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A Comparative Analysis of Bangladesh, India, Thailand, and Vietnam
with particular reference to institutional and socio-economic aspects

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Literature Review on World Shrimp Farming
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Literature Review on World Shrimp Farming

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Table of Contents

Literature Review on World Shrimp Farming

Introduction

The statistics and the ecological, economic and social implications of shrimp farming differ significantly according to whether they come from an NGO or an industrial point of view. Researchers' publications often illustrate this diverse range of opinions, but some major trends can be extracted. This report attempts to summarize the bulk of the existing information, ranging from these two diametrically opposed protagonists of shrimp farming and remains as neutral as possible. The goal is not to achieve any kind of judgment but simply to review all the research documents addressing issues related to:

- an overview of the world shrimp production and industry
- the economics of production
- environmental issues
- legal issues
- social issues
- policy, institutional and political economic analysis

The goal of this literature review will rather be to identify gaps in the literature and areas where updating research is necessary.

The diversity of production systems and their organisation underline the shrimp culture development and its instability at the local level. If stakes in the matter of sustainable development seem to be similar, very different problems nevertheless arise in their application according to the different development schemes encountered. Asian experiences illustrate this aspect rather well, with the diversity and age of Asia's development profiles.

Culturally, Asian knowledge in the field of aquaculture, combined with artificial reproduction and larvae growth control, has allowed a more rapid and spontaneous development of shrimp culture than in other regions. This self-development is mainly based on the resources of village communities and the technical knowledge provided by local extension workers and feed providers. The longevity of this development puts it in better stead than other more recent, or still developing, production sites (the Middle-East, the Pacific, Africa) and attests to the viability and sustainability of such endogenous development. A more capitalist system of production is often opposed to these systems. Based on exogenous development and established intensive techniques, it often has to face criticism over its environmental impact, low local fall out and a speculative nature. But beyond these two points of view or this overly simplistic opposition, a wide variety of production systems exist both in terms of techniques and intensification, and in terms of modes of organisation. The latter explain the diversity of logical constructs. Furthermore, they provide answers to diverse constraints encountered by farming systems: environmental (ecological potential), social and economic (access to inputs, knowledge and technical skills, etc).

A first overview of world shrimp production and industry allows for a better assessment of these development contexts, technical schemes and modes of organisation.

1. Overview of World Shrimp Production and Industry

Shrimp culture has a long history in some countries, such as Indonesia. Shrimps ponds gave value to flood plains alternating with salt marshes. From an animal science point of view, it was pure growth production, mixing several species of shrimp with fish. Reproduction control and larvae growth in the 1970s pushed shrimp culture towards a mode of development based on intensification and specialisation of production. Rapid growth in Asia and South America lead world production from 50,000 tons at the mid-1970s to more than 600,000 tons in 1988, with an annual growth rate ranging from 20 to 30%. Over the decade spanning 1985-1995, the contribution from farm-raised shrimp to the total world supply of shrimp grew by approximately 400%. Cultured shrimp from commercial aquaculture operations now contributes at least 25% to the world's total supply of shrimp (Globefish).

This development of shrimp culture in developing countries is based on several favourable factors. The first is a strong demand for products from shrimp catches or aquaculture (principally from Japan and the United States). Demand is located in high income level countries while the majority of the production is located in southern, low income level countries. The second factor, already quoted, was the artificial reproduction control over shrimp. At least, the level of interest of national and international development agencies at the end of the 1970s was a third factor contributing to the rapid and widespread shrimp pond colonisation of tropical coastal areas.

World Production, Producers and Products

This explosive phenomenon of development is more noticeable in Asia, where aquaculture is a traditional activity, and gives the world leadership to this region in terms of shrimp culture, holding 70 to 80% of world production (Shrimp Culture Newsletter March 2000). The dominant species is the Giant Black Tiger Shrimp (*Penaeus monodon*) with 86% of the Eastern hemisphere production and 56% of world production in 1999. This presents advantages for times of growth, added value and an important adaptation in terms of salinity. It is followed by the white peneid shrimps, often less valued, (*P. merguiensis* (banana shrimp)*, P. indicus, P. chinensis*) and dominant species in the Western hemisphere (*P. vannamei*). *P. penicillatus* (like white shrimp) and *P. semisulcatus* (green tiger prawns) are also farmed. Black tiger shrimp production peaked at almost 600,000 Metric Tons (MT) in 1995, and has since declined (Fishstat).

From the beginning of the nineties, world shrimp production levelled out between 700 and 800,000 tons, with important substitution effects in the leadership group. China decreased to 20,000 tons in 1994 after reaching 200,000 tons in 1992 and is today returning to a production level of 100,000 tons – a level maintained with difficulty. Taiwan, the second largest world producer at the beginning of the 1980s, is currently in 8th place with a production just over the 10,000 ton mark. Ecuador experienced its longest period of stability before experiencing a first major crisis in 1999 (Taura syndrome and White Spot Virus), losing half of its average production within the space of one year. Thailand, the largest producer with more than 200,000 tons, went through two difficult years in 1996 and 1997, followed by a decrease in demand for shrimp in 1999 and the implementation of the shrimp freshwater aquaculture ban. Thailand (25%), China (14%) and Indonesia (12%) were respectively the world leaders in 1999, followed by Ecuador (10%) and India, before the moratorium (9%).

Table 1: World Shrimp Farming Summary 1999 - Production in Metric Tons

Eastern Hemisphere				**Western Hemisphere**			
Countries	**Metric tons**		**Changes**	**Countries**	**Metric tons**		**Changes**
	1998	**1999**	**%**		**1998**	**1999**	**%**
Thailand	210	200	-	Ecuador	130	85	-35
China	-	110	-	Mexico	17	-	-
Indonesia	50	100	100	Belize	4	-	-
India	70	70	-	Nicaragua	4	4	-
Vietnam	-	40	-	Venezuela	3	4	33
Philippines	35	40	14	Panama	8	2	-75
Malaysia	8	6	-25	Peru	5	-	-
Sri Lanka	5	-	-	USA	2	1.5	-25
Others	152.2	76.75	-41	Others	34	75	43
Total	**530.2**	**642.75**	**21**	**Total**	**207**	**171.5**	**-17**

Source: CP Group (Thailand) Shrimp Culture Newsletter, March 2000.

Indonesia, Vietnam and China have the most land devoted to shrimp farms. There are approximately 1,251,450 hectares devoted to shrimp farming worldwide, with 1,114,050 hectares in the Eastern hemisphere. From 1998 to 1999, Asian countries showed a 75% increase in the number of shrimp farms while North, Central and South America, registered a 39% decrease.

Table 2: World Shrimp Farming Summary 1999 - Farming Area in Hectares

Eastern Hemisphere			**Western Hemisphere**		
	Hectares			**Hectares**	
Country	**1998**	**1999**	**Country**	**1998**	**1999**
Thai	70,000	80,000	Ecuador	160,000	100,000
China	-	180,000	Mexico	24,000	-
Indonesia	200,000	350,000	Belize	1,200	-
India	140,000	130,000	Nicaragua	5,500	6,000
Vietnam	-	200,000	Venezuela	1,200	2,000
Philippines	20,000	60,000	Panama	8,500	3,000
Malaysia	4,000	4,000	Peru	3,200	-
Sri Lanka	3,000	-	USA	1,000	400
Others	200,550	110,050	Others	22,000	26,000
Total	**637,550**	**1,114,050**	**Total**	**226,800**	**137,400**

Source: CP Group (Thailand) Shrimp Culture Newsletter, March 2000.

There are few shrimp farms in Africa. In addition to the rare traditional farms, there is at least one large farm in Madagascar in Mahajamba Bay, comprising over 4000 hectares (Rasolofoharinoro & Blasco). In Africa, most shrimp farming projects in potential areas have to face strong opposition from local people supported by NGOs: Shell Petroleum Company of Nigeria Contractors, sponsored by the International Finance Corporation (World Bank branch); a huge farm project planned in the Rufigi River delta of Tanzania has been abandoned – the consequences of the company's huge debt accumulated over the years, facing local opposition supported by NGOs (despite the agreement of the National Environmental Management Council), (World Rainforest Movement, Bulletin 51, October 2001).

The total world production for farm-raised shrimp in 1999 was 814,250 metric tons of which 642,750 metric tons (equivalent to 79%) were from the Eastern Hemisphere and 171,500 metric tons were from the Western Hemisphere These statistics represent a 21% increase for Eastern production over the previous year (530,000 metric tons in 1998) and a 17% decrease for Western production, (CP Group (Thailand) Shrimp Culture Newsletter March 2000 & www.GlobalFoodExchange.com).

FAO aquaculture statistics provide more recent figures (Table 3 and Appendix 1 for a ten-year trend) about shrimp culture in volume, value and species. But according to other sources, it seems that FAO statistics are overestimated. For instance, Thailand is listed as producing 253,000 and 275,000 tons in 1998 and 1999 respectively, against 210,000 and 200,000 tons from other sources (World Shrimp Farming, CP, etc). If the leading group remains the same, Ecuador will face a serious collapse, with a decreasing production rate of more than 50%, mainly due to Taura Syndrome. Despite differences in values, trends over the past ten years remain the same as the one detailed previously (Cf. Appendix 1).

Table 3: Top 25 Producers of Farmed Shrimp in 2000 by Weight and Value

Country	Production (MT) Year 2000	Production (in thousands of US$) Year 2000
Thailand	299,700	2,125,384
China	217,994	1,307,964
Indonesia	138,023	847,429
India	52,771	393,938
Vietnam	69,433	319,392
Ecuador	50,110	300,66
Philippines	41,811	271,385
Bangladesh	58,183	199,901
Mexico	33,480	194,184
Brazil	25,000	175,000
Malaysia	15,895	124,577
Colombia	11,390	91,120
Sri Lanka	6,970	78,342
Taiwan, RoC	7,237	60,483
Honduras	8,500	59,500
Venezuela	8,200	34,03
Australia	2,799	27,557
Madagascar	4,800	24,000
Nicaragua	5,411	17,423
USA	2,163	14,513
Belize	2,648	12,710
New Caledonia	1,723	12,061
Costa Rica	1,350	11,475
Panama	1,212	6,399
Peru	512	3,741

Source: FAO Aquaculture Statistics, 2002 – (MT: Metric Tons)
In World Bank, NACA, WWF and FAO. 2002. Shrimp Farming and the Environment.

Techniques and location

Many documents present global statements according to each main producing country (particularly the FAO Aqua-book about shrimp culture in India). But talking about techniques referring to detailed systems is quite difficult, as there is a discrepancy between official and practical criteria, mainly due to a trend of intensification. Basically, the level of intensification is mainly based on stoking density, area and yields and is usually split into three main techniques: extensive, semi-intensive and intensive. Even in literature, authors write about techniques according to different norms (Primavera 1994, 1997), especially concerning semi-intensive techniques, which are today the former intensive techniques of the early 1990s. With technical progress and pushed by the dramatic and profitable development of shrimp culture, techniques have evolved a great deal. The social, economic and political context also leads to several kinds of organisation modes that can sometimes be translated into different techniques. That is why the present literature review proposes a farming typology based on both technical criteria (beyond of stocking density is also considered energy (feed and kind of feed) supply and its access) and on modes of organisation. Typology is given in the appendices. The technical one (close to that of Primavera) is split into five levels:

- extensive
- improved extensive or traditional
- semi-intensive
- intensive
- super-intensive.

It will be useful to describe farms' animal science and economics as a part of the wider typology based on organisation modes. This latter will be more useful to describe the social and institutional impact of shrimp culture.

According to the above remarks about the difference in applying techniques according to regions or countries, the following world statement in terms of techniques and intensification remains based on wide and non-detailed criteria. Beyond the national level (when applicable) there is no data about farm distribution relative to technical levels at regional, continental or world level. This is also true concerning direct and induced employment. Based on each country LR report, a kind of labour multiplication factor according to techniques could be assessed - upstream and downstream activities (fry collectors, providers, middlemen, processing plants, export companies, etc.). For example, in 1991, an estimated 82,000 workers were employed by the shrimp farming industry in Ecuador (Hirono and Leslie 1992). This was about one worker for every 1.2 hectares of production (GAA[1]). Approximately 114,000 people were employed in 19,000 Thai shrimp farms in 1991 (FAO/NACA, 1994) and shrimp processing plants in India counted some 500,000 skilled personnel (Primavera).
In this report, employment will be only assessed at the farm level through economics of production and social issues.

Farming diversity is one of the characteristics of Asian shrimp culture, even if it is more marked at the local or regional level. Although not exclusively, Thailand thus presents an intensive nature while Vietnam and Philippines, as well as India and Bangladesh, are characterised by an extensive development. But 70 to 80% of Thai farms are small-holdings. Indonesia presents a more intermediary scheme where, together or separately, the quasi totality of production systems co-exist. This system’s diversity is the result of both different choices and logics: the progressive intensification of growout farms, the technical evolution to go beyond low favourable environmental constraints, self-limitations (technical knowledge, costs, etc.) or limitations induced by administrative standards or by a particular social and economic context (access to production factors, capital or land, lack of infrastructures, etc), back to extensive or mixed systems (polyculture) after several setbacks.

The Asian production systems’ characteristics are completely different to those encountered in the Americas, where the lack of a tradition in aquaculture has produced fewer endogenous developments. The Americas mainly have semi-intensive systems, but over a large geographical area, with all previous reserves attached to the gap between technical standards and real practices. Semi-intensive shrimp farming is still the chosen method for most farms in the Western hemisphere. Farms are usually between 100-500 hectares in size. The majority of commercial farms are stocking between 8-25 animals per square metre, and use little or no aeration. A pelleted feed is generally provided and there is a strong reliance on fertilization to stimulate phytoplankton blooms. The yield is normally between 1000-2000 kg/hectare. Yields above 2000 kg per hectare for semi-intensive farming is considered excellent. Farms in tropical climates typically have 2 to 2.5 crops per year (www.fishfarming.com). These big systems are based on large ponds, from 5 to 20 hectares and are becoming ever larger and vertically integrated (from hatcheries to processing plants).

It is estimated that approximately 10% of world farms are currently using intensive or super-intensive production strategies. There is a tendency for Asian farms to be smaller in size but more intensive in the production methods. This is particularly true in Taiwan and Thailand, where the industry is extremely well-developed (GAA). If the total land area devoted to farming as well as the number of farms is much greater in Asia than in the Americas, the average farm size in Asia is 4.4 hectares as compared to 100 hectares in the Americas.

According to Table 4, it is interesting to note that in spite of the common belief that Asian shrimp farming is very intensive, the average annual production per hectare is slightly greater in the Western Hemisphere than in Asia: 1797 kilograms per hectare compared to 1455 kilograms per hectare (even in Thailand). This is often used to argue in favour of an intensification increase through culture methods without the need for a large expansion area devoted to farms (Global Aquaculture Alliance). But the average production reported to the total area leads to 432 kg per hectare per year in the Eastern Hemisphere as opposed to 831 kg per hectare per year in the Western Hemisphere. It still illustrates the high level of diversity of production systems in Asia and the relative homogeneity in Western Hemisphere. The data is rather old, but these are the most recent figures relating to the level of detail (Nb. of country, area, number of hatcheries and farms).

Australia accounts for a relatively small level of shrimp production, but methods are quite intensive. There are about ten times more hatcheries in Asia than in the Americas (Table 4). This is the result of the need for fewer postlarvae for stocking ponds in the Americas and the tendency for hatcheries in the Americas to be larger than those in Asia (Global Aquaculture Alliance).

Table 4: World Shrimp Farming in 1997 and Total for 1999

Country	Production Heads-on (metric tons)	Growout Area (hectares)	Average Production (Kg/ha)	Estimated Number of Hatcheries	Estimated Number of Farms
E. Hemisphere					
Thailand	150 000	70 000	2 134	1 000	25 000
China	80 000	160 000	500	1 500	8 000
Indonesia	80 000	350 000	229	400	60 000
India	40 000	100 000	400	200	100 000
Bangladesh	34 000	140 000	243	45	32 000
Vietnam	30 000	200 000	150	900	8 000
Taiwan	14 000	4 500	3 111	200	2 500
Philippines	10 000	20 000	500	90	2 000
Malaysia	6 000	2 500	2 400	60	800
Australia	1 600	480	3 333	12	35
Sri Lanka	1 200	1 000	1 200	40	800
Japan	1 200	300	4 000	100	135
Other Countries	14 000	20 000	700	30	2 000
E. H. Total	**462 000**	**1 068 780**	**432**	**4 577**	**241 270**
Average Global %	**70%**	**82%**	**1 455**	**91%**	**99%**
W. Hemisphere					
Ecuador	130 000	180 000	722	350	1 800
Mexico	16 000	20 000	800	23	220
Honduras	12 000	14 000	857	13	90
Colombia	10 000	2 800	3 571	15	20
Panama	7 500	5 500	1 364	10	40
Peru	6 000	3 200	1 875	3	45
Brazil	4 000	4 000	1 000	18	100
Nicaragua	4 000	5 000	800	4	25
Venezuela	3 000	1 000	3 000	5	8
Belize	2 500	700	3 571	1	7
United-States	1 200	400	3 000	8	20
Other Countries	2 000	2 000	1 000	5	15
W. H. Total	**198 200**	**238 600**	**831**	**455**	**2 390**
Average Global %	**30%**	**18%**	**1 797**	**9%**	**1%**
World Totals1997	**660 200**	**1 307 380**	**505**	**5 032**	**243 660**
	Average on countries' yields:		**1 626**		
World Totals 1999	**814 250**	**1 251 450**	**651**	**5 777**	**375 913**
	Average on countries' yields:		**1 832**		

Source: World Shrimp Farming 1998 & 2000

Trades and Markets[1]

Shrimp is the most important commodity, accounting for about twenty percent of international trade in value terms. This share remained stable over the past twenty years, despite the substantial changes in trade patterns and in the supply of fish and fishing produce to the world market (FAO 2000).

Total annual revenues generated from the production of farm-raised shrimp worldwide was estimated at US$6.4 billion. But other sources, extrapolating the import volumes and the dollar value of the US and Japan imports, estimate the total value of frozen shrimp trade worldwide in 1999 as at least US$10 billion, which seems closer to the reality (CP Group (Thailand) Shrimp Culture Newsletter March 2000 & www.GlobalFoodExchange.com). The value of US imports alone are now around $3.6 billion annually.

Major importing countries of shrimp are the USA, Japan and the EU countries. The US imported 331,706 metric tons in 1999, whereas Japan imported 247,000 metric tons in the same year. These import volumes account for 41% and 30% of total world shrimp production, respectively. The three major markets for farm-raised shrimp are therefore the United States, Europe and Japan. However, a number of new and developing markets throughout the world are now demanding higher and higher levels of shrimp products. The growing middle class and subsequent opening-up of the market into China are just one example (GAA).
Shrimp imports into Europe continue to grow, with Spain as the principal market, followed by France and the UK. Danish shrimp imports are mainly re-exported (Globefish).
If European countries, Japan, and the United States are major players in the shrimp culture industry, they produce materials and supplies needed in shrimp farming, and they provide a great deal of technical expertise on production and processing techniques (Global Aquaculture Alliance).

Thailand and Ecuador have the highest reliance on farmed shrimp supply for exports. Thailand is the world's largest exporter of shrimp, with total exports of frozen shrimp reaching 136,182 metric tons, worth 58,950.42 million baht in 2000 - a 7% increase in terms of quantity and an almost 26% increase in terms of value from 127,229 tons worth 46,837.10 million baht in 1999. Other major exporting countries are Ecuador, Mexico, India, China and Indonesia. Indonesian exports are stable around 80,000 metric tons. In 1998 and 1999, exports of shrimp were down as a result of the Asian crisis and also due to some problems of disease. The four biggest shrimp exporting countries are all developing countries, exporting tropical shrimp. Thailand and Indonesia mainly sell black tiger shrimp from aquaculture, while Ecuador sells white shrimp, also from shrimp farms (Globefish).

Prices increased during the 1989-1994 period, dropping suddenly in the course of 1995. This drop in prices was caused by less demand in Japan, due to the poison gas scare, which overshadowed the restaurant-going habits in the country for a long period. In 1996, the situation in Japan got back to normal and prices started to climb again. The economic crisis in Japan and other Asian countries which started in late 1997 led to a second fall in world shrimp prices. At present (from July 1999) they seem to have bottomed out. Thai Black Tiger shell-on 21/25 registered a record low of US$5.15 in 1994 and a record high of US$8.30 in 1998. After the high price-levels in early 1998, prices declined, to bottom out in late 1998. Only recently there has been a certain tendency for price increases. The EU market does not play a dominant role in fixing tropical shrimp prices, rather following the price trend set by Japan. But on

[1] Detailed data according to flows and charts are given in the appendices

average, and beyond national or regional variability, it can be said that tropical shrimp prices have remained fairly stable over the past decade. For coldwater shrimp, on the other hand, the EU is setting prices, taking some 90% of the total supply of this type of shrimp on the world market (Globefish).

Today's world market for farm-raised shrimp continues to be characterized by strong product demand. It is a seller's market, according to industry sources, because demand exceeds supply. A report, published in February 2000 by the Bangkok Bank PLC Research Department pointed out that world demand for shrimp in 1999 reached 2.1 million metric tons against a supply of only 800,000 tons.

Future and trends
From a technical point of view, facing both environmental threats and devastated mortalities in shrimps farmed, in order to make systems biologically secure in for a significantly lower risk of disease, recirculating shrimp farming technology has been developed. Farms in the Americas typically have large ponds (8-15 hectares). These are not ideal for recirculation technology. Re-engineering the ponds to smaller sizes is often not economically feasible (GAA).

From a development point of view, many of the best sites for shrimp farms already have been used, but there is still opportunity for the expansion of shrimp farming, especially in Brazil, several African nations, and the often quoted “sleeping giant” - Vietnam. But this is a reflection on the boom and bust cycle characterising shrimp farming. Shrimp culture counts for about 25 to 30% of world shrimp production, but in spite of the dramatic developments during the 1980s, this share has remained stable from the 1990s onwards. A relative stability characterises world shrimp farming production - an upper limit that masks the boom and bust cycle at national and regional scales. If these crises appear or act as a regulator of world supply (and also affecting prices), confronted by the emergence of new producing countries, at these scales they constitute an important factor of economic and social instability. The sustainability of shrimp farming development is highly questionable, as the Taiwanese crisis illustrated - Taiwan went from the position of biggest world producer to being an insignificant producer.

Problems leading to these crises are multiple and complex and crisis analysis has to be very performed with the utmost care. Thus it has to face the combination of several phenomena:

- pathology phenomena,
- environmental degradation,
- lack of growout knowledge (scientific knowledge is often not enough in order to know the practical limits for sustainable technical practices).

According to existing literature, the following sections will try to assess some of these factors and key points where they can or should be addressed (institutional and stakeholder failures, etc).

International funding in shrimp culture development has played a key role. *"Spurred on by governments eager for increased export dollars, shrimp aquaculture development has been aided by generous support and incentives from international lending institutes, including the World Bank, Asian Development Bank, Inter-American Development Bank, and others. The World Bank participated actively in the launching of the shrimp industry in Asia. Out of an investment of US $ 1.685 billion in 1992 for Indian agriculture and fisheries, the World Bank* *allocated US $425 million for aquaculture development. A substantial part of this sum seems to be destined for intensification and expansion of shrimp ponds..."* Barraclough and Finger-Stich. In addition to government incentives, grants and other kind of public funding, another important one is the funding through private agribusiness company.

2. Economics of production

As regards farming diversity, a comparative economics analysis of production systems remain difficult at the world level. Written studies on the subject mainly focus on one segment of the industry or on one country or area. Only Shang et al (based on a 1994 farm performance survey conducted by the Asian Development Bank and NACA1994) provide a comparative analysis of technical systems according to the usual classification of Extensive, Semi-Intensive and Intensive. It is rather an intra-country comparison and there is great diversity in terms of intensification of area under the same technical nomenclature. In addition and as seen previously, techniques have evolved rapidly since 1994, both in intensification and diversification. In addition, from one country to another, even on a local scale, standards are quite different. Through the typology detailed above in section 1, we will try to review some global, albeit non-exhaustive trends.

The difficulty in conducting this comparative analysis at a global level is also well illustrated in terms of production. It is reasonably difficult to portray the different systems according to their production as any portrayal should integrate the risk of failure or collapse. Some authors consider this risk as a full part of the system (Berthe 1995). The range of production through systems can therefore be quite wide. For instance, Rosenberry (Shrimpnews) considers farming up to 500 kg per hectare per year extensive, from 500 to 5000 kg per hectare is considered semi-intensive, from 5000 to 20,000 kg per hectare is intensive and from 20,000 to 100,000 kg per hectare per year is super intensive.

Farming economics and cost structures

In past studies, many applications conducted through a cost/benefit analysis use either cost/kg as well as costs/hectare in the same way. This requires some preliminary remarks. Although the yield results in a certain volume of shrimp, the conversion of this yield into an economic analysis is not solely concerned with the quantification of this result or the production level (turnover), but also with the means of production and with the qualification of the result. That means that the different indicators should refer to the amount of shrimp produced rather than the area (hectare). Indicators or costs referring to the area are more illustrative of the infrastructure or technical choice. In the same way, SD, pond size, FCR, the survival rate and technical efficiency are not indicators of economic performance but of productivity. They are indicators of the technical choice and of the mode of organisation. Therefore, if the technique and its performance influence the production and the economic performance, that does not mean that a good technical performance will naturally correspond to a good economic performance.

Differences in cost/kg and cost/hectare can give a different picture according to what you wish to demonstrate and many authors mistakenly use costs/hectare as indicator of performance.

With its wide diversity of farming techniques, Indonesia provides a good illustration of many production systems and organisation modes. It can be complemented by mixed extensive production systems based on family resources, low investment and knowledge, such as those encountered in the Mekong Delta, the Philippines or Malaysia. At the other extreme, the

Nucleus Estate Smallholders Scheme (NESS) can complete this overview of production systems, also covering the different methods of reasoning. An intermediate level will consist of the satellite farms concept, seemingly close to the NESS as regards techniques and management, organising existing farms or developing cooperation systems between smallholdings and big units.

As regards traditional or extensive farms, the semi-intensive systems and the intensive ones, the costs structures present different characteristics despite occasional similar financial performance. This will have an influence on the ability to face a crisis and also on the social impact and the relationship with institutional and legal issues. Conclusions from literature as regards financial performance are sometimes disputed, whatever standpoint these conclusions come from (researcher, administration, NGO or industry), thereby illustrating the diversity of production systems according to their environment. Main trends over several years are tentatively isolated for the same kind of environment.

Fixed costs and operational costs per hectare increase alongside the intensification level. In terms of structure, fixed costs represent no more than 10 to 20% of total costs. Among these costs, pond construction and pumping (if applicable) are the principal ones for extensive or traditional culture systems, representing 40% of the investment cost. For more intensive systems, pond construction costs range from 10 to 20% as other equipment costs increase (paddle wheel as 30%; pumping and sluice about 20%). The investment level usually ranges from less than $5000 per hectare for a traditional system, to more than $50,000 per hectare for an intensive system.

Based on official typology per country, Shang (1998) underlines different results (from 15% to 50% for the same technical level) always illustrating high diversity through a similar "official" technique level and showing the environmental importance in the results (country as an environmental proxy).

Concerning operational costs, feeding costs are the most significant, depending on techniques used (equivalent with PL cost in low intensification systems). They represent more than 50% of the total cost for semi and intensive systems and 20% for traditional systems. In addition to the labour costs, they can contribute to an intra country comparison - in the Eastern hemisphere, especially South-East Asia, feed contains a higher volume of fishmeal (30 to 35%) and in more extensive countries farmers use feeds with lower protein and fishmeal levels, often farm-made or based on natural food. At the same time, the Western hemisphere depends almost entirely on dry feeds (also true for intensive areas). PL cost range from more than 10% for semi and intensive systems to 20% for extensive and some very intensive systems (more than 25 PL/m²).
The other important operational costs are labour costs, especially for traditional systems, accounting for 50% of total operational costs (other techniques costing half this amount).

Profitability and factors influencing farms' efficiency
According to the previous remarks concerning cost indicators (per kg or hectare), financial incentives to farming development are strong but there is no significant difference among traditional and intensive systems in terms of economic efficiency (profit rate above 50%) or wealth distribution (added value between 65 and 73%) (Bailly et al. 1999, Appendix 2 Economics of Production Systems, Parts 1, 2 & 3). The relatively low average results of semi-intensive systems can be explained by the tendency to over-stock in ponds designed and managed to support a relatively low stocking density. This increases the risk of high

mortalities and low average economic results come from this higher variability. In well managed semi-intensive ponds, financial performance is comparable to that observed in other technical systems. From the cost-benefit analysis there is no evidence of financial motives to support one technical system over another.

Production cost per kg is about $3 per kg, except for semi-intensive, which more often reaches up to $4 or $5/kg. Extensive/traditional systems seem to have lower production costs per kg. While illustrating the difference in official criteria and according to Rosenberry (2001), total production cost will theoretically range from $1 to $3, $2 to $6 and $4 to $8 per kg respectively for extensive, semi-intensive and intensive systems.

To complete this overview and assess the importance of farm management or choice of reasoning in failure or success, mixed extensive farms and Nucleus Estate Smallholders Scheme (NESS) will be briefly presented:

Mixed extensive farms are characterised by local endogenous development. This is typical of a rapid and unorganised development in which all local resources have been invested. This development has been induced by the high profitability in shrimp culture where yield is successful compared to other activities, such as rice growing. The cost structure is fully represented by the pond construction cost and PL cost and sometimes by labour costs, as they remain mainly based on family labour. They have to face several major problems, such as a lack of knowledge or access to capital. The stocking of yields is often staggered and this is more a continuous growout than a crop based one. Based on multi species and mangrove exploitation, they can have good results during the first years of operation (low operational cost, no energy or feed costs, profit rate higher than 80% but low profitability per hectare) for an average production of 250 kg per hectare per year, but there is currently a tendency to overstock in order to balance failures with success. These farms often enter into vicious circle of setbacks.

Developed in Indonesia and Malaysia, the NESS scheme is based on huge areas developed by an external single investor providing technology, inputs and market outlet to individual small farmers. Such units currently represent the world largest farms (several thousand farms) This is a very intensive production (25 to 50 PL/m²) with a comparatively poor average technical performance (7 kg/1000 PL) but very good economic results with an overall pressure on coastal waters very high and thus it can be said that in the short term, environmental sustainability has been fairly well controlled. Part of the success can be explained by centralised management of water, technology and marketing. Nevertheless, social conditions and environmental sustainability of such a development is highly questionable, as recent events (social problems) on this kind of farm makes clear. NESS is also revealed to be quite fragile when faced with a financial crisis.

The industrial point of view (through GAA) about economics is quite different from that found in grey literature but is more related to intensive techniques (in value). Depending on site and farm design, construction costs range from about $10,000 per hectare in South and Central America to as much as $50,000 per hectare in the United States and Australia. $10,000,000 per hectare is also quoted by Rosenberry as an upper limit of construction costs. The operational costs related to producing crops are also considerable. In intensive shrimp farming, the cost of postlarvae for stocking 1 hectare may be between $2500 and $5000, and feed costs may exceed $25,000 per hectare in intensive ponds. Added to other operational costs (labour, pumping water, and operating aerators, etc.) the industry often argues that it

should be obvious that the shrimp farmer wants a sustainable operation, because many years may be required to recover investment costs. This last point is highly questionable, according to different research projects underlining a short time return on investment (no more than one year in some cases). From the same source (GAA), the farm gate revenue for well-managed intensive farms with a sustainable production rate of 4 to 5 tons per hectare per crop is around \$50,000 to \$75,000 per year with an export value of about 1.5 times greater.
A 20% profit margin is considered good in this high-risk industry.

Earnings from shrimp farming are often far better than those obtained in traditional agriculture or fisheries in the short term, and they are a real incentive to turn to shrimp cultivation by turning traditional activities such as mangrove plantations or paddy fields into shrimp ponds.

In terms of economics, the cost and revenue structure of the different production systems underlines the fact that intensive farms have lower fixed costs but higher variable costs than less intensive farms. This leads them to be more sensitive to crises, as illustrated by their break-even prices. But often aiming at maximising the profit per hectare that doesn't mean they're the highest performing ones from a financial point of view.

Most intensive farms usually present higher profitability per hectare but a lower profit per kg (financial performance) than less intensive farms. In 1994, Primavera also quoted that low-density (2/sq m) culture gave higher income per kilogram but lower profit per hectare. As a consequence of this difference, according to the local environment (ecology, economics and social) several kinds of developments may arise, as environmental and social issues should illustrate these development profiles.

It can be said that although the levels and structure of investment are very different, the global economic performance is extremely good and comparable, on an average basis, between traditional/extensive and intensive systems. High profitability is the real generator of the dynamic development (with a quick return on investment in the better well managed farms). But differences in risk factor affect this performance.

To conclude, with the exception of semi-intensive systems (in general) there is no evidence of economic reasons to support one technical system over another. The difficulty to control sustainability at low levels of intensification questions the soundness of public policies supporting the development of such systems over more intensified systems, for precautionary reasons. The same applies for advocates of high intensification against the improvement of the technical criteria for sustainable extensive production.

But the incentives or limitation for intensification largely depends on factors other than profitability. Conditions of access to land, capital, know-how or markets are key factors to explain the level of intensification observed in any given area (socio-economic organisations of shrimp farming). The local ecological conditions are another important factor constraining the local potential for intensification.

3. Environmental issues of shrimp farming

Environmental and social issues are often well correlated. Important issues arising in this sector will therefore help with social and legal issues.

Environmental issues of shrimp farming are now well known, studied and documented. But most studies only focus on a few topics with particular attention made to mangroves with conflicting messages. If we may tentatively draw up a list of environmental issues of shrimp farming:

- Deterioration of mangrove ecosystems
- Salt water intrusion
- Feed and pollution / Food insecurity
- Disused ponds
- Seeds and broodstock / Biodiversity

Others problems, such as disease or sanitary risks, are split on the above issues (food availability as a consequence of salt water intrusion and mangroves losses, fair trade, etc). But all contribute to the unsustainable nature of shrimp farming.

Primavera (1978, 1993, 1994, 1997) is certainly the author addressing the most environmental issues from a global point of view and in relationships with other issues such as social and legal issues (as a global production cost beyond farm boundaries, including social and environmental costs). On the other hand, industrial shrimp lobby groups and NGO's appear to take two diametrically opposed positions.

Mangrove issue

Mangrove appears as the most frequent and conflicting environmental issue. If its importance is currently fairly well recognised, its value and the how to restore or protect it are not so clear.

Although shrimp culture is not the only cause of mangrove clearance or conversion (salt beds, agricultural land), it is the most significant one. Examples of shrimp farming development linked to mangrove clearance are many (Macintosh D.J., Primavera). Comparing the economics of land use options for mangrove areas underlines the strong financial incentive of shrimp farming (Nautilus). For instance Shrimp Sentinel Online estimates the lost economic value of mangrove plantations for one year as follows: the cost of destroyed mangrove plantations per hectare per year stands at about $7200 as opposed to marine fisheries: $2000, poles, firewood, charcoal: $400, other products: $800 and the estimated cost for coastal protection: $4000. This cost is opposed to the gross income of semi-intensive farms which is here estimated at approximately $5000 per hectare per year (risk-taking intensive farms make up to $15,000 per hectare per year gross).

Others causes are sometimes advanced or opposed, as in Hambrey (1996) who asks the question "In the absence of shrimp farming, what would be happening to the mangrove?" As background, he shows some shrimp ponds in mangrove area already under heavy pressure (agriculture and especially rice production, grazing, urban development, fuel, construction materials, wood pulp and tourism). This is also the case with several others authors (Piamsak Menasveta and Arlo W. Fast) but all focus on Thailand mangrove. In the Philippines at the beginning of the 1990s, half of all mangrove clearance could be attributed to pond development. Today, the impact of shrimp farming on mangrove areas is put forward as being quite different depending on the technique used. Intensive system supporters advance that shrimp farming does not currently need to operate in mangrove areas on the seashore if they are based on adequate pumping infrastructures and that the practice of removing mangroves to build shrimp farms has, by and large, stopped (GAA).

The role and function of mangrove areas is now well known in terms of spawning areas, including wild shrimp seeds. The protective mangrove buffer zone helps minimize damage to property and loss of life from hurricanes and storms. In regions where these coastal fringe forests have been cleared, tremendous problems of erosion and siltation have arisen. Although mangroves have also been useful in treating effluent, as the plants absorb excess nitrates and phosphates, thereby preventing the contamination of nearshore waters (MAP Working Paper by Alfredo Quarto), their effective role (in terms of capacity) as a filter of ponds' waste remains difficult to fund (Blasco). In addition to the ecological function, alternative uses for local communities are many: fishing, timber, charcoal, medicine, etc.

Mangrove and shrimp farming are two sensitive topics which lead to violent opposition between industry and environmentalist NGO's (1997 Greenpeace report on shrimp "the devastating delicacy", The Mangrove Action Project (MAP) and GAA websites).

The literature review illustrates the potential of valuation methods for evaluating management alternatives of mangroves, as well as the practical limitations to their application. Spaninks (1997) conducts a review of theses methods. In principle, methods are available but the lack of data and quantitative knowledge regarding some key ecological relationships affirm the need for further inquiry (market failure, non tradability goods, etc). Most of these studies with reference to shrimp culture and its impact are located in Western hemisphere (Ecuador, Salvador, Mexico, Brazil) (Gammage, Spaninks, MAP) compared to Eastern hemisphere (Philippines mainly) (Primavera).

Saltwater intrusion

The rapid extension of shrimp culture in coastal agricultural areas often used irrigation infrastructures such as the coastal embankment to control salt water intruding into paddy fields, for the most part. Based on expensive national or international operation building (such as Dutch projects in Indonesia, Vietnam etc), irrigation canals used as inlet and outlet canals by shrimp culture become inadequate for rice farming. There are also a lot of examples of former rice farmers illegally cutting dykes to build pond sluices. Saltwater intrusion from shrimp ponds and brackish water aquaculture to agriculture land such as paddy fields is a major source of conflict (Raux, Do Quang Tien Vuong). Rice crops decrease a great deal and farmers have either to abandon their land (and often leave the area) or turn it into shrimp ponds. Conversion without sufficient knowledge or access to capital is often the source of failure in shrimp culture. The salinization of ground water is also another consequence of the uncontrolled discharge of salty pond water (Primavera 1997), reducing the domestic and agricultural water supply.

Feed and pollution / Food insecurity

Shrimp production produces large quantities of shrimp waste, unused food and chemical substances used to treat diseases, which are allowed to drain into estuaries without being treated first. Packing companies also produce waste, such as shrimp exoskeletons. This waste is sometimes thrown directly into the estuaries or left along highways or in open fields where they rot and cause pollution (MAP). Many – indeed most – environmental studies (as regards

ecology) are based on carrying capacity and the ecological impact of shrimp culture. The rates of consumed produce are not well documented.
In terms of production systems, impacts are quite different. "Because it relies mainly on natural food and tidal water exchange, extensive culture in ponds places minimal stress on the environment (aside from the major loss of habitats in the case of mangrove-based ponds). Evidence of such sustainability is the centuries' old culture of milkfish in Tambak in Indonesia and the Philippines" (Primavera 1994).

In addition to pollution, the use of antibiotics and other chemicals used in aquaculture may be toxic also to other cultured species and human consumers. It is illustrated by recent bans of shrimp imports from Asian countries to the EU and the United States.

Finally, shrimp feeding can contribute to negative externalities such as fishing for pellet. More that 40 percent of all fish caught from the world's oceans and seas are being ground into fishmeal. By the year 2000, however, aquaculture's share of global fishmeal production was expected to be 20-25 percent, creating what has been called a "fish meal trap" (Greenpeace).

Disused ponds
As a consequence of a great deal of unsustainable development, many ponds have been left idle or abandoned. In some area it can range from 20 to almost 90% of the shrimp area abandoned (Bangkok Post 1995). Md. Zakir Hossain and C. Kwei Lin (2001) have well illustrated the process of shrimp farms abandonment in Thailand. Potential acid sulphate soils exist in many mangrove soils and, as a result of the excavation of shrimp ponds, become oxidized and form actual acid sulphate soils (AASS) which release large quantities of acid and toxic level of iron and aluminium upon wetting directly responsible for fish and prawn losses (Stevenson and Burbridge 1997). In spite of liming and combined with improper site selection, poor construction methods, water quality and practices, etc. it often leads to the ponds' abandon. In the short term (5 to 10 years), the restoration or conversion of unproductive ponds remains difficult (AASS may persist for many years) and expensive. Most farmers would like to come back to traditional shrimp farming systems but often have no real success. Sylvo fisheries conversion seems to give interesting results in a formerly destroyed area in Indonesia. Fish cage culture, salt farms or integrated shrimp culture are often the least unattractive answers, but other means of catalysing and funding rehabilitation or restoration activities must be found.
Soil alteration as environmental consequences leads to: accelerating erosion, decreasing soil water storage capacity, reducing biodiversity of soil fauna, altering the transport of sediments (dissolved inorganic and organic constituents and principal nutrients), increasing level of toxic chemicals and depleting organic matter through leaching and mineralization (Stevenson and Burbridge 1997).

Seeds and Broodstock / Biodiversity
Mangrove degradation is implicated in the decline in abundance of wild shrimp larvae (Primavera 1994 and Twilley, 1989). Combined with an overexploitation of broodstock for hatcheries, there is also a threat of broodstock depletion for the future.
In order to supplement inadequate local supply, spawners and broodstock are imported from other countries which are sometimes not secure as regards viruses, contributing to the spread of viruses and other pathogens, increasing farmers' difficulties and contributing to the boom and bust cycle hidden behind the world production stagnation. Looking for fast growth rates (*P.monodon* and *P.vannamei* mainly), exotic species are introduced and contribute to this

spread in addition to habitat changes, competition and predation, and genetic interactions with native species (Primavera).

Beyond institutional answers, some technical attempts are also proposed: recirculating systems (RAS), bio filters associating mangrove; integrated aquaculture concept, the reduction of crop numbers. Alternatively, NGOs propose to come back to sustainable extensive systems such as the Indonesia's traditional "Tambak" system or the Gei Wai system (Hong Kong) or to an improved model such as Modern Closed System Shrimp Aquaculture.

The above environmental issues concern also shrimp culture, as environmental degradations induced by some shrimp farms can threat other shrimp production systems where there is a high farming density. Finally, most environmental issues are echoed in social issues.

4. Social issues

Most social issues are linked to the above environmental issues and mostly reported in environmentalist NGO studies. Greenpeace underlines and opposes the high social cost and the creation of a host of new complex environmental problems to farms' profitability. Shrimp farming as another exploitation of natural resources provokes the argument of private costs versus social and environmental costs.

Assessing the global cost (including external costs) and benefits of the shrimp farming industry remains the main problem for stakeholders, decision makers and policy makers. Thus two opposite and extreme points of view continue to confront each other. Very few studies try to assess the relative weight of shrimp culture combining economics, environmental, social and public policy topics beyond of a simple listing of troubles, issues or farm's benefits.

Land privatisation

The importance for local communities of mangrove uses, beyond of ecological role already quoted at section 3, is today well known. Alternative uses of mangroves are well documented in literature but evaluating these uses remains difficult, as we have already seen.

Local fishermen have complained of decreasing catches of commercial fish. Often this decrease is attributed to the industry practice of catching larvae and destroying the accompanying fauna. Another social impact accompanying changes made by the shrimp farming industry is that in some areas, access to mangroves, lagoons and estuaries are compromised or lost. Sometimes, local people are forced to move away, with the support of national or regional decrees. The consequence of this is that the source of food, energy (firewood) and ultimately income is lost to some of the local population (MAP). This is recognized by the industry, in some countries where shrimp farmers have obtained permission from the government to use coastal lands that are not under private ownership. "This land had formerly been used by local people for home sites, agriculture, the gathering of wood for fuel and construction, hunting, fishing, and other purposes. The conversion of the land to shrimp farms can restrict resources for local inhabitants or even force people from the land" (GAA). But from the industry point of view, the loss of traditional uses is balanced by regular employment from shrimp culture development.

Employment
Shrimp culture development has created many jobs, both directly and indirectly. Many coastal village economies have been profoundly changed by these developments and the rush to 'pink gold'.

For environmentalists, for the most part it is only a relatively few investors that have received "the lion's share of benefits, while large portions of society, particularly the rural poor, have become disenfranchised and marginalized into severely degraded environments" (Greenpeace, MAP).

Facing these critics, the shrimp industry answers that there also are many small family farmers, giving the example of Thai farmers: "For example, a study of shrimp farms in Thailand revealed that about 90% of the shrimp-farming area consisted of farms smaller than 6 hectares, and many of the farms are only 0.5 to 2 hectares in size" (GAA). But small-scale farmers often run under private association with external investors.
People controlling the production process (large rural landowners, urban entrepreneurs, government officials, bankers, etc.) are invariably seen in a pejorative sense (Neiland 2001) "They can also be viewed as rational economic actors responding to prevailing opportunities and constraints, and gaining appropriate returns to enterprise and risk-taking. In turn, this may contribute to the generation of surplus capital for investment in other productive enterprises; a necessary component of economic growth".

In terms of employment, if fewer workers are needed in semi-intensive shrimp farming, even semi-intensive shrimp farming is labour intensive. But family labour is sometimes neglected as real employment "intensive shrimp culture creates more employment than the extensive culture method using mostly family members" (GAA). Intensive shrimp farms usually employ 1 to 2 full-time workers per hectare (Hambrey 1996). The difference in labour according to production systems is very big, ranging respectively from more than 1 to 10 shrimp workers for intensive and extensive farms. On average and based on several surveys (Raux et al 1997) it can be considered that 10 hectares of ponds will provide 23 full time equivalent labour units. On the other hand, more than a hundred families can make a living from 10 hectares of mangrove.

Combined with the phenomena of disused ponds, this can lead to some rural unemployment and the migration of the local population to suburban and already crowded cities. But differences according to region or country can be important. Indirect employment and real benefits remaining in the country or region along the value chain have never been really studied at this scale.

Losses for communities, increasing of value gap between local populations can also lead to social conflicts.

Social conflicts and poverty
Beyond demonstrations related to environmental degradations and the losses of use of daily social conflicts can accompany shrimp culture development, (such examples of shrimp culture's externalities and testimonies are many and can be found on NGO website such as Sentinel Shrimp Online, Mangrove Action Project, Greenpeace, World Rainforest Movement, etc).

Theft of shrimp is more and more commonplace and sometimes murders related. This engenders the problem of poverty and aquaculture and sometimes the opposite results of the goal aimed by public policy based on aquaculture. As Edwards says, "The contribution of aquaculture to sustainable rural livelihoods of poor farming households is not widely appreciated" (Edwards P.). Reviews of donor funded fisheries development projects targeted at poor farmers up to the 1980s revealed limited sustainable impact. Access to knowledge and land tenure systems remain a large obstacle to aquaculture and the alleviation poverty.

The alleviation of poverty and the development of aquaculture can lead to opposite issues. Beyond of shrimp culture, Anantha Duraiappah highlights the institutional and market failures which encourage unsustainable activities (Duraiappah A., 1996). Poverty is then often linked to environmental degradation. To avoid this antagonism, several draft or public policies have been implemented or are still undergoing implementation, such as the SAPA strategy in Vietnam (Sustainable Aquaculture for Poverty Alleviation). Concerning shrimp culture, it appears to be one of the main present directions in research for funding projects.

Another, indirect social impact can be the increase of prices in human consumer goods in places where shrimp culture is mostly developed. As the basic raw materials used in shrimp farming are the same ones used in the production of meat, vegetables, fruit, and grain for human consumption, in some areas, due to the high demand of the shrimp industry, it can increase the prices of human food. Disused ponds reinforce this impact by decreasing the local rice or other traditional agriculture supply.

It is then rather difficult to assess the relative and global benefits of shrimp culture in local communities as the technical, ecological, socio-economic and institutional context can be very different from an area to the other. There is a great lack of research projects and studies is the lack of interest or ability to study global development profiles combining these factors. The FAO code of conduct illustrates this aspect (FAO, Barg et al, Towards Sustainable Shrimp Culture Development: Implementing the FAO Code of Conduct for Responsible Fisheries).
Concerning benefits of shrimp culture, including production, foreign exchange and employment, nearly all responding governments have provided data on the production and exported quantity and value of cultured shrimp as well as on the number and size distribution of shrimp farms. About half of the responses also included information on employment but only a few reported on average daily earnings in shrimp farming.

5. Legal issues

The importance of legal, procedural and planning frameworks designed to facilitate sustainable aquaculture development is emphasised in the FAO Code of Conduct for Responsible Fisheries (GESAMP 2001).

Legal issues are mainly one-way, aiming to reduce externalities generated by shrimp culture. Very few laws are in place to support the shrimp industry (mainly legislating on trades and markets) and they are often part of a more global seafood policy.

On the global scale, it is difficult to isolate legal and institutional issues, as legal issues are so numerous and closely related to institutional issues. Although in one country it is possible to give an exhaustive list, at the world scale it remains difficult. As with other coastal activities, shrimp culture covers a wide range of regulations such as environmental, forestry, fisheries, agriculture or water regulations. But in spite of this, some main trends can be identified:

- existing laws, especially those related to the environment, were suitable to control and accompany the shrimp culture development. Governments already have relevant laws and regulations to protect the interests of all those who live in coastal areas. But up against shrimp farming profitability and a rapid, uncontrolled and anarchic development (especially endogenously) often far away from where decision making takes place, existing regulations often remain ineffective. In addition, numerous corruption problems accompany important shrimp plans according to country or region (Indonesian "Korupsi"). Under local and international pressure and facing social problems or environmental damage, specific laws targeting shrimp culture are implemented with particular attention to land tenure systems, sanitary norms, Environmental Impact Assessment or zoning. But law enforcement problems still remain in many areas.
- These specific laws mainly target: land tenure system and water management, mangrove protection (conservation and/or restoration, sustainable exploitation), resources preservation (fry and broodstock) and sanitary norms of products (more largely fish products).
- There are very few economic incentives through licences, fees or input-output taxes (excepted Bangladesh) to orientate the development of shrimp culture in a more sustainable manner (Willman and Bailly 2001). Direct shrimp products taxes are not specifically devoted to shrimp culture management.

According to the different national or local context, depending on shrimp lobbying, environmentalists' influence, and political and local communities organisations, these trends can lead to very different results. Regional or national shrimping history is equally important (duration and extension of the activity, etc.) and some countries could go the way of others. These different results can be perceived through:

- the Indian ban on coastal shrimp farm construction (December 1996 Supreme Court decision which found industrial shrimp farming illegal under that nation's coastal resource protection laws);
- the Thai ban on inland shrimp farm construction;
- the ban of wild fry collection in Bangladesh;
- the forced restoration of mangrove belts by forcing local population to move in Indonesia (under the "transmigrasi" policy or local decrees);
- As provided for under Indonesian law, any aquaculture development over 30 hectares in Java and 50 hectares in islands outside Java has to be developed under the Tambak Inti Rakyat (TIR) or nucleus-estate concept.
- Ban of clearance and forest conversion in Salvador (1992) as well as many tropical countries today. The ban extends to all use for firewood, construction, and commercial trade. But if it is possible to establish that the tides no longer service an area of mangrove, an application can be made to remove the remaining mangrove trees (Gammage).
- The Government-Imposed Moratorium of 1996–97 until 1998 in Honduras for new shrimp farms (Stanley).

This list is far from exhaustive - other examples exist, such as in the Americas, like for example enforcement.

More specific actions or laws depending on the country, its history, its social, political, economic and environmental context can sometimes lead to contradictory objectives such as the mangrove issue in Vietnam. Mangrove's dimension is quite different from other countries according to its refuge and fighting role during wartime. The characteristics of the mighty mangrove has lead to important legal constraints. The mixed mangrove shrimp farming model is developed on a large scale but it questions the soundness of its real efficiency and research can lead to different results (Brennan, Aciar, Raux). Some models lead to very low efficiency both in terms of mangrove and shrimp farming, both from environmental (biodiversity) and economics. Farm design according to mangrove and shrimp disposition remains to be defined more clearly and the law needs adapting (based on the same area and proportion). On the other hand, the legal constraints combined with a low investment capacity and opportunity, but also a less favourable environment in terms of global carrying capacity, lead to a low intensification level until the end of the 1990s. But today, existing and potential areas are under huge pressure from investors.

A more exhaustive list of illustrative laws according to the above trends related to the shrimp culture development context (water resources, land use and land tenure systems, forest, agriculture, fisheries, etc.) is provided in national literature review reports ((Nissapa et al, Ahmed et al, Nhuong et al, Vasudevappa et al, 2002). But at the international level there are no international laws or regulations aimed directly at shrimp cultivation. The law is only perceived through codes of conduct (CoC) presented in the following section and through international agreements related to sustainable development and biodiversity.

6. Policy and Institutional Issues

Beyond the specific case of shrimp culture, in the framework of "Planning and Management for Sustainable Coastal Aquaculture Development" (GESAMP 2001) it is necessary to reconsider institutional needs for effective implementation, although institutional issues are addressed at the outset. Institutional arrangements for implementing, monitoring and adapting a coastal management plan are rarely afforded sufficient emphasis (GESAMP 2001).

If actual arrangements will vary tremendously according to local and national circumstances, the Joint Group of Experts on the Scientific Aspects of Marine Environmental Protection (GESAMP 2001) lists a few simple rules:

- responsibilities for implementation must be clearly allocated to particular institutions and individuals;
- overlapping responsibilities between agencies should be minimised;
- institutions must be able, willing and allowed to implement or administer the incentives and constraints detailed in the plan;
- there must be co-ordinating and integrating institutions - which may take the form of institutional procedures; or particular agencies or individuals with a co-ordinating role;
- the institutional responsibilities must be defined within, or allowed for by, a legislative framework.

Institutional analysis and Stakeholder Analysis are recognised as an essential part of any new planning and management initiative, especially where a greater degree of integration is sought. Some guidelines are proposed but until now it seems they have not really been implemented beyond a local level.

Primarily related to mangrove degradation, Primavera quotes several main institutional issues: promotion of aquaculture, low economic rent for mangroves, conflicting policies, and ineffective government management (Primavera, 2001, Sea and Oceans).

Some of them have been already discussed (need for further inquiry related to mangrove use valuation (ignore non-marketed goods), poverty alleviation and aquaculture development, poverty and environmental preservation, multiplicity of people involved, etc.). It illustrates that it is rather difficult to separate social, legal and institutional issues. Institution is a concept that may have different meanings for different groups and people, and it is also reinforced by the confusion over the legal and institutional position of aquaculture (Neiland). See also North (1990), Elster (1989) and Olsen (1989). According to Svein Jentoft (2002) assessment through three levels is proposed: local, national and international.

National level
Aquaculture as a development strategy can lead to several extraneous and aggravating results. Between development (poverty alleviation, foreign currencies) and environmental preservation (with many associated financial supports from NGO's and International Agencies for protected areas or alternative uses based on environmentally friendly practices) public policy choices have to face several challenges concerning shrimp aquaculture development. For instance, World Bank loan for the Bank's Resettlement Action Plan implemented in Southern Vietnam would have to be repaid due to shrimp culture development (World Rainforest Movement).

But rather than a way to produce, shrimp culture is too often thought of in terms of exported values or foreign exchange and then thought of in terms of profitability per hectare. Social advantages are then attributed to this way of development.
Environmentalists argue that changes in foreign exchange only benefits industry. "Over time, most of the small aquaculture farmers have failed due to the decline of their harvest as well as a lack of technical and financial assistance for their recovery. All the while, foreign investors, cooperating with national ones were supported by international financial organisations and were able to convert large areas of coastal wetlands into shrimp farms, in order to produce foreign exchange" (MAP).
The industry claimed that some of the benefits of the foreign exchange generated would include payments to the State or the private banks for management services. Because shrimp are produced for export, they benefit the balance of trade in many developing countries. Nevertheless, shrimp farming is like any other commercial agriculture enterprise in that there are many risks (both technical and financial). (GAA)

Between the two extreme opinions, looking for a sustainable way of development, public choices have to be made under pressure and lobbying both from environmentalists, industry or communities with many environmental and social constraints. This shows through in public policy through environmental preservation measures as well as facilities given to shrimp farming considered as an export industry.
Failures in sustainable development are often linked to confused bureaucracy and inconsistent policies, corruption, weak law enforcement and a lack of political will. But difficulties at local level institutions are other important causes of failures.

The number of public administration organisations involved in shrimp culture regulation also increase organisational problems. Quoting Neiland "The literature reviewed seems clear in proposing the creation of single institutions with power over development in the coastal zone as a key requirement for all countries, to ensure development of a shrimp industry in which all interests are fairly represented" (Neiland 2001).

Local level

This search of single institutions is often based on local communities, local government autonomy (Primavera, 1997) or on concerted action from the industrial side. This latter one highlights the need for better pond design and construction, and better site selection and management practices.

Environmental damage, often demonstrated by the outbreak of disease in ponds, is not a simple linear cause-and-effect phenomenon. It is both an animal science problem, and also to a great extent, a matter of water quality management. It can partly be monitored either by improving rearing practices at the farm level, by imposing technical standards at the collective level or by improving collective management of water. But in all cases, when many farms are interconnected through water flows, the problem of sustainability can be only addressed at a collective level. The literature shows that this collective action level is more efficient based on community management (excepted in the case of NESS schemes).

Therefore, both at national and local levels, the divergence between private and social optimum is encountered. According to Gammage (1997), the corrective mechanisms that are available to reconcile the divergence between the private and social optimum are:

- the reallocation of resource rights and property rights to the community; and,
- the levying of environmental charges commensurate with the shadow cost of damage (licenses, fees, and taxes).

The option for community management favours the first mechanism. Whilst the second option remains a possibility, it would imply a significant investment in monitoring and administration. It is also apparent that monitoring would be more efficient if it occurred at the local community level (need to be based on credible and binding disincentive to encroachment violations). (Gammage)

Answers remains often based on technical improvements (mainly water treatment oriented with recirculating or biofilter) and often ignore other means of actions such as the collective action level in order to manage a common resources (water quality) in high-density farming areas (Farmers associations, villagers associations, etc).

International level

At the international level, the definition of standards such as the ISO 14001, whose purpose is the improvement of environmental performance through improved management systems, and guidelines towards sustainable shrimp farming are the main actions that can be noticed.

But the most important research consists mainly in the definition and implementation of codes of conduct through international organisations, NGOs, networks, associations (industrial as well as smallholders). They are mainly based on the example of the FAO Code of Conduct for Responsible Fisheries (CCRF). This latter was developed under "Towards Sustainable Shrimp Culture Development: Implementing the FAO Code of Conduct for Responsible Fisheries (CCRF)" (Barg et al, 2000).

Derived from the previous action, "Shrimp farming and the environment (Naca)" is now the most important and global action addressing shrimp farming development issues. ‘Shrimp farming and the environment’ is The World Bank, NACA, WWF and FAO Consortium

Program to analyse and share experiences on better management of shrimp aquaculture in coastal areas. The follow provides an overview of the themes taken on:
•Thematic Review of Coastal Wetland Habitats and Shrimp Aquaculture.
•Codes of Practice for Marine Shrimp Farming.
•Chemicals and Shrimp Aquaculture.
•Thematic Review on Management Strategies for Major Diseases in Shrimp Aquaculture.
•Thematic Overview of Social Equity, Benefits and Poverty Alleviation BMPs of the Shrimp Aquaculture Industry.
•Thematic Reviews on Legislation and Shrimp Aquaculture.
•Global Review of Feeds and Feed Management Practices in Shrimp Aquaculture.

Through this program the Code of Practice and Conduct for Marine Shrimp Aquaculture (Boyd et al, 2002) reviews the main others codes. According to Boyd, a code of conduct is a system of principles proposed for adoption by those conducting certain similar activities in an industry (e.g. shrimp aquaculture) so that they do not infringe on the rights of others or cause some other unwanted consequence.

The most basic form of a code of conduct is a set of guiding principles consisting of broad statements about how management and other operational activities should be conducted. Most codes do not have any legal authority, and adoption is usually voluntary. In fact, codes can be developed in circumstances whereby either government regulations do not exist or are not enforced. In such circumstances, a code of conduct can serve as the precursor to, or the basis for, formal regulation. Codes of conduct are popular in manufacturing industries because many industry leaders perceive that adoption of a code of conduct conveys a message of responsibility to consumers (Boyd et al, 2002).

Beyond FAO CCRF, the main existing codes (conduct or practices) and guidelines are:

- Australian Prawn Farmers Association CoC
- Shrimp Farming Industry of Belize CoC
- Global Aquaculture Alliance CoP
- The Marine Shrimp Culture Industry of Thailand Code of Conduct (BTG-Golder 1999). The World Bank funded the initial phases of the program and the effort was conducted by the BTG-Golder Company (Canada) and the Thailand Department of Fisheries.
- Development of a code of practice in Malaysia, under the Department of Fisheries in Malaysia
- The Coastal Resources Center of the University of Rhode Island has initiated a project, supported by the US Agency for International Development, to promote good management practices in shrimp farming in Latin America
- Organic Aquaculture (Agro Eco Consultancy of the Netherlands)
- The Brisbane Expert Consultation (FAO/Government of Australia, 2001)
- The Industrial Shrimp Action Network's Draft Guidelines for Shrimp Aquaculture (ISANet). It is a global network of organizations and individuals who are deeply troubled by the environmental and socioeconomic costs of industrial shrimp aquaculture. Draft guidelines in 1998 from Environmental Defence Fund and World Wildlife Fund-US.
- As of now, other attempts have been developed or are underway, such as in Bangladesh or India (2002)

None of the codes reviewed from industry or government address social issues directly, in a proactive way. Boyd et al rank the different codes and assess benefits and weakness:

The benefits of codes of conduct:
•Valuable discussions among stakeholders can occur during the formation of codes of conduct.
•The Best or Better Management Practices (BMPs) in codes of conduct can make shrimp aquaculture more environmentally and socially responsible.
•Codes of conduct can make shrimp aquaculture more efficient, sustainable, and profitable.
•Codes of conduct provide an excellent means of technology transfer to producers.
•Positive interactions with environmental agencies and other governmental agencies could result from the efforts to form and operate codes of practice programs.
•The BMPs in codes of conduct could provide the basis for future environmental regulations.
•Codes of conduct can provide marketing advantages.

Weaknesses:
•Adoption is voluntary, so some producers may not follow codes of conduct despite promotional efforts.
•Producers who adopt a code of conduct may selectively adopt BMPs and avoid those that are expensive or difficult to implement.
•There are many obstacles to effective self-evaluation and third-party verification.
•Producers, especially small producers, may lack technical knowledge for using BMPs, and education and training will be difficult and expensive.
•Implementation of programs could be slow and result in substantial costs to farmers.
•Effectiveness of BMPs in codes of conduct is assumed, but monitoring is needed to verify this assumption.
•Unless all stakeholders are involved in preparing codes of conduct, the BMPs may not address significant issues. This is especially true for social issues.

Particular attention is given to the GAA program that may be the most promising because the group has already discovered the need to bring in outside parties.

Conclusion

Environmental, social and economics issues are often linked, as their different combinations will lead to several development profiles with different goals. But among these combinations few of them are possible (technically, ecologically, etc.) and fewer are sustainable.

Problems are multiple and complex and they can be tentatively and roughly sum up through Table 5. It is difficult to isolate financial, environmental, social, legal and institutional issues. Such a policy will depend on a specific institution or environment or on a particular socio-economic context. This technique will have a specific impact in a specific area, etc. It is therefore difficult to say (and this is not our purpose) that one technique is better than another (what does 'better' mean, in this case?). It depends mainly on public policy choices and it would be better to attempt to isolate some main development profiles, taking into account the main issues encountered all along the value chain. Dealing with development profiles is similar to dealing with technical typology and trying to isolate factors affecting this typology of development. The lack of studies or research projects in the area is shared by the bulk of grey literature, as it requires very close multidisciplinary skills beyond the usual and simple pilling up of different disciplinary under the sustainability argument.

ENDNOTES

[1] The Global Aquaculture Alliance (GAA) was formed in 1997 as an international NGO supported by aquaculture businesses and organisations.

Table 5: Main impacts and consequences of tropical peneid shrimp culture development

Environment	Social	Legal	Institutional
Degradation of ecosystems and mangrove area Alternative uses and ecological importance of these ecosystems. Lack of quantitative valuations. **Salt water intrusion** **Food and pollution / Food insecurity** Discharges, non-assimilated feed and chemical products; antibiotic groups being toxic for others species and human food consumption, ban of exportation (EU). **Disused ponds** Irreversibility on short run due to acido sulphate soils. **Larvae and broodstocks / Biodiversity** Decline of PL and broodstock (overexploitation and mangrove clearance; introduction of exotic species)	**Access to land and land tenure system** Privatisation of common areas, disturbance in traditional land tenure systems. **Employment** Generation of direct and indirect employment; valuation of costs and benefits at the market chain level vs. costs and benefits for local communities? Employment level according to production systems; rural exodus or population fixation? Lack of global valuation. **Social conflicts and poverty** Conflicts between poverty alleviation and environmental protection illustrating market failures. Conflicts related to structure changes in local communities. Indirect price increasing of humans' goods related to shrimp culture.	**Laws mainly aimed at reducing shrimp culture's externalities through regulations and standards; very few laws in support of the activity (sanitary aspect mainly).** Existing laws and regulations covering coastal uses and activities, but problem of compliance and effectiveness. Specific laws implemented with and after shrimp culture development but essentially aimed at: the land tenure system, water management, mangrove preservation and sanitary standards. Few financial incentives through licences or input/output taxes to drive the activity development on a more sustainable way. Direct income through existing fees on shrimp products are not specifically devoted to the shrimp industry management.	**The Institutions concept can have a different meaning for different groups. This is reinforced by the confusion between the legal and institutional position of aquaculture.** <u>At a national level</u>: public choices under pressures of environmental and industrial organisations or local communities. Choosing between producing for foreign currencies and exchange or giving importance to the way to product. Uses of shrimp benefits in support to policy aimed at balancing shrimp culture externalities. The large amount of bureaucracy involved in the sector management increases organisational problems. <u>At a local level</u>: looking for a single institution based on local communities, local gvt. Or from the industrial point of view looking for a favourable context to develop concerted actions to implement better management practices. Divergence between private and social optimum Private choices (shrimp culture is an activity like any other ones) vs. public choices (implication of public policy stakes) <u>At international level</u>: Standards and CoC or BMPs

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APPENDIX

- **Appendix 1: Shrimps Statistics**
- **Appendix 2: Typology of Productions Systems and Farms economics**

Appendix 1: Shrimps statistics:

World shrimp farming production by country (in MT)

Country	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000
Thailand	119,510	162,051	184,884	225,515	267,764	260,713	240,609	227,860	253,001	275,544	299,700
Ecuador	76,420	105,238	113,137	85,472	98,731	105,597	107,920	132,709	144,000	119,700	50,110
Indonesia	107,295	140,131	141,690	138,786	167,410	146,608	151,759	167,445	118,111	140,946	138,023
Philippines	53,989	51,434	78,397	95,816	92,647	90,179	78,067	41,610	37,798	35,573	41,803
India	29,985	35,500	40	72,200	91,974	97,539	95,152	65,581	78,709	71,072	52,771
China	184,817	219,571	206,866	87,856	63,872	78,416	88,851	102,923	143,086	170,830	217,994
Taiwan	18,126	23,318	17,693	14,378	9,242	12,234	13,472	5,926	5,549	6,065	7,237
Others	72,211	85,457	97,952	115,137	128,977	166,480	177,188	201,010	232,809	265,145	279,473
Total	662,353	822,700	880,619	835,160	920,617	957,766	953,018	945,064	1,013,063	1,084,875	1,087,111

Source: FAO Aquaculture Statistics, 2001
In World Bank, NACA, WWF and FAO. 2002. Shrimp Farming and the Environment.

World production of shrimp: wild catches and aquaculture (1000s OF MT)

	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000
Catches	1,947	2,043	2,107	2,149	2,361	2,440	2,554	2,629	2,749	3,034	3,081
Aquaculture	659	813	867	823	867	932	926	911	974	1,033	1,021
Sum	2,606	2,856	2,974	2,972	3,228	3,372	3,480	3,540	3,723	4,067	4,102

Source: FAO Aquaculture Statistics, 2001
In World Bank, NACA, WWF and FAO. 2002. Shrimp Farming and the Environment.

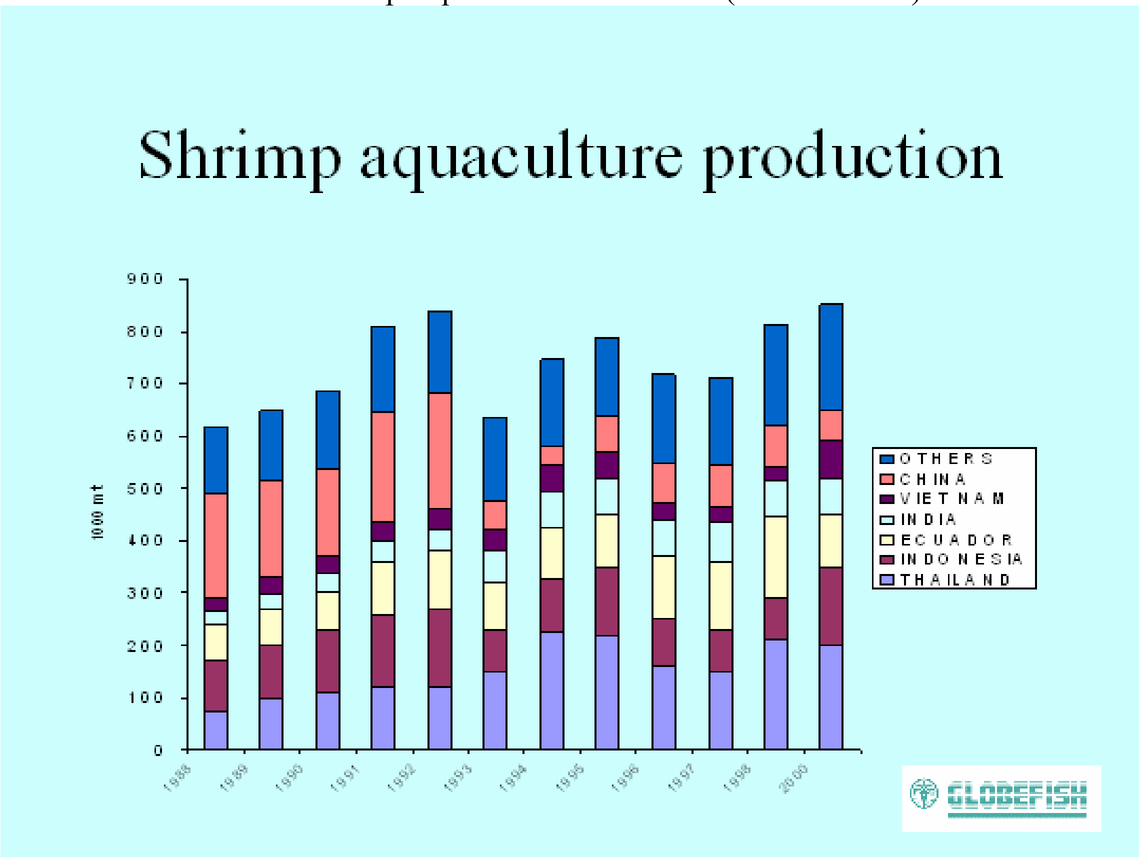
World shrimