)

Viet Nam provides long leases for aquaculture; it also guarantees a rapid response to license requests. Long (20 to 50 year) land use certificates for aquaculture (as for agriculture and forestry) are available for public land. These certificates are transferable. Similarly, water rights require a certificate that can be transferred. To gain a permit, applicants have to satisfy two criteria: that the farm be part of an area designated for aquaculture and that there are no conflicts over water use. A decision has to be given within 90 days of the application; otherwise the applicant has de facto a permit. This rapid response is a clear benefit to potential investors.

5.5 AQUACULTURE WATER REGULATIONS

Water is often considered a common resource. Thus, its allocation among competing users such as other fish farmers, or agriculture, can be critical to the development of the sector. When disease struck shrimp farms concentrated along the Gulf of Thailand (southeastern coast) in the late 1980s, the King initiated the development of a marine irrigation project in Kung Kra Bin Bay in an effort to save the industry through a new development model. The project provided centralized seawater supply drawn one km from the shoreline, where the water is clean and not likely to be polluted by shrimp farm effluents. This was a pilot project which was to be duplicated in other areas. However, attempts by the Department of Fisheries to introduce similar schemes elsewhere were thwarted by issues over water rights. There were difficulties in securing rights-of-way for the common canals among shrimp farmers.

The availability of fresh water is often a source of conflict. In Thailand, fresh water is used in agriculture. Moreover, fresh water culture of shrimp entailed the conversion of rice paddies into shrimp farms and the trucking of hypersaline water. There were fears that this practice would make areas unsuitable for rice farming. Fresh water is also used in brackishwater shrimp culture to reach optimal salinity levels for shrimp.

Its use in shrimp culture does not appear a critical constraint if strains of shrimp can be developed to tolerate hypersaline levels, as in the Middle East. Evaporation in Saudi Arabia causes very high salinity, but selectively bred shrimp can be successfully cultured there.

Use of fresh water in agriculture also can cause conflicts. In Myanmar, irrigation for agriculture is given priority over aquaculture in the allocation of water. This policy has hampered the development of aquaculture. However, the two sectors need not be mutually incompatible; the use of water in aquaculture is not necessarily a loss for agriculture. Unlike rice, fish is a non-consumptive user of water; any reduction in the volume will be due only to losses from evaporation and seepage. Moreover, multiple uses of water can be an efficient means of using scarce fresh water. Integrating rice and fish can be beneficial with the fish fed on the rice stalks, and rice yields increasing as a result of the fish (Halwart, Funge-Smith and Moehl, 2002). Hence, payment for the right to use irrigation water for aquaculture, as in the Philippines, is illogical. In the Philippines, full payment is required, even if the irrigation water is merely diverted to a fishpond and then returned to the irrigation canal.

Surface water is often considered a common resource when found over public property, and even when found within private property. Lakes, rivers and the sea are by tradition and by law always considered part of public domain and can never be alienated or disposed. In Thailand and most other countries in Southeast Asia, the right to set up any structure in open water areas, such as fish traps and fish cages, requires a permit from the local or regional unit of the national fisheries agency.

In the Philippines, one cannot dam flowing water for exclusive private use without a proper permit or licence to do so. This permit or licence must be obtained from a national agency mandated to regulate water use. Where aquaculture is using municipal waters, a one-year renewable but non-transferable permit is required. However, drilling or digging a well for the extraction of ground water within one's property is always done without any prior permit from authorities. Although there might be laws requiring such permits, such laws are often difficult to enforce since it is not possible to monitor such activities.

In Indonesia, farmer associations resolve conflicts and manage resources through Water User Farm Associations. These associations, in addition to water allocation, also provide marketing assistance. Thailand similarly leaves local committees to allocate water resources. This community approach is a means of implementing Integrated Coastal Zone Management.

5.6 POLICIES AND REGULATION OF AQUACULTURE PRODUCTS

Important for domestic consumers and for gaining access to international markets, fish quality is gaining regulators' attention. Thus, it is becoming part of some countries' policy armory. Standards of quality and hygiene, labour regulations, animal welfare and GMOs,[6] can be sometimes suspect as non-tariff barriers, but they must be met by exporting countries. Some are also demanded by domestic consumers.

In Indonesia, policies are based on the FAO Code of Conduct. To ensure the quality of aquaculture products, the National Centre for Fish Quality and Processing Development supervises the provincial laboratories for fish inspection and quality control, which alone are responsible for certifying the end product according to HACCP[7] and the Integrated Quality Management Program of 2002. Among the main points in the latter programme are: a) each processing unit has to possess a Processing Cleanliness Certificate; b) the owner of the processing unit has to possess a fish processing certificate; c) each fishery export facility has to apply the programme

[6] Genetically modified organisms.
[7] Hazard Analysis and Critical Control Point.

based on HACCP; and d) every fishery export facility must possess the Integrated Quality Certificate or Health Certificate issued by the laboratories for fish inspection and quality control. Only health certificates issued by these laboratories are acceptable for exports to the European Union. There are also inspections of inputs used in aquaculture. Seed are inspected for quality according to ISO 9000 standards while standards used in feed inspections vary with species farmed (shrimp, catfish, common carp river eel and frog). Regulations extend also to imports: all imported fish must have a health certificate. There are provisions planned for GMOs as well.

Chloramphenicol has become a concern for Indonesian exports to Europe, where it is completely banned. In 2001, all shrimp exported from Asia to Europe were subject to antibiotic analysis with the Rapid Alert System at the port of entry. This policy was followed by the United States of America and Canada. Officially, Indonesia has prohibited chloramphenicol use in animals for human consumption since 1982 and enacted a number of regulations. However, in reaction to policies in importing countries, Indonesia has disseminated information about the ban on chloramphenicol to shrimp growers and processors.

The Malaysian government has taken a number of steps to ensure that products sold domestically are safe and that fish exported meet international standards. A Fish Inspection and Quality Control (FIQC) system and a network of Fish Health and Quarantine Centres have been implemented. Health Certificates are issued by the Health Ministry, and an Inspection Certificate by the FIQC. This is in accordance with Codex Alimentarius. Quarantine Centres, at all main entry and exit points, implement regulations on the international trade of live fish, thereby controlling the spread of fish diseases.

In Myanmar, while some regulations for environmental issues are in place, regulations for farmed fish are non-existent. On the other hand, one of Thailand's objectives for 2020 is to assure the quality and safety of aquaculture products. Chemical use in aquaculture is controlled through a Chemical and Drug Quality Control Board with a traceability procedure. This service is free of charge to producers. It also has a Fisheries Products Quality Control Board with registration, inspection, and enforcement. The purpose is to maintain HACCP standards. These regulations on drug and chemical use are driven by standards set by importing countries and are provided free of charge to farmers. Both policies have been very effective.

5.7 POLICIES TOWARDS INDUSTRY STRUCTURE

5.7.1 Farm size

Farm size varies by country, species and culture intensity. In the Philippines, the average land holding of commercial tilapia farmers is about 3.5 ha, with the range going from a small-scale average of 1.4 ha to a large-scale average of 8.4 ha. For milkfish farming, small-scale is considered to be less than 50 ha, and large-scale from 100 ha to more than 1 000 ha. However, because carp is not highly marketable, most of the fresh water fish farms are stocked with tilapia and are generally small. About 70 percent of them are equal to or less than 0.5 ha, while another 10 percent are between 0.5 ha and 1.0 ha. Carp farms average about 300 m^2 in Cambodia and a "few hundred square metres" in Indonesia, while in Thailand they can be as much as 0.81 ha for extensive farms and 14.08 ha for semi-intensive farms.

Shrimp farms tend to be larger than fresh water farms, with all countries reporting an average area of more than 2.3 ha. Brackishwater ponds may be stocked with milkfish, shrimp or both. In the Philippines, more than a third of the farms are larger than 10 ha with averages exceeding 12 ha for both semi-intensive and intensive. This may reflect ownership consolidation; one fifth of the farms account for almost two thirds of the area under brackishwater cultivation. In Indonesia, the number of households engaged in brackishwater cultivation is a quarter of the number engaged

in fresh water culture. A reason for this could be that brackishwater farms tend to be larger.

Indonesia has implemented a policy to encourage small-scale producers of shrimp and tilapia. Voluntary business partnerships have been encouraged since 2000. A large farm (nucleus) ensures the seed and feed production and also the marketing for small-scale farms which are primarily growout operations. In addition, the nucleus farm provides technical knowledge and often credit. The government's role has been to facilitate these partnerships, to monitor and to suggest improvements. These small-scale farms are predominant in shrimp (60 percent) and particularly grouper and seaweed (100 percent). In the Philippines, such collaboration between small-scale farms and a large operation (San Miguel Corporation), which was engaged in shrimp feed and processing, used to exist but has since ceased.

Thailand, one of the world's largest producers of shrimp, owes its high production to small family-run farms (Kongkeo, 1995). It is estimated that 80 percent of Thai shrimp production comes from farms with an area of less than two hectares.

5.7.2 Farm ownership

Ownership of most grow-out farms in the region is private, with small farms likely to be individually owned while large farms belong to corporations. This is particularly the case for carp farms but in most cases also for shrimp. Exceptions exist in Myanmar where government-owned farms persist but they have often been leased to individuals. Community farms also exist in Myanmar, sometimes as a source of income generation in mangrove rehabilitation projects. In Viet Nam, cooperatives are involved in production activities, particularly in the Central region. They first appeared in 1990 and their number reached a peak of 531 in 1995, but their importance is gradually fading as individual settings prove more effective. In 2001 their number had fallen to 33.

In all the countries, there are public hatcheries for stocking public waterways or for fingerling production. These public facilities are also research stations assisting with breeding programmes, and training. In the Philippines, there are conflicting views on public fish stations. Some see them as a means of providing subsidized fingerlings to small-scale farmers. Others perceive them as source of corruption because of price manipulation. In Myanmar, in addition to growout farms, public hatcheries are being leased to individuals with sufficient technical expertise.

The overall extent of foreign ownership is uncertain, but it is generally small in relation to the size of the sector. The Philippines and Viet Nam have limits on the proportion of assets held by foreigners. In the Philippines, foreign participation is restricted in natural resource operations (including aquaculture) to a maximum of 40 percent, but, as discussed earlier, this may have been circumvented by using local people as "fronts". In Viet Nam the proportion is 70 percent. Myanmar has no set limit on foreign participation.

In Indonesia, foreign ownership varies by species. Farming of groupers is primarily foreign-owned while crab and tilapia farms are evenly split between foreign and national ownership. In ornamental fish operations and in seaweed farming, there is very low or zero foreign participation. The average proportion of all aquaculture operations owned by foreigners is 30 percent. In Malaysia, the only major foreign participation is ornamental fish cultivation in Jahore State, where there are many investors from Singapore. Viet Nam has encouraged foreign investors with fiscal incentives such as tax holidays. As a result, the number of foreign companies involved in aquaculture doubled every year between 1998 and 2003. Feed is still produced predominantly by foreign firms, but their share has been declining in favor of domestic producers. Within Viet Nam, foreign investment has been evenly distributed regionally.

5.8 POLICIES TOWARDS SEED PRODUCTION

A serious constraint for certain species is seed availability and quality. Catfish in Cambodia, milkfish and grouper in Indonesia, tilapia in Malaysia and the Philippines, and seabass and grouper in Thailand and Viet Nam are among the species whose cultivation is constrained by seed. Shrimp farming is also handicapped by seed shortages in some countries such as Malaysia, Myanmar and Viet Nam. Carp culture, on the other hand, does not have a problem with seed. In an Asia-wide survey of carp farmers, only 9 percent of respondents in Cambodia mentioned seed supply as problem (ADB/NACA, 1996).

In addition to seed availability for certain species, the quality of seed is also an issue. Countries in the region have had a similar approach to the supply of seed, particularly for fresh water species such as carp and tilapia. Policy-makers recognize that the public sector, through public fish hatcheries, should provide seed if private hatcheries do not exist, or lack the capacity. Public hatcheries were established either for the whole country or for individual regions in the country. Their purpose was to supply fry and fingerlings, and also to demonstrate hatchery technologies. Interested farmers were given training and provided with broodstock. In addition to publicly funded fish stations providing seed, most countries have seen the development of private hatcheries, sometimes competing with the public hatcheries, with a mix of private and public hatcheries. The role of public hatcheries was then to spur the farming of a species by supplying fry and fingerlings free or at low cost. But, as private hatcheries developed the role of public hatcheries has changed to that of providing fry to small-holders, or of stocking public waterways.

Public hatcheries frequently concentrate on products that have a broader social interest, such as broodstock, or on species that are unattractive to the private sector. In Cambodia, twelve public hatcheries focus on raising indigenous fresh water species. In addition to producing fingerlings, these hatcheries provide some extension and even undertake research. However, they lack funding, and are obliged to generate some income by selling fish. There are about 45 private operations, but these suffer from a number of problems, including lack of modern information.

In Indonesia, there are both private and public nurseries, although the private predominate (92 percent on average for all species). Indonesia has a network of hatcheries and nurseries for fresh water aquaculture that supplies the 100 g carp fingerlings preferred by farmers. Carp seed production is highly segmented, with farmers specialized in breeding and producing young fry, and then selling them to others who grow them to a larger size. This hatchery-nursery system benefited from the popularity of intensive cage culture of carp. The one exception to private sector predominance in Indonesia is grouper. Grouper seed is primarily from public hatcheries, which assist with maintaining quality broodstock. An illustration of the dynamism of the private sector is the evolution of shrimp hatcheries. When there was a shortage of shrimp fry in the early 1970s, Indonesia decided to construct public hatcheries in different locations. Financed by the Asian Development Bank, the project took some time to develop and, by the completion date in the late 1980s, private commercial hatcheries were already operating. The public hatcheries were privatized shortly after completion.

In Malaysia, the six public hatcheries focus on production of seed that is ignored by the private hatcheries, or that are scarce. These include marine shrimp, giant fresh water prawn, mud crab seabass and a number of fresh water fish. The purpose is to provide impetus to the farming of these species.

Similarly, in the Philippines, the private sector predominates but the government has some hatcheries to assist production of certain species (mainly fresh water). The government Bureau of Fisheries and Aquatic Resources (BFAR) has thirty-six fresh water stations, many of which produce seed, particularly tilapia. Carp success has been limited because demand for growout has been low. In the case of tilapia, public

hatcheries are sometimes viewed negatively, even as a source of corruption. In order to encourage aquaculture as a livelihood, BFAR has a policy of pricing their fry much lower than market price (as much as 50 percent less), and at times even giving them away free. The Bureau also restricts the number of fry it will sell to any single producer. This policy helps small-scale growers, while handicapping large-scale producers who will need more than the public stations will supply. A further complaint is that government-produced tilapia is often sold below industry standards, which in turn forces small-scale private hatcheries to lower their standards to remain competitive. The end result is a poor economic performance of the industry following low yields from understocking.

Thailand's network of twenty Fisheries Centres and 57 Fisheries Stations are mandated to produce seed for ecologically desirable and commercial species, but they also provide seed when demand is high. Generally, fish seed production is in private hands. In northeastern Thailand, most of the private fish farms are also involved in seed production of carp, ruhu and tilapia, but seed shortages in the area may be as much due to poor roads as lack of seed.

With its ambitious aquaculture development programme, Viet Nam faces seed shortages for most species and has regional imbalances in seed distribution that it plans to rectify. Viet Nam is among the countries that have specifically targeted hatcheries for incentives. For fresh water seed, a National Centre of Fresh water Fish Seed has been established to provide broodstock, but private nurseries are also actively encouraged. The National Centre in the north of the country has the responsibility of providing broodstock for every hatchery in Viet Nam. Fresh water seed quantity has gradually increased, but there is a problem with the quality of broodstock and fingerlings at the local level. Thus, when destined to remote and mountainous regions, fresh water seed enjoys transport subsidy and price support mechanisms.

To cope with shortages and regional imbalances of shrimp seed, Viet Nam has implemented a number of successful initiatives. It imports shrimp seed from other countries under strict quarantine and quality controls and permits the transport of shrimp seed from one region to another. It also encourages shrimp seed production in the North where shrimp seed production is less developed. For shrimp hatcheries, there is preferential credit for both household farmers and large-scale farms. Results of these policies have been impressive, even in the North. The number of hatcheries has increased sharply to almost 3 000, with more than 85 percent devoted to shrimp production.

Marine fish seed in Viet Nam comes from the wild or from imports and remains insufficient. A national marine development strategy has been developed that will focus on seed production. A National Centre for Marine Seed in the North conducts research on marine seed and provides broodstock for different hatcheries throughout the country. By 2010, the plan is to have a sufficient amount of quality seed of valuable species such as grouper, cobia and milkfish. Malaysia includes hatcheries along with growout for tax exemptions, but Viet Nam has specific incentives for those producing marine seed. Under Regulation 103 in 2000, about VND 1 000 billion of government money was allocated to seed production during 2000–2005 in the form of soft loans. Credit was available for five years with collateral only required for loans of more than VND 50 million. For priority marine species such as grouper, cobia and milkfish where demand for seed exceeds supply, there are also tax exemptions for imported seed, broodstock, and material for hatcheries and farms. Foreign companies investing in marine seed production are exempt from value added tax (VAT); they also enjoy reduced land taxes. Government funds are available to send students abroad to learn the technology of marine seed production.

A common constraint in increasing seed availability is poor linkage between seed producers and fish growers. Seed producers may not see the need for a central clearing

house to inform growers of their closest seed supplier; so growers often have to rely on fry traders. Indonesia and Thailand are attempting to improve communication among hatcheries and growers. Indonesia, therefore, has organized regular private/public seed markets. The policies are designed to improve the market system and match hatcheries with farmers. Similarly, to encourage better linkages in the production chain, Thailand has developed information centres to connect seed producers and fish growers. This requires databases of hatcheries and species. Other policies include the import of seed of marine finfish by Malaysia and permission to employ foreign technicians by Myanmar.

To increase availability of seed, and lower the price of seed at home, in addition to improving communication among hatcheries and growers, some countries have strict prohibitions on the export of broodstock. The Philippine Fisheries Code of 1998 expressly prohibits the export of seed of milkfish (*Chanos chanos*) and black tiger shrimp (*P. monodon*). This policy is contrary to the wishes of milkfish and shrimp hatchery operators who would like the ban lifted to take advantage of seasonal demand abroad. The Philippines also prohibits the export of live wild fish of all other species. Malaysia bans the export of *P. monodon* broodstock and Viet Nam has implemented a temporary ban on exports of marine broodstock.

Seed quality is also a policy issue in some countries. In fresh water aquaculture, where farms produce their own seed or buy from others, there is a risk of inbreeding if careful husbandry is not implemented. This can lead to slow growth and even deformities. In marine shrimp, the fry may be infected with bacterial or viral diseases which appear when the animals are under stress, and cause high mortality. Marine fish such as grouper are also susceptible to viral diseases. Inbreeding can be avoided by keeping a large selection of breeders and by sound selection. Governments can assist with research into new strains and with certification of hatcheries.

In Indonesia, seed quality is assured by a number of regulations. There are production standards specified in the Indonesian National Seed Standards. There is also seed inspection with certification and monitoring. These measures appear to have been successful. Malaysia bans the import of all species of marine shrimp, but shrimp broodstock can be imported (particularly *P. vannamei*) if certified, and comes from accredited sources in Hawaii and Florida.

In the Philippines, the Nile tilapia stock has been improved through a breeding programme that has had considerable international assistance (Mair *et al*., 1994). With the expertise of Central Luzon State University (CLSU), the Genetically Improved Farm Tilapia (GIFT) has been developed. Producers of GIFT tilapia must pay a refundable cash bond and a royalty fee based on the number of fry produced per broodstock. Hatcheries purchase the broodstock at a price equivalent to production costs but the stock remains the property of the GIFT Foundation, which accredits producers. Problems with royalty and licensing have limited the expansion of GIFT to seven large hatcheries. In 2002, the GIFT Foundation was acquired by Genomar (a commercial enterprise) and the tilapia have been renamed Genomar Supreme since then. The Bureau of Fisheries and Aquatic Resources has launched its own GET-EXCEL breed. In addition, there is the Genetically Male Tilapia (GMT) which is supplied by the CLSU College of Fisheries. Those wishing to become GMT producers must have training at the CLSU and have their facilities monitored. GMT breeders are sold at a premium, at least six times the price of a generic tilapia. Except for these cases, there is little regulation over hatcheries; establishment only requires a mayor's permission.

In both the Philippines and Viet Nam, there is public pressure to require certification for shrimp hatcheries, at the least. This is due to recognition that fry can become vectors of disease. Improving research institutions and the technology of seed production are national priorities in Viet Nam. The National Centres in Viet Nam are responsible for broodstock. The government also regulates and inspects seed under a 1996 Decree.

TABLE 15
Some policy measures adopted to increase the availability and quality of seed in the region and their results

Policy goal	Measure	Country	Results	Remarks
Increase the supply of fry through the public sector	Provide government hatcheries	All countries	Positive	Useful for broodstock quality and social goals (seed for the poor)
		Cambodia	Negative	Lack of funding
		Indonesia	Negative	Took too long (shrimp) and the private sector took over
		Malaysia	Positive	For new species or for species with seed shortages or for species difficult to reproduce
		Philippines	Mixed	Seen as source of corruption-mark-up pricing
Increase the supply of fry through the private sector	Laisser-faire	Most	Positive	
		Cambodia	Negative	Private hatcheries lack expertise
	Privatize/lease government stations	Myanmar	Positive	Leases transferred to those with expertise
	Tax exemptions, credits for hatchery upgrades	Philippines	Positive	Tilapia hatcheries are very profitable
	Tax exemptions	Viet Nam	Positive	For shrimp and for marine seed (grouper, cobia and milkfish)
	Incentives for foreign investors	Viet Nam	Positive	For shrimp and for marine seed (grouper, cobia and milkfish)
	Price support and transport subsidy for fresh water seed	Viet Nam	Positive	To assist farmers in remote and mountainous areas
Improve seed quality	Selective breeding (tilapia)	Thailand	Positive	
	Allow foreign technicians	Philippines	Positive	
	Set standards ISO 9000	Indonesia	Positive	
	Seed inspection	Indonesia	Positive	Costly
	Seed certification and monitoring	Indonesia	Positive	Costly
	Specialized seed production	Philippines	Positive	Tilapia hatcheries concentrate on strains
			Positive	Develop strains with universities

In conclusion, for some species such as grouper and seabass where fry is collected from the wild, there continues to be widespread shortages of seed. However, for most species, a combination of public and private hatcheries has provided a suitable supply response. Government hatcheries often concentrate on broodstock and subsidized seed supply but, because they do not attempt to make a profit, concerns over lack of funding have emerged. Also, there is the potential for corruption. In Indonesia, they are becoming redundant.

Private hatcheries have usually developed under a laisser-faire (with little government regulations) policy. However, this policy is changing with concern over diseases. With shrimp fry, there is pressure for certification in the Philippines and Viet Nam. One effective strategy to improve stocks is to follow the Philippine example of developing tilapia strains in partnership with universities. Table 15 summarizes policy measures adopted to increase the availability and quality of seed in the countries studied.

5.9. POLICIES TOWARDS FEED PRODUCTION

As is the case for seed, the availability and cost of feed can be a constraint critical to aquaculture development. Shortages or irregularity of feed supplies add to risks and may jeopardize operations. This has been a problem in Myanmar where border delays have led to spoilage. To circumvent delays, sea freight is used, but it doubles the cost of delivered feed. In Cambodia, there is the problem of seasonal availability of trash fish to feed carp. The cost of feed is particularly important because feed is the major expense in cultivating most species.

TABLE 16
Estimated relative costs and returns for selected aquaculture farm enterprises in the Philippines

Item	Tilapia (pond)	Tilapia (cage)	Carp (cage)	Milkfish (pond)	Milkfish (cage)	Shrimp (pond)	Seabass (cage)	Grouper (pond)
	US$/kg	*US$/kg*	*US$/kg*	*US$/kg*	*US$/kg*	*US$/kg*	*US$/kg*	*US$/kg*
Variable costs	0.74	0.84	0.08	0.77	1.07	2.49	2.49	3.02
Labour	0.01	0.01	0.06	0.17	0.10	0.08	0.08	0.28
Feed	0.64	0.61	0.00	0.36	0.62	1.53	1.53	1.60
Other	0.09	0.22	0.02	0.24	0.35	0.88	0.88	1.14
Fixed costs	0.04	0.03	0.01	0.13	0.06	0.18	0.18	0.60
Total costs (TC)	0.78	0.87	0.09	0.90	1.13	2.67	2.67	3.62
Farm-gate price	0.82	1.01	0.18	1.21	1.4	3.50	3.50	5.66
Profit	0.04	1.01	0.09	0.31	0.27	0.83	0.83	2.04
Labour as a % of TC	1.28	1.15	66.67	18.88	8.85	3.00	3.00	7.73
Feed as a % of TC	82.05	70.11	0.00	40.00	54.87	57.30	57.30	44.20

Sources: Baliao *et al.* (1998); Baliao *et al.* (2000); BFAR (2001); BFAR (2002); Ling, Leung and Shang (1998).

As shown in Table 16 for the Philippines, for all species except carp, feed costs far outweigh labour costs. Feed accounts for as much as 82 percent and 70 percent of total costs for tilapia (in ponds and cages respectively), more than 50 percent for milkfish and seabass cage culture and for shrimp pond culture. Only carp culture has very low feed expenses because residuals from farms such as rice bran are used. However, the use of trash fish for feeding carp in the dry season (November to April) is not without cost. An estimated 4 kg of trash feed is needed to produce one kilo of fish, which has implications for food security among the very poor.

The supply of shrimp feed is not a major problem in the region; feed is available, if expensive. As with carp, natural feed is often used for extensive and semi-intensive shrimp culture. However, concerns about feed quality have prompted the use of formulated feed in Malaysia for these two production systems.

Manufactured formulated diets are used for intensive shrimp farming; in most countries, the manufacturing plants are private and domestic. They developed largely without government incentives in response to a perceived demand. Originally catering to livestock producers, the plants diversified from livestock to aquaculture feed in response to market forces. In the early years of shrimp culture, feed was imported, but demand created domestic suppliers as in Indonesia, where 37 private feed mills now have the capacity to produce 2.5 million tonnes of feed annually. Viet Nam, with its ambitious aquaculture plan to double aquaculture output by 2013, needs to increase domestic feed production and avoid relying on imports. As a solution, Viet Nam permits foreign investment in the feed sector. Most fish feed in Viet Nam is produced by foreign companies from Asia, Europe and the United States of America, but domestic firms are accounting for a growing share of the market. There are about 40 feed companies, which meet most of the current demand for aquaculture feed. Myanmar has adopted the same policy.

Feed companies may supply additional services. In the Philippines, they provide free technical advice and credit to growers in return for the option to buy the produce. They therefore provide unofficial extension and banking services, making up for institutional shortcomings. Reputable feed companies provide interim financing to growers in the form of delayed payments. Their representatives are consulted on husbandry and technical matters, and, if there are problems, will advise which government agency to approach. They may also source fry and other inputs, and find buyers for the produce.

Where feed is a constraint, it is usually because of its high cost rather than its unavailability. This is the case for shrimp feed for *P. monodon* in Indonesia and catfish *Pangasius* in Malaysia. The high cost of feed is due to the need to import essential

TABLE 17
Indonesia feed standards for carp, catfish, eel, frog and shrimp

Standard (maximum % in feed*)	Carp	Catfish	Eel	Frog	Shrimp
Water	14.0	8.0	10.0	10.0	12.0
Protein	25.0	30.0	36.0	38.0	36.0
Fat	4.0	6.0	4.0	4.0	4.0
Fibre	7.0	3.0	2.0	4.0	3.0
Ash	13.0	17.0	11.0	11.0	17.0
Free nitrogen	–	0.15	0.15	0.15	0.15

* For fat content, the percentages under eel, frog and shrimp represent the minimum acceptable.

ingredients such as fish meal. The problem was exacerbated during the Asian crisis, when currencies depreciated causing import prices to rise. Indonesia's import of fish meal in 1998 was a third of the 1997 imports. As a result of high import costs, Indonesia and Malaysia are attempting to develop feed with local ingredients (Subasinghe *et al*., 2002). In the meantime, the cost of fish meal is lowered by both governments by exempting imported ingredients from taxes.

Tariffs on feed and imported fish meal have also fallen, lowering prices. In the Philippines tariffs have fallen from 30 percent in 1981–1983 to 3 percent at present (Ridler and Hishamunda, 2001). This has forced domestic feed companies to compete with international producers. However, there is some reluctance by governments to eliminate tariffs completely, partly because of the loss of revenues, but also because of the wish to protect domestic feed producers.

In addition to feed cost, the quality of feed is an issue. In Indonesia, the government controls quality through monitoring and inspection. Samples are regularly taken to ensure that feeds meet general Indonesian Feed Standards. Table 17 shows the standards for the five species (carp, catfish, eel, frog and shrimp) for which feed quality is regulated.

In conclusion, the feed industry in market economies has developed according to economic theory. As the aquaculture industry developed, entrepreneurs saw opportunities for profits in manufacturing fish feed. The result is a predominance of the private sector in all countries except Cambodia. The high cost of imported ingredients, partly due to depreciating currencies after the 1997 Asian Financial Crisis, has prompted experimentation with local ingredients. Unfortunately, the region does not have a sufficient quantity of trash fish to convert into fishmeal. As for feed quality, regulations may be desirable if they are not prohibitively expensive to monitor and enforce. There may also be a lack of expertise. Table 18 summarizes policy measures which have been adopted to increase the availability and quality of feed in the region.

5.10 POLICIES TOWARDS INVESTMENT CAPITAL

Six of the seven countries provide incentives for investment in aquaculture, whether as part of a broader strategy for food production, or as a policy specific to aquaculture. The exception is Cambodia. Some have targeted the incentives to the poor, or to certain regions. Recognizing that investment in an aquaculture business is risky, loans may be given at a preferential rate, or access to loans made easier. Given the willingness of farmers to pay high interest rates in the informal sector for other activities and their ability to repay, it is questionable that the major constraint to investing in aquaculture is the cost of capital. The constraint may have to do more with the reluctance of farmers to invest in high risk activities; access to credit for those lacking documentation may be another impediment.

Funding for high risk operations such as aquaculture can come from foreign investment. The region lacks a well-developed venture capital market willing to invest in new projects with potentially high financial risk. This may have limited the region's capability to develop and commercialize new technologies without turning to foreign investment. However, as mentioned earlier in the section on ownership,

TABLE 18
Some policy measures adopted to increase the availability and quality of feed

Policy goal	Policy measure/tool	Country	Results	Remarks
Increase availability	Encourage (domestic and foreign) feed companies	Viet Nam	Positive	Production now meets most domestic demand
Reduce feed costs	Reduce imported ingredients through increased use of local trash fish	Indonesia	Poor	Quality of trash fish did not meet nutritional standards
	Reduce protectionism (tariffs)	Malaysia	Positive	Encouraged foreign feed companies
	Use local ingredients	Malaysia	Positive	Saved on imports
	Exempt imported ingredients from import taxes	Malaysia	Positive	Lowered feed costs
	Encourage integrated aquaculture	Cambodia	Positive	More profitable
Improve feed quality	Set feed standards for each species	Indonesia	Positive	
	Frequent monitoring	Indonesia	Unknown	Weak enforcement
	Regular inspection	Indonesia	Unknown	Costly
	Encourage use of formulated feed	Malaysia	Positive	
	Establish feed standards	Malaysia	Positive	
	Set up a Feed Quality Assurance Board	Thailand	Positive	
	Define feed formulas	Thailand	Positive	

foreign investment in aquaculture, particularly in new technologies, has been scarce. Aquaculture development has relied largely on local, rather than foreign, risk-takers. One exception is shrimp farming, which, during its heyday in the 1980s, drove substantial foreign investment into many of the Southeast Asian countries. This capital inflow, however, has never been on a scale that is comparable to the manufacturing industry. Also, such investments are often short term "fast-buck" types of operation, done sub-rosa, and not officially reflected as foreign since they are made through local partners. This is often done to skirt local laws on investment in natural-resource based industries. As discussed earlier, in the Philippines, such industries are reserved to nationals or to companies with 60 percent local ownership. In Viet Nam, foreign investors are allowed up to a 70 percent share while apparently no ceiling has been set on foreign ownership in Myanmar.

Stringent banking regulations such as the need for collateral, high equity requirements and the high cost of money are often cited as some of the factors retarding the growth of the industry, but this may only be part of the picture. A more important factor may be the willingness of existing or potential aquaculture farmers to make new or further investments in what is at best a medium risk venture. In the 1980s, during the height of the "shrimp fever", banking regulations on lending to aquaculture were stringent in the Philippines. Yet, many shrimp farmers accessed all available credit, to the extent of pledging even their residences as collateral, because they were convinced that high returns would more than offset the risks. The shrimp market crash in 1989–1990 saw many of such farmers lose their entire assets. Subsequently, the increasing incidence of diseases, and therefore increased risks of production failure, has made farmers averse to accessing bank financing. The banks themselves became more wary about lending to shrimp farmers. For the culture of foodfish such as carp, tilapia or milkfish, bank financing is often out of the question because of the very low profit margin. Debt servicing can spell the difference between profit and loss. Credit from financial institutions is, therefore, often avoided.

The farming of milkfish in marine pens and cages is proliferating in the Philippines, despite the lack of any special financing programme. Although there have been no studies on the subject, it is generally known that most of the fish cages are self-financed, or perhaps partly financed by feed suppliers through deferred feed payments (Bagarinao, 1999). This type of informal financing is common in Southeast Asia. This

is true not only for locally consumed fish, but even more so for shrimp. The most common approach is for feed suppliers to require growers to issue post-dated checks to cover the cost of the feed delivered. If business relationships are good, and the grower has a good track record, the checks can even be dated to the time of expected harvest. Often though, the checks are dated from 30 to 90 days after feed delivery. For farmers with multiple cages or ponds, and staggered stocking and harvesting, this arrangement is often adequate, since the proceeds from the harvest of one cage or pond can be used to pay for the feed being used for an on-going culture at another unit. Feed suppliers resort to such approaches especially when there are several companies competing for market share. The same deferred payment approach may also be available from hatcheries for fry and fingerlings. However, this is less common since hatcheries often do not have the same financial capacity as feed millers.

It should be noted that, while feed is the major expense item in aquaculture operations and informal de facto short-term financing is available from feed suppliers, financing cannot be accessed unless the farmer owns the physical culture facilities in the first place. It is in the financing of pond construction, and cage acquisition and installation that a potential grower will probably encounter problems. Because of such constraints, cage culture operations in the Philippines are often restricted to those who have their own means of financing.

Obviously, there is a need for special loan programmes to assist those who do not have their own funds to acquire or develop culture facilities. In Indonesia, since 2001, the government provides credit for fixed and operating expenditures at a 16 percent interest rate. An interest rate subsidy may be necessary if market rates exceed this. Private banks are also required to avail one to five percent of their profits as credits to cooperatives and small-scale farmers. In addition to these interest rate subsidies, Indonesia offers fiscal incentives for those willing to invest in certain regions. Domestic and international entrepreneurs who are willing to invest in the eastern parts of Indonesia are eligible for a tax holiday.

The Philippines has a loan programme under the Fishery Sector Program. Even after the termination of the Program in 1995, the credit component was continued. The Philippine Department of Agriculture's credit programme is implemented by the Quedan and Rural Credit Guarantee Corporation (QUEDANCOR). The programme is aimed at enabling local government units to extend financial assistance by lending to farmers and fishermen, or their respective organizations. QUEDANCOR-accredited local government units which are able to submit viable agro-fishery project proposals may obtain loans from PHP500 000 (about US$10 000) and above for re-lending. However, the loan mechanism of this credit programme is changing as a result of new legislation.

Under the Agriculture and Fisheries Modernization Act, which was signed into law in 1997, credit reforms in the agricultural sector were instituted under the Agro-Industry Modernization Credit and Financing Program (AMCFP). The reforms are based on the following observations on past credit programmes. Firstly, subsidized interest rates in many previous programmes benefited mostly the large borrowers rather than the targeted clientele. Secondly, large borrowers compete for the cheaper funds and often prevail, simply because they have the collateral and are considered less risky. Thirdly, lower interest rates often give the wrong signal to borrowers who tend to interpret the loans from government as dole-outs. And, finally, programmes involving direct lending by government agencies, which are not financial institutions, generally end up with poor repayment performances as a result of inferior fund management.

The policy framework of the AMCFP is based on the following principles. First, starting in 2002, non-financial agencies are refrained from implementing directed credit programmes. Second, existing agricultural credit programmes are rationalized. Third, lending decisions and/or credit delivery are limited only to banks, viable cooperatives

and non-governmental organizations (NGOs). Fourth, market-driven lending rates shall be instituted to enable conduits to cover their costs and achieve sustainability in the long run. And, finally, the Department of Agriculture shall focus on the provision of infrastructure, institution building, research and development, policy development and advocacy and other support services that shall enable the smallholders in agriculture and fisheries to become eligible for bank loans.

Since the reforms have just been instituted, it remains to be seen how the new agricultural credit policy and direction will work in the Philippines. There is a persistent perception from some quarters that interest rates should continue to be subsidized for farmers and fishers. There are also those who point out that interest rates may not be the only, or even the most important, determinant for smallholders to make use of the available financing. Citing the fact that many farmers and small entrepreneurs regularly avail themselves of credit from informal financiers, even at usurious rates, and are often able to repay such loans, it is pointed out that more important than the interest per se is the ease and convenience of getting a loan approved with minimal paper work and documentary requirements. Although these observations are based purely on the Philippine situation, it appears to be applicable to the other Southeast Asian countries with similar directed credit programmes.

Governments in other countries also provide start-up funds. Malaysia provides financing for food projects through its Fund for Food (3F) project. It has also a special fund for small and medium sized agro-businesses. Viet Nam provides incentives for those interested in aquaculture enterprises. Beginning in 2001, Viet Nam provides land tax exemptions to commercial farmers faced with market risks. This is in addition to three year exemptions on income taxes for farmers who engage in aquaculture in non-productive land or lagoons. There is a minimum size to qualify for the land tax exemption, which varies by region and species. The minimum is one hectare for shrimp and two hectares for other species.

In conclusion, because of the risks involved with aquaculture, entrepreneurs are often attracted to other sectors. It is risk rather than financing that handicaps aquaculture development. However, incentives targeting income groups, regions or sectors for credit appear to have been successful. Indonesia, with its policies designating a fraction of bank profits to low-income groups; Malaysia, where the food sector is actively promoted; and Viet Nam, with its regional approach to development, provide useful examples. Nonetheless, the cost of monitoring is unknown and there may be other hidden costs to economic efficiency.

General monetary incentives for aquaculture are of doubtful effectiveness. Interest rate subsidies can have negative efficiency and equity consequences. The 1997 Agriculture and Fisheries Modernization Act in the Philippines recognized the disincentive impact of low interest loans. Loans were viewed as hand-outs. Also, they also benefited primarily the larger borrowers, who held more collateral and less risk. As a result, reforms have been enacted. Because non-financial government agencies had a poor record of financial management, lending decisions are now limited to banks. In addition, to increase sustainability, market rather than subsidized interest rates are charged.

Fiscal policies are perhaps the least costly to administer. Custom exemptions and easing of custom procedures can be regulated by a few officials. Similarly, income tax exemptions and land tax deductions do not require heavy monitoring. Unlike interest rate subsidies, tax exemptions also require no direct outlay from the public purse.

Finally, the encouragement and easing of foreign investment, and of foreign technical assistance, appear to be a successful means of acquiring capital and knowledge. Limits can be placed on the degree of foreign control of natural resources. By limiting capital and profit repatriation to firms that have operated for several years, governments can also ensure that foreign investment does not have only short-run goals. Table 19

TABLE 19
Some policy measures used in Southeast Asia to increase availability and access to capital in aquaculture

Policy goal	Policy measure/tool	Country	Result	Remarks
Increase access to credit	Regulation of credit allocation to small farms	Indonesia	Positive	Some costs
	Micro-financing by government through banks or by NGOs	Indonesia	Positive	
	Special funds for cooperatives	Indonesia	Positive	
	No collateral needed for (small-scale) food operations	Malaysia	Positive	Increases default risks
	Livestock and Fisheries Bank concentrates on carp farming (excludes hatcheries and shrimp)	Myanmar	Did not work	Requires collateral; only lends small amounts
	Low interest loans without collateral for diversification of fishers to cage culture	Philippines	Positive	
Lower credit costs	Interest rate subsidy to all farmers (Food Security Credit)	Indonesia	Positive	
	Require banks and companies to allocate a share of their profit to small-scale business at low interest rates	Indonesia	Positive	
	Low to zero interest rate for food industries	Malaysia	Positive	
Tax breaks	Tax holidays for least developed (eastern) regions	Indonesia	Unknown	Regional development goal
	Exempt import duty and sales tax on machinery and equipment	Malaysia	Positive	
	Various other tax deductions and exemptions-not specific to aquaculture	Malaysia	Positive	
	Waive income tax for 3 years	Myanmar	Mixed	
	Tax exemptions and tax credits	Philippines	Positive	
	Simplify custom procedures	Philippines	Positive	
	Waive land tax for 3-5 years	Myanmar	Unknown	Only fallow lands
	Targeted tax exemptions for species and locations	Viet Nam	Positive	Regional goal and species development
Encourage foreign investors	Tax holidays	Indonesia	Positive	
	Exemptions from import duties	Indonesia	Positive	
	Guarantee capital and profit repatriation	Myanmar	Positive	
	Joint ventures only	Myanmar	Unknown	
	Three year tax exemption for FDI	Myanmar	Positive	
	Deduction of 50 percent of tax on profits of exports	Myanmar	Mixed	Too many obstacles
	Low interest rates	Viet Nam	Positive	

recapitulates some policies that have been used to increase the availability and access to aquaculture capital in the region.

5.11 MARKETING POLICIES

Generally, the region is dependent on fish as a source of protein, but the species and form consumed depends on availability and preferences. Cambodia's high fish consumption in 2003 was met almost exclusively (more than 90 percent) by fresh water fish. This compares with Malaysia, where only about 6 percent of the much higher per capita fish consumption consisted of fresh water fish (FAO, 2007b).

Farm-gate prices of shrimp were halved in 2001 as a consequence of weakening world demand, a phenomenon accentuated by the terrorist attacks on the World Trade Center in September 2001. This suggests that the price received by shrimp farmers is determined in the international market. For domestically-traded species, prices are determined by preferences. Preferences are, therefore, a critical incentive for farmers attempting to satisfy domestic markets. This argument is illustrated by catfish farming in Cambodia and Indonesia. Unlike Indonesia, where hybrid catfish is the dominant catfish species, very few farms grow the hybrid catfish in Cambodia because consumer demand is virtually non-existent. Consumers prefer the local catfish (*Clarias batracus*) to the imported species.

The farming of bighead carp in the Philippines provides another example where preferences, and therefore markets, determine which commodities are produced. The species, as well as the hatchery technology, was introduced in 1965 as part of the Food for Hunger Campaign. Fingerlings were produced in government hatcheries, and cage and pen culture in Laguna Bay was established. However, because the species was not well known, it did not sell well, even when prices were 50 percent lower than those of milkfish and tilapia. Yet, once gutted and cut up, bighead carp resembles the expensive red snapper, and was sold as such to undiscriminating city shoppers. The species became popular for fish head soup in specialty restaurants. When, in 1998, turbidity in Laguna Bay forced farmers to shift away from milkfish to carp, output of carp went from 3 000 tonnes in 1999 to 18 000 tonnes in 2001. By then, a market for carp was established and growers had no difficulty selling their fish.

In addition to preferences, price is also influenced by supply. Many farmers harvesting at the same time can cause the price to drop sometimes below the cost of production. Thus, even when demand is constant, milkfish prices in the Philippines can decline by half, or even by a third, depending on supply.

The marketing channels of farmed fish tends to have a shorter distribution chain than for other agricultural products. The reason is the fragility and perishable nature of fish. The length and process depend in part on the size of operation, the species, the location of the farm, and even the destination.

In Malaysia and the Philippines, brokers and wholesalers send teams to farmers to purchase their harvest, with packaging done on site for shrimp. They, in turn, will sell to restaurants and retailers (or to each other) thereby saving growers the expense of marketing. This practice is typical in farms with large outputs of a few hundred kilos or more, but small-scale producers (less than a hundred kilos) may sell directly to consumers. In Cambodia, the opposite occurs. Small-scale farmers tend to go through traders who provide credit and who will market the product to consumers, while large-scale farmers bypass the middlemen and sell directly to retailers. In areas of the Philippines with so few farms that wholesalers do not find it worthwhile to send in teams, growers may sell to brokers, or even pack the shrimp themselves. In the Philippines, therefore, the market chain includes four types of middlemen, namely the broker, the wholesaler, the wholesaler/retailer and the retailer; large markups are common. The marketing channels in Viet Nam vary by species, with carp and tilapia growers selling directly to retailers and marine fish growers to wholesalers. Catfish and shrimp are sold either to wholesalers or to retailers.

Generally, with rising living standards and improved transport, fresh fish is increasingly preferred. Farm-raised tilapia or marine fish are usually sold alive because they are worth only half as much otherwise. The grower may sell to a broker who deals with the transportation risk. However, the grower's price is much higher if sold directly to the retailer. The importance of marketing fresh and live fish to the domestic market appears to be increasing in Indonesia, the Philippines and Viet Nam. Packaging techniques are well established and for some species, such as groupers, their high value makes air freight cost effective.

Transport is critical in determining the form and destination of fish marketed. Thus, neighbouring Singapore and China, Hong Kong Special Administrative Region are Malaysia's main destination for live fish while processed products are exported to Europe and the United States of America. In Indonesia, per capita consumption of fresh fish in rural areas has increased, but most fish consumed is processed. Transport is also a major factor in the location of processing plants, particularly for the distribution of live fish. In Viet Nam, for example, two-thirds of processing plants are located in the south because of its large population.

The extent of processing depends on species. In Indonesia, exports of milkfish are usually in the form of fingerlings or in frozen form, whereas tilapia exports tend to be sold whole, or for large fish, as frozen fillets. Marine fish are sold live, whether as exports or

TABLE 20
Farm-gate, wholesale and retail prices and markups of various aquaculture species in the Philippines, 2003

Species	Farm-gate price (US$/kg)	Wholesale price (US$/kg)	Retail price (US$/kg)	Farm to retail markup (%)
Tilapia	0.91	0.98	1.20	32
Carps	0.65	0.74	0.92	42
Milkfish	1.02	1.22	1.59	56
Shrimp	5.56	6.48	7.41	33
Groupers	5.92	6.48	8.33	41
Seabass	2.41	2.78	3.33	38

Source: Adapted from BFAR (2004).

for the domestic market. Shrimp is processed according to market demand. The National Centre for Fish Quality and Processing Development located in Jakarta is responsible for the dissemination of fish processing technology. It also supervises provincial laboratories for fish safety and quality control, and the implementation of HACCP.

Exports from the region tend to increase overtime. Cambodia's exports of fishery (not aquaculture) products account for about one-quarter of the total fish catch. Most are exported to Thailand for re-export. If destined for export, all fishery products must go through the state company, Kampuchea Fisheries Import and Export, which ensures that a 10 percent export tax is paid. Most fresh water aquaculture exports from the region are destined to neighboring countries, with a markup about twice the price paid to farmers. In some countries, if traders sell the fish domestically but to another province, a four percent fee is levied. In the Philippines, most of the milkfish and tilapia produced are for domestic consumption but shrimp is exported. Shrimp, seaweed and tuna are the principal fishery exports, with Japan, the United States of America and Korea (Republic of) as the major markets. In Viet Nam, both exports and processing of fish have been increasing, with total aquaculture export volume quadrupling between 1990 and 2000. The major market has traditionally been Japan, but an increasingly larger share of exports is being destined to the United States of America. Taiwan, Province of China and the Republic of Korea are also important export markets. Viet Nam's main export is shrimp, whose export value doubled between 1990 and 2000, but other species have also seen rapid growth. Catfish exports almost doubled in volume and value from 2000 to 2001 with ten companies exporting to Europe and the United States of America.

The markup in the distribution channel is variable. The export price in Cambodia approximately doubles the price paid to the farmer although for some species, such as snake head fish, the margin is higher. In the Philippines, margins appear to be smaller with a 30 percent to 60 percent spread between farm-gate prices and domestic retail prices. This is illustrated in Table 20.

Tilapia has the smallest markup at 32 percent from the farm-gate to retail, and milkfish the highest at 56 percent. For all species, the largest markup occurred between wholesale and retail. Margins through the marketing channels in Viet Nam appear to approximate those of the Philippines with relatively small markups at each stage.

5.12 POLICIES TOWARDS STATISTICS COLLECTION

In Cambodia, those engaged in aquaculture activities are required to record the pen, pond or cage area and the quantity of species fed. This monthly record is submitted to the provincial fisheries administration. The Department of Fisheries, in turn, estimates the total culture area and the tax to be collected at the local level, and all this information is then transmitted to the departmental headquarters. In Indonesia, the sequence for gathering aquaculture data begins by determining a sample of villages which provide data for the local authorities. Annual data on production

area and aquaculture households, and quarterly data on production, are then sent to the provincial government. In turn, these data are sent to the Directorate General of Aquaculture to be compiled and published. Malaysia collects its data in a similar fashion. Aquaculture extension workers stationed at District Offices send data to the State Fisheries Office where information is compiled and vetted before being forwarded to the Fisheries Department for further verification. In the Philippines, data are collected by survey. The Bureau of Agricultural Statistics surveys farms according to production environment (fresh water, brackishwater and marine water), estimating quarterly data on harvest volume and value for each species. This information is generated at the regional, provincial and national level.

5.13 POLICIES TOWARDS RESEARCH, EDUCATION, TRAINING AND EXTENSION

Research and training are important in maintaining a dynamic sector. However, often farmers lack the resources to undertake research themselves. Even when they can afford them, there is a disincentive to undertake privately-funded research if innovations will be disseminated. On the other hand, research can benefit the whole industry and society at large. This positive externality justifies some government involvement. If publicly-funded research occurs, priorities should be demand driven or determined by industry needs, rather than decided by government officials according to their skills or wishes. To encourage government research being demand driven, the Philippines implemented private-public research partnerships. As mentioned above in the section on species, this policy has proven very successful.

Cambodia undertakes research through its fish stations around the country. These stations also supply fingerlings and provide advice to fresh water farmers. However, as discussed earlier, these stations have recurrent funding difficulties; their sustainability is questionable. In addition, the Department of Fisheries has a small staff at district and municipal levels for fisheries management and aquaculture extension. Among the tertiary educational institutions, there are four colleges and universities that provide aquaculture qualifications ranging from a one-year certificate to a four-year degree. Malaysia also has (six) government-owned fish stations that provide fry and undertake research and technology dissemination. Among the fry produced are shrimp, prawn, crab, seabass and a number of fresh water fish. The Department of Fisheries, through its Fisheries Research Institute, undertakes research that is of use to the industry on issues such as disease prevention, quality control and product development. The industry has access to the facilities for carrying out collaborative research. Extension services are provided by the Department whether as training courses, information sessions for investors, or by providing materials in hard copy, such as pamphlets and audio visual tapes.

Indonesia has a well-defined research and extension policy for the development of aquaculture, particularly small-scale aquaculture. The Ministry of Marine Affairs and Fisheries is mandated to develop appropriate aquaculture techniques and to assist farmers in managing their aquaculture operations. More than a dozen producer organizations exist to lobby and to assist in policy development. The Board of Marine and Fisheries Research has five specialized institutions, one of which is exclusively devoted to aquaculture. Moreover, there are National Development Centres, and also local centres devoted to technology transfer. These centres specialize in specific aquaculture environments, whether fresh water, brackishwater or marine, and are located in areas appropriate to their extension services. They provide training as well as extension services. With their limited resources, their successful method of technology transfer consists in inviting representative farmers from each village for training, who then disseminate the information to other farmers. Within the formal education system, there are fisheries high schools and academies and a fisheries university. There are also 24 fisheries faculties within public and private universities.

In the Philippines, the agency responsible for the development and management of aquatic resources is the Bureau of Fisheries and Aquatic Resources (BFAR), housed under the Department of Agriculture. The principal research organization within BFAR is the National Fisheries Research and Development Institute. Its research activities are complemented by the Aquaculture Department of the Southeast Asian Fisheries Development Centre, a regional agency located in the Philippines. At the latter, the research agenda is determined by stakeholders in the region as a whole, but the Centre has filled many research gaps in the Philippines itself. There is, in addition, the Philippine Council for Aquatic and Marine Research and Development (under the Department of Science and Technology). Universities also undertake research; their involvement has increased with the growing competition for research grants. Extension services devolve from BFAR, at the national level, to BFAR regional offices and then to Local Government Units. In addition to their research participation, universities provide formal education in fisheries. There are 94 colleges and universities offering undergraduate courses in fisheries and about 80 graduates a year.

Research and extension fall under the Ministry of Fisheries in Viet Nam. The Ministry houses five institutions, three of which (Research Institutes for Aquaculture Nos. 1, 2 and 3; known by the acronyms RIA1, RIA2 and RIA3) work on aquaculture. RIA1 works on research in all three environments (fresh water, blackish and marine) and on aquaculture extension and training in the North. RIA2 and RIA3 are responsible for aquaculture in the South and in the Central and Highland provinces, respectively. These institutions have achieved some notable successes in broodstock selection of fresh water fish, in seed production technologies and in the domestication of some imported species such as Indian carp, tilapia and molluscs.

The National Centre for Fisheries Extension was established in 2000 to implement extension services throughout the entire country, but the effectiveness of the service is limited by lack of capacity. Twenty-four provinces have aquaculture extension centres but other provinces lack aquaculture specialists; in the latter, extension services are provided by agricultural workers. This shortage of expertise is particularly acute for coastal and marine aquaculture. Extension services are also provided by the Institute of Fisheries Economics and Planning and by the three RIAs. To facilitate extension, the government established three national extension programmes in 2001 targeting shrimp, crab and marine fish aquaculture, covering intensive pond and cage culture systems.

In conclusion, a shortage of expertise among officials as well as farmers is a serious handicap to aquaculture development. Policies and regulations may have been formulated but unless there are sufficient government personnel with adequate skills to monitor and enforce, they will remain ineffective. Similarly, technology dissemination requires personnel who have the expertise to undertake research and extension. Cambodia, for example, lacks this capacity. Table 21 recapitulates policies which have been used to increase aquaculture capacity in the region.

TABLE 21
Some policy measures used in the region to increase aquaculture capacity

Policy goal	Policy measure/tool	Country	Result	Remarks
Technology transfer	Farmer-to-farmer technology transfer	Indonesia	Positive	
		Myanmar		
	Associations as government partners	Indonesia	Positive	In-learning process. Limited resources
	Funding high school and university education in aquaculture	Indonesia	Positive	
	Encourage public sector to provide advice	Indonesia	Positive	
	Public extension services	Malaysia	Limited	Expensive
		Viet Nam	Limited	Limited capacity

Note: Appendix 3 provides additional policies used in various instances.

6. Summary and conclusions: lessons learned, major strengths, weaknesses and future directions

The region has a long history of aquaculture but rapid expansion began only after 1975, when total output was still less than half a million tonnes. By 1987, the seven countries in the study were producing one million tonnes, excluding aquatic plants. Thereafter, each decade has seen a doubling of output, with production of foodfish exceeding five million tonnes in 2005. By 2005, the region already produced a significant proportion of world aquaculture output: 10 percent by volume and 12 percent by value, excluding aquatic plants. Moreover, the region's share of world volume has been growing. The region has significant coastal water resources, technical capacity, and the ability to produce at low cost. In addition, governments have ambitious plans for aquaculture development while markets for farmed species have been established. It seems likely, therefore, that the region's absolute volume of aquaculture output and its share of the world's produce will continue to increase.

However, these attributes are not uniform among the seven countries. Cambodia has only a limited coastline (435 km) and little technical capacity. Both Cambodia and Myanmar fail to recognize the role of aquaculture as a potential contributor to economic growth, and thus, to poverty reduction; they also fail to understand the need for good governance, which is a pre-requisite for private investment. Commercial aquaculture, therefore, is unlikely to develop rapidly in these two countries. Other countries, however, have fully recognized the potential of commercial aquaculture to stimulate economic growth, alleviate poverty and contribute to their balance of payments. Besides, they have learned from past mistakes and are aware of the need for development to be sustainable. Hence, the region as a whole has considerable strengths but also some weaknesses. The objective of this concluding chapter is to give a balanced perspective on the region's potential.

6.1 POLICY LESSONS

Shrimp farming has illustrated how strong an incentive the potential for profit can be in order to achieve aquaculture development. However, the same experience has demonstrated how damaging these forces can be if left unrestrained. Lured by short-sighted prospects of large profits, farmers' actions contributed to mangrove destruction, the outbreak of diseases and land salinization in the Philippines and Thailand. These environmental and fish health problems have since prompted governments to regulate the industry; while aquaculture is encouraged, policies are now focused on its sustainability.

This report has described the policies used to promote the sector. Myanmar has demonstrated the usefulness of aquaculture legislation in promoting the sector in a more orderly fashion. By legalizing aquaculture in 1998, the legislation encouraged farms to register. While water rights in agriculture still have priority over aquaculture, farmers have been permitted to convert rice paddies in the delta to shrimp farms. The result has been a rapid expansion in area devoted to shrimp farming and in output. From almost zero a decade earlier, shrimp output reached close to 49 000 tonnes in

2005. In terms of leases for aquaculture farms however, Viet Nam appears to have developed the most sensible policies. Leases are for long periods (20–50 years); they are also transferable. This compares with the lease period in Myanmar which may be for only three years; too brief to provide an incentive to improve property. To obtain a permit in Viet Nam, applicants must demonstrate that they are going to operate in an area designated for aquaculture, and that there are no disputes over water rights. Officials are obliged to process these permits within 90 days of the application.

Seed production and seed quality have also been a focus of policies and regulations. All countries have public hatcheries which undertake research, training and technology dissemination. They also produce fingerlings. Some are destined to small-scale farmers and are subsidized as in the Philippines; others are oriented to particular regions as in Viet Nam. They may also concentrate on particular species deemed to have potential commercial value, as in Malaysia. However, in all countries but Cambodia, public hatcheries have been outnumbered by private hatcheries. The latter have developed in parallel with the industry. The Indonesian experience with public shrimp hatcheries has demonstrated the dynamism of the private sector. By the time public stations were constructed, they became redundant because of the appearance of private hatcheries.

Some countries have deliberately encouraged private hatcheries. Malaysia, the Philippines and Viet Nam provide incentives in the form of soft loans or tax exemptions. These incentives can be oriented to particular species such as shrimp and marine fry in Viet Nam. The incentives may also be available to foreign investors. Such incentives have succeeded in increasing seed production. To improve seed quality from the private sector, regulations and inspections are used in Indonesia and Thailand. However, monitoring and enforcement are expensive; they also require skilled personnel that may be unavailable as in Cambodia. The Philippines has improved culture traits of farmed species by encouraging collaborative research with universities.

Feed expenses are the most important cost in farming. Among the policies used to lower these expenses are reductions in tariffs on imported feed. This helps domestic producers to become more efficient. The use of local ingredients is also seen as a means of lowering the foreign exchange burden of imported fishmeal. Indonesia and Malaysia are actively conducting research in this field. Viet Nam has enticed foreign investment into the feed sector, which has increased feed availability and lowered costs. Feed availability and low fish production costs stimulated the aquaculture sector and investment by domestic feed industries. These domestic feed companies are competing so successfully that they are gaining market share. Feed standards are controlled in some countries by regulations, but as with seed quality, monitoring can be constrained by lack of financial resources or skilled personnel.

A further policy that has been selectively used to promote investment in aquaculture has been the provision of incentives to potential investors. Indonesia and the Philippines have offered subsidized credit, sometimes focused on small-scale farmers. The Philippines have abandoned this policy because of its apparent bias. Large-scale farmers clearly took advantage of the system to further their own objectives. Another policy, successful in Malaysia, consists of providing loans without collateral to small-scale farmers. In Myanmar, policies focusing on carp farmers have not worked. Not only is collateral required but loan limits are very low.

In addition to feed and seed policies, fiscal exemptions and foreign investment have been successfully used to encourage development in aquaculture. Exemptions or reductions on income tax, land taxes, sales taxes and import duties are offered in a number of countries. Such incentives are not unique to aquaculture; they may be granted to other food producing sectors, as in Malaysia. They can be species or location specific as in Myanmar and Viet Nam. Unlike interest rate subsidies, such fiscal incentives have no direct cost to the public treasury. Foreign investment can take the form of joint-ventures exclusively (Myanmar), or with maximum limits on

foreign participation (the Philippines). A minimum requirement for these policies to be successful is to guarantee capital and profit repatriation; in addition, Indonesia, Myanmar and Viet Nam offer fiscal incentives such as tax holidays or exemptions from import duties. While foreign investment in aquaculture within the seven countries is generally low, foreign participation in Viet Nam has been increasing rapidly.

Viet Nam is the country that has demonstrated the greatest commitment to aquaculture; thus far without widespread negative externalities. Mangrove destruction has resulted from shrimp farming, but losses are more associated with extensive farming by the landless poor. Viet Nam's commitment is due to aquaculture's potential as a source of livelihoods for the rural poor. By providing rural employment aquaculture might mitigate migration to urban centres. Aquaculture can also earn foreign exchange as an export. Thus the government has offered incentives to those who wish to start farming, invest in hatcheries, and produce feed. Such incentives also have a regional bias, to entice aquaculture development in the mountainous regions where fish protein is most needed.

6.2 MAJOR STRENGTHS, WEAKNESSES AND FUTURE DIRECTIONS

The region provides several lessons to learn from, but it has also generated problems of its own which could limit expansion of aquaculture output. With the possible exception of Indonesia, the major constraint to aquaculture expansion in the region is a shortage of land. Different governments have taken different approaches to tackle this problem. The Thai government has limited the brackishwater area available for marine shrimp to 80 000 ha. No official limit has been set in the Philippines, but no additional is available. Less than a third of the original 400 000 ha of mangroves remain, but they are protected against encroachment. Posterior development in the mid 1980s occurred in agricultural land, primarily in sugar plantations. Because land area cannot be increased, a solution is to intensify land-based production. Another option is to move to marine cage culture. Already more seabass and groupers are being cultivated in sea cages than ponds, with higher returns. The Philippines is also moving to sea cage culture of milkfish.

Except for Indonesia and Malaysia, the availability of fresh water is the second most important constraint. In addition to agriculture and the farming of fresh water aquaculture species, fresh water is used in brackishwater shrimp culture to reach optimal salinity levels. Its use in aquaculture is frequently regarded as a loss for agriculture; in Myanmar, agriculture has been given priority for water-allocation rights. Yet, the two sectors need not be mutually incompatible; agriculture and aquaculture can be integrated. Multiple uses of water, including integrated agriculture-aquaculture such as rice-fish culture already known in the region, can provide solutions. Moreover, fresh water in shrimp culture does not appear to be a critical requirement if strains of shrimp can be developed to tolerate hyper saline levels as in the Middle East. Evaporation in Saudi Arabia causes very high salinity, but selectively bred shrimp can be successfully cultured there.

A third constraint is the availability and the cost of feed. While carp does not depend on protein from other fish, carnivores (grouper) or quasi carnivores (shrimp) require fish protein. Fishmeal has to be imported, often from as far as South America and elsewhere, which is very costly. The increased cost of imported fish meal was exacerbated by the currency devaluations which occurred in all these countries (excepting Malaysia) at the end of the 1990s. Substantial quantities of fresh fish are also sometimes used to feed species such as groupers. This provides environmental activists with arguments to accuse the aquaculture industry of transforming a low-value protein source that could be used to feed the poor into an expensive commodity that can only be afforded by the wealthy. For this reason, the Department of Fisheries in Cambodia prohibited the culture of snakehead in 2004. One of the solutions to this problem could be to promote research into domestic ingredients. Malaysia and others are attempting

to find substitutes for fishmeal, such as legumes, slaughterhouse wastes and single-cell proteins.

Unavailability of quality seed encouraged the establishment of public fish stations and selected brood stock in the region. Except for Cambodia, private hatcheries have emerged to supplement the public stations, but the latter remain. Their goal is to provide subsidized fingerlings to the poor, improve brood stock and supply fish for restocking public waters. The Philippines has 36 fresh water public stations. These stations are sometimes viewed negatively. They offer tilapia seed which is below industry standards, thereby forcing private hatcheries to lower their standards to remain competitive. Low quality standards could limit further success of the tilapia industry in the region. Thailand has 20 Fisheries Centres and 57 Fish Stations that provide seed for commercial species. Viet Nam has established National Centres for Fish Seed. For some species, especially marine fish, seed must be collected from the wild or imported. Viet Nam imported black king fish (*Rachycentron canadus*) and red snapper (*Lutjanus* sp.) from China, Hong Kong Special Administrative Region as well as groupers (*Mycteroperca* sp.) and seabass (*Dicentrarchus labrax*) from Taiwan Province of China. It also imports seed, often from Cambodia. Quality seed availability is the main limiting factor to expanded culture of these species. Governments in the region are working to address this issue. In most countries, there is the need to ensure seed standards. In the Philippines and Viet Nam, there is pressure to require the certification of shrimp hatcheries. Viet Nam regulates and inspects seed. So does Indonesia where seed quality is ensured by a number of regulations. Production standards are specified by the Indonesian National Seed Standards with certification and monitoring. These are experiences to learn from, but they are also issues to focus on for further development of the sector.

A fourth constraint is the supply of adequate energy. Intensification often requires pumping and aeration and, hence, energy. As for fresh water, aquaculture must compete with other activities for energy. More efficient pumps may be one solution. Another solution is the use of recirculating systems. While recirculation requires energy, it does not need water pumped from lower levels; and so, it is energy efficient. Wind powered pumps are being used on a limited scale in fresh water aquaculture, but their capital cost is high. The inability to design a low cost high volume pump for saltwater shrimp farming has also restricted its use. Solar-powered pumps suffer from the same problems.

The region also suffers from pollution and environmental degradation problems. The most severe form of pollution takes a direct toll on the species being raised due to high levels of toxicants. The excessive use of inputs and poor husbandry practices led to severe production setbacks in Thailand, Indonesia and the Philippines. Damage may also occur from urbanization and industrialization, both of which are increasing in Southeast Asia. Late-comers to shrimp culture, such as Viet Nam and Myanmar, have hopefully learned from past mistakes. They are aware of the need for development to be sustainable. A less severe form of pollution may not kill the harvest, but may make it unfit for human consumption. This could be caused by high levels of contaminants that may not be known until the produce comes to market. The need to fulfill HACCP requirements for exports has led to increased awareness of quality control and forced farmers to minimize the use of antibiotics. These higher standards should be transferred to fish marketed domestically overtime.

Limited expertise among officials as well as farmers is a serious handicap to development in some countries. Policies and regulations may be enacted, but unless there are sufficient government personnel with adequate skills to monitor and enforce them, they will remain ineffective. Similarly, technology dissemination requires personnel who have the expertise to undertake research and extension. Cambodia and Myanmar, for example, lack this capacity.

Despite these caveats, however, aquaculture will, in all likelihood, remain important for the region in the near and mid-term future.

On the supply side, the region already produces a significant proportion of the world's aquaculture output; this trend has been accentuated in recent years. The region as a whole has considerable strengths. It has species whose culture is both technically feasible and economically viable. By volume, the principal species are shrimp, milkfish, Nile tilapia, the common carp and the rohu. By value, shrimp and milkfish top the list, followed by the rohu, the common carp and tilapia. With the exception of shrimp, a high-value species, which is raised mainly for export, these species are raised primarily for local consumption. In addition to viable brackish and fresh water species, a number of countries have sufficient coastline for marine fish farming. Mariculture is the fastest growing aquaculture environment in the region and cage culture of marine finfish offers considerable potential in a number of countries including Indonesia and Viet Nam. Although expansion of certain species such as seabass and grouper remains constrained by seed availability and feed costs, other species offer high returns. For example, milkfish continues to enjoy a sustained expansion in the Philippines. While brackishwater cultivation of milkfish has declined, culture in marine waters has increased more than four times between 2000 and 2005, from less than 9 000 tonnes to 44 000 tonnes. This upward trend in milkfish production is expected to continue.

Whether motivated by a concern for food security or foreign exchange, with the exception of Cambodia and Myanmar, governments in the region have actively supported aquaculture by providing research and, in many cases, by offering incentives. This trend is likely to continue. Recognition that there are limits to production from the capture fisheries and livelihood benefits from aquaculture prompted many governments, Viet Nam in particular, to focus on aquaculture as a high priority sector. Although results have not been homogeneous across countries, these policies are yielding tangible benefits.

Government support by itself does not guarantee the success of aquaculture; an individual entrepreneur has to be willing to invest in a risky enterprise. Aquaculture by itself is a risky investment often with considerable capital required. These risks can be minimized by an enabling environment through good governance which includes transparency in regulatory processes and minimal corruption. An enabling investment environment will also ensure, for example, that land and produce will not be expropriated. In most of the countries in the region, these conditions are met and have resulted in production increases. As is the case in Viet Nam, they have also prompted the much needed private hatcheries and feed mills to meet seed and feed demand.

On the demand side, per capita incomes and urbanization, two of the robust determinants of fish demand, are growing rapidly in most of the countries. Domestic demand of fish, therefore, is likely to continue growing. Because production from the capture fisheries has reached its maximum sustainable yields in most countries, aquaculture supply is likely to expand in order to meet the growing demand. In addition, the region as a whole has a comparative advantage in shrimp production, which augers well for continued expansion of that species, particularly for export markets.

In addition to fresh water fish and shrimp, other species (e.g. groupers) also enjoy strong demand. While there are concerns about the use of trash fish, the culture of such high-value species offers a means of raising living standards of the poor. The profit margins of grouper are much higher than milkfish. With 2 000 groupers a year, the return to farmers is equal to the return on growing 20 000 milkfish. Moreover, the total investment is reduced by 50 percent. Some are concerned that these species are exotic. Yet, the Nile tilapia, for which China is the world's top producer, is also exotic to Asia. After its initial introduction in the late 1960s and early 1970s in the Philippines, market acceptance was minimal at first. However, there was a large increase in production between 1989 and 1992 coinciding with a decline in milkfish output, which suggests that tilapia had gained acceptance.

References

ADB/NACA. 1996. *Report on a Regional Study and Workshop on Aquaculture Sustainability and Environment*. Asian Development Bank and the Network of Aquaculture Centers in Asia-Pacific, Bangkok, Thailand.

Ali, A.B. 1992. Rice-fish farming in Malaysia: past, present and future. In C.R. de la Cruz, C. Lightfoot, B.A. Costa-Pierce, V.R. Carangal & M.P. Bimbao (eds). *Rice-fish Research and Development in Asia*. pp. 69-76. ICLARM Conference Proceedings No. 24. International Center for Living Aquatic Resources Management, Manila, Philippines.

Bagarinao, T. 1999. *Ecology and Farming of Milkfish*. SEAFDEC Aquaculture Department, Tigbauan, Iloilo, Philippines.

Baliao, D.D., de los Santos, M.A., Franco, N.M. & Jamon, N.R.S. 2000. *Net Cage Culture of Tilapia in Dams and Small Farm Reservoirs*. Aquaculture Extension Manual No. 30. SEAFDEC Aquaculture Department, Iloilo, Philippines.

Baliao, D.D., de los Santos, M.A., Rodriguez, E.M. & Ticar, R.B. 1998. *Grouper Culture in Brackishwater Ponds*. Aquaculture Extension Manual No. 24. SEAFDEC Aquaculture Department, Iloilo, Philippines.

BFAR [Bureau of Fisheries and Aquatic Resources]. 2001. *Philippine Fisheries Profile, 2000*. Fisheries Policy and Economics Division, Department of Agriculture – BFAR, Quezon City, Philippines.

BFAR [Bureau of Fisheries and Aquatic Resources]. 2002. *Philippine Fisheries Profile, 2001*. Fisheries Policy and Economics Division, Department of Agriculture – BFAR, Quezon City, Philippines.

BFAR [Bureau of Fisheries and Aquatic Resources]. 2004. *Philippine Fisheries Profile, 2003*. Fisheries Policy and Economics Division, Department of Agriculture – BFAR, Quezon City, Philippines.

Budiono, A. 2002. Country report: Indonesia. In *Review of the State of World Aquaculture*. pp. 176-188. FAO Fisheries Circular No. 886. Inland Water Resources and Aquaculture Service, Fishery Resources Division, FAO Fisheries Department, Rome, Italy.

Cai, R., Ni, D. & Wang, J. 1995. Rice-fish culture in China: the past, present and future. In K.T. MacKay (ed). *Rice-fish Culture in China*. pp. 3-14. The International Development Research Centre (IDRC), Ottawa, Canada.

Coche, A.G. 1967. Fish culture in rice fields: a worldwide synthesis. *Hydrobiologia* 30:1-44.

Cruz, P.S. 2002. *Costs and Returns in Milkfish Culture: Intensive Ponds versus Sea Cages*. Cruz Aquaculture Corporation, Bacolod City, Philippines.

Delmendo, M.N. & Gedney, R.H. 1974. *Fish Farming in Pens: A New Fishery Business in Laguna de Bay*. Technical Paper No. 2. Laguna Lake Development Authority, Pasig, Metro Manila, the Philippines.

DGF [Directorate General of Fisheries]. 1998. *Program Peningkatan Ekspor Hasil Perikanan 2003* (A Program to Boost Fisheries Exports 2003). Directorate General of Fisheries, Jakarta, Indonesia.

Fan, S., Hazell P. & Thorat, S. 1999. *Linkages between Government Spending, Growth and Poverty in Rural India*. IFPRI Research Report 110. International Food Policy Research Institute, Washington, D.C., United States of America.

FAO. 2006. *Food Balance Sheets 2003*. The Statistics Division, Food and Agriculture Organization of the United Nations, Rome, Italy.

FAO. 2007a. *FishStat Plus – Universal Software for Fishery Statistical Time Series*. Fisheries and Aquaculture Department, Food and Agriculture Organization of the United Nations, Rome, Italy.

FAO. 2007b. *FAO Corporate Database for Substantive Statistical Data – FAOSTAT*. Food and Agriculture Organization of the United Nations, Rome, Italy.

Halwart, M.S., Funge-Smith, S. & Moehl, J. 2002. The role of aquaculture in rural development. In *Review of the State of World Aquaculture*. pp. 71-83. FAO Fisheries Circular No. 886. Inland Water Resources and Aquaculture Service, Fishery Resources Division, FAO Fisheries Department, Rome, Italy.

Herre, A.W. & Mendoza, J. 1929. Bangos culture in the Philippine Islands. *Philippine Journal of Science* 38(4):451-509.

ICLARM [International Center for Living Aquatic Resources Management]. 1998. *Dissemination and Evaluation of Genetically Improved Tilapia Species in Asia (DEGITA): Final Report*. International Center for Living Aquatic Resources Management, Manila, Philippines.

Kongkeo, H. 1995. How Thailand made it to the top. *Infofish International* 1/1995: 23-31.

Leung, P. & Sharma, K.R. (eds). 2001. *Economics and Management of Shrimp and Carp Farming in Asia: A Collection of Research Papers Based on the ADB/NACA Farm Performance Survey.* Network of Aquaculture Centers in Asia-Pacific (NACA), Bangkok, Thailand.

Li, K. 1992. Rice-fish farming in China: past, present and future. In C.R. de la Cruz, C. Lightfoot, B.A. Costa-Pierce, V.R. Carangal & M.P. Bimbao (eds). *Rice-fish Research and Development in Asia*. pp. 17-26. ICLARM Conference Proceedings No. 24. International Center for Living Aquatic Resources Management, Manila, Philippines.

Ling, B-H., Leung, P. & Shang, Y.C. 1998. Behaviour of price transmissions in vertically coordinated markets: the case of frozen black tiger shrimp (*Penaeus monodon*). *Aquaculture Economics and Management* 2:119-128.

MacKay, K.T. 1992. Why do rice-fish research on farms? In C.R. de la Cruz, C. Lightfoot, B.A. Costa-Pierce, V.R. Carangal & M.P. Bimbao (eds). *Rice-fish Research and Development in Asia*. pp. 393-397. ICLARM Conference Proceedings No. 24. International Center for Living Aquatic Resources Management, Manila, Philippines.

Mair, G.C., Abucay, J.S., Capili, J.B., Dahilig, L.R., Sevilleja, R.C., Beardmore, J.A. and Skibinski, D.O.F. 1994. The development of YY-male technology for production of monosex tilapia in the Philippines. In *Tilapia Farming: Genetic Improvement and Advances in Culture Technology. Proceedings of the Third National Symposium and Workshop on Tilapia Farming, University of the Philippines in the Visayas, Iloilo, Philippines, November 25-27, 1993*. Philippine Council for Aquatic and Marine Research Development, Los Baños, Laguna, Philippines.

Muñoz, J. 2002. Country Report: Philippines. In *Review of the State of World Aquaculture*. pp. 257-269. FAO Fisheries Circular No. 886. Inland Water Resources and Aquaculture Service, Fishery Resources Division, FAO Fisheries Department, Rome, Italy.

Pillay, T.V.R & Kutty, M.N. 2005. *Aquaculture: Principles and Practices*. Second edition. Blackwell Publishing, Oxford, United Kingdom.

Rabanal, H.R. 2000. Aquaculture in the Philippines (1898-1998). In R.D. Guerrero III (ed). *100 Years of Philippine Fisheries and Marine Science*. pp. 70-115. Philippine Council for Aquatic and Marine Research and Development, Los Baños, Laguna, the Philippines.

Ridler, N. & Hishamunda, N. 2001. *Promotion of Sustainable Commercial Aquaculture in Sub-Saharan Africa. Volume 1: Policy Framework.* FAO Fisheries Technical Paper No. 408/1. Food and Agriculture Organization of the United Nations, Rome, Italy.

Rosenberry, B. (ed). 1995. *World Shrimp Farming 1995*. Shrimp News International, San Diego, California, USA.

SFIC [Sport and Fitness Insurance Corporation]. 2006. *Seafood for Health*. http://www.sealord.biz/

Shang, Y.C., Leung, P. & Ling, B-H. 1998. Comparative economics of shrimp farming in Asia. *Aquaculture* 164:183-200.

Subasinghe, R.P., Curry, D., McGladdery, S.E. & Bartley, D. 2002. Recent technological innovations in aquaculture. In *Review of the State of World Aquaculture*. pp. 85-102. FAO Fisheries Circular No. 886. Inland Water Resources and Aquaculture Service, Fishery Resources Division, FAO Fisheries Department, Rome, Italy.

Tamura, T. 1961. Carp cultivation in Japan. In G. Borgstrom (ed). *Fish as Foods*. pp. 103-120. Academic Press, New York and London.

Tarnchalanukit, W. 1974. *Aquaculture Manual* (in Thai). Faculty of Fisheries, Kasetsart University, Bangkok, Thailand.

VASEP [Viet Nam Association of Seafood Exporters and Producers]. 2006. *Growth in Seafood Export Revenues for Viet Nam*. Peoples' Daily Online, 6 June 2006.

Villaluz, D.K. 1953. *Fish Farming in the Philippines*. Bookman, Manila, Philippines.

Virapat, C. 2005. Status and role of aquaculture in rural development of Thailand. In M. Halwart, D. Kumar, M.G. Bondad-Reantaso (comp). *Papers presented at the FAO/ NACA Consultation on Aquaculture for Sustainable Rural Development. Chiang Rai, Thailand, 29–31 March 1999*. pp. 77-91. FAO Fisheries Report. No. 611, Suppl. Food and Agriculture Organization of the United Nations, Rome, Italy.

World Bank. 2005. *The Little Data Book 2005*. The World Bank, Washington, D.C., USA.

Yap, W.G. 1999. *Rural Aquaculture in the Philippines*. RAP Publication 1999/20. Regional Office for Asia and the Pacific, Food and Agriculture Organization of the United Nations, Bangkok, Thailand.

Appendix 1

Estimated aquaculture farm household income by farming environment and selected species in Thailand, 1992

Farming environment	Annual income (US$)*
Coastal aquaculture	
Marine shrimp	11 668.88
Blood cockle	412.24
Fresh water aquaculture	
Nile tilapia	1 818.04
Common carp	165.44
Thai silver carp	728.08
Chinese carp	428.64
Walking catfish	2 731.08
Snakehead	3 478.24
Sepat siam	1 541.80

* Original figures were in Thai Baht (THB). They were converted to US dollars at US$1 = THB25.00.
Source: Virapat (2005).

Appendix 2

Mangrove area and brackishwater pond development in the Philippines, 1920 to 2000

	Mangrove area *(ha)*	Brackishwater culture pond *(ha)*	Other uses* *(ha)*
1920	450 000		
1940		60 998	
1950		72 753	
1960		123 252	
1965	362 334		
1970	288 000	168 118	(6 118)**
1980	242 000	176 231	31 769
1988	149 300		
1990		222 907	
1995	232 065	239 323	(21 388)**
2000	139 735	239 323	70 942

*Computed by subtracting remaining mangrove area and brackishwater culture area from the 1920 estimate of 450 000 ha

**Either the 1920 mangrove area is underestimated or the 1970 and 1995 figures are overestimated

Source: BFAR (2001)

Appendix 3

Summary of additional policies adopted by countries in the region, and their effects

Issue	Causes and/or possible correctives measures
Resource conflicts (water, land)	Competing uses (tourism, other crops, housing, navigation); Corrective measures could consist of: 1. have and implement aquaculture law (the Myanmar experience); 2. zoning for different activities including aquaculture (the Malaysia experience); 3. creation of farmers associations to work out conflicts/manage the resource use (the Indonesian experience); 4. use of local committees to allocate resources (water) (the Thai experience); 5. adopt the Integrated Coastal Zones Management approach.
Possible continuing environmental degradation	Reasons a. Poor siting (mangroves cleared for pond construction). b. Lack of, or poor, government aquaculture planning/regulations. c. Absence or inadequate application of codes of practice. Corrective/preventive measures could consist of: 1. establish environment friendly technical guidelines for establishing aquaculture facilities (the Thai experience); 2. aquaculture zoning + integrated coastal management (the Indonesia experience); 3. Make more stringent laws and regulations and enforce them (the Philippine experience); 4. Establish and promote the application of codes of practice (the Malaysia experience).
Food safety	Domestic and foreign consumers are increasingly concerned about the quality of products. Foreign consumers are even more demanding in terms of assurance of the quality of aquaculture products from foreign producers especially. If this issue is not given the attention demanded by foreign buyers, this might seriously impede the development of the sector. Corrective/preventive measures could consist of: 1. quality control of aquaculture products: a. HACCP(the Indonesian and Thai experiences); b. farm accreditation (certification) schemes; c. traceability (the Thai experience); d. Fish Health Certificates (the Malaysian and Indonesian experiences).
Farm size/foreign control	Concern that small-scale farming may be uncompetitive and inefficient. Corrective/preventive measures could consist of: 1. joint ventures with foreign investors (the Vietnamese experience); 2. develop nucleus farms (the Indonesian experience). 3. limit extent of foreign participation (the Philippine experience).
Fish seed quantity and quality	Seed for a number of species is limited. Corrective/preventive measures could consist of: 1. public hatcheries for brood stock (all countries); 2. provide incentives for hatcheries for designated species and locations (the Vietnamese experience); 3. import seed and fry under quarantine (the Vietnamese experience); 4. set seed standards (the Indonesian experience); 5. develop breeding programmes (the Philippine experience).

Summary of additional policies adopted by countries in the region, and their effects *(Cont.)*

Issue	Causes and/or possible correctives measures
High fish feed prices	Trash fish in the region is limited and high competition for feed ingredients (raw materials), especially fishmeals. Corrective/preventive measures could consist of: 1. explore ways of using cheaper substitutes (the Indonesian and Malaysian experience); 2. valuate the possibilities of more efficient aquaculture systems (such as integrated farming, polyculture, organic farming) (the Cambodian experience).
Financing still a problem in many cases	Difficult access to loans is rendered difficult by the: a. lack of collateral and of equity by farmers; b. perception by lenders that aquaculture is a high risk activity; c. high interest rates charged to farmers. Corrective/preventive measures could consist of: 1. interest rate subsidies (the Indonesian, Malaysia, Philippines, and Vietnamese experiences); 2. establish stable legal frameworks reassuring lenders and investors (the Myanmar experience); 3. encourage foreign investment (the Malaysian and Vietnamese experiences); 4. require financial institutions to lend (the Indonesian experience);
Increasing costs of production across the region	Caused by the high cost of imported inputs (feed, feed stuffs) especially, and high cost of labour in some cases (Malaysia). Corrective/preventive measures could consist of: 1. more aggressive fiscal incentives (the Vietnamese experience); 2. economies of scale (the Indonesian experience); 3. mechanization in some cases (the Indonesian experience) 4.market diversification (the Vietnamese experience); 5. commodity diversification (the Vietnamese experience); 6. value added (the Thai experience); 7. encourage more investments through joint venture schemes.
Poor linkages in the production chain (seed producers and growers).	Corrective/preventive measures could consist of: 1. networking between production segments (the Philippines experience); 2. promotion by producers (government and/or public), information centres to connect seed producers and fish growers which needs the establishment of data bases on hatcheries and growers by species (the Thai experience); 3. install and regularly organize public/private seed markets (the Indonesian experience).
Poor transport (road) infrastructure	Poor or inexistent roads. The problem could be alleviated by: 1. the use of preservation techniques (dry, smoke, ferment, salt); 2. encouraging large-scale commercial farms (the Indonesian experience).
Lack of or not reliable statistics	Reasons a. Lack of understanding of the importance of statistics and given low priority. b. Lack of standardized methods and forms of statistics collection. c. Lack of trust (by farmers and other investors) about the use of statistics provided. d. Lack of farm records (reliance on memory). Corrective/preventive measures could consist of: 1. if used for tax purposes, a danger of evasion (the Cambodian experience); 2. use of local agencies (the Malaysian and Philippine experience).

Summary of additional policies adopted by countries in the region, and their effects *(Cont.)*

Issue	Causes and/or possible correctives measures
Increasing shortage of skilled manpower in both the public and private sectors	The problem arises from the shortage of proper training institutions, the existence of better opportunities (aquaculture is less attractive/competitive). Corrective/preventive measures could consist of: 1. establish specialized training institutions (all countries); 2. use public fish stations for training (the Cambodian experience); 3. outsource training to other countries (the Vietnamese experience).
Persistently weak mechanisms of information dissemination	The reasons include: a. government information arms/units (extension workers) not used properly; b. weak/missing link between researchers and farmers, except in few cases such as Thailand; c. limited resources, especially financial. Corrective/preventive measures could consist of: 1. allocate extension funds to research budget and get researchers to deliver information directly to farmers; 2. encourage meetings and workshops between researchers and farmers (the Thai experience); 3. collaborative research between governments and the private sector (the Philippine experience).
The still unsatisfactory adoption of "good aquaculture practices"	The technology package to extend (good practices) is known; what remains is to: (1) deliver the package to farmers; (2) convince farmers to adopt the package. To do so: 1. for small-scale (poor) farmers, think of arrangements such as " Commodity Levy" at harvest through Farmers Associations for example, to pay for extension services; 2. for other farmers, use Voluntary Codes of practice and regulations (penalties).

This paper shows that the rapid expansion of aquaculture in Southeast Asia occurred in response to market demand and profit opportunities with little government involvement. Governments were more enabling than pro-active; they endorsed aquaculture as a source of livelihood or export earnings, but did not provide generous incentives to farmers. It is only recently that, motivated by the sector's contribution to economic development, food security and the balance of payments, some governments have been pro-active, deliberately promoting the sector with such incentives. Having learned from earlier mistakes in the region, most governments intervene with regulations to limit laisser-faire excesses. Further development could be limited by the unavailability of land and fresh water, shortage and price of good quality feed, adequate energy supply and its rising cost, pollution and environmental degradation problems and limited expertise among government officials, but aquaculture is likely to remain important in Southeast Asia for a long time.

ISBN 978-92-5-106339-2 ISSN 2070-7010

9 789251 063392

I0950E/1/08.09/1350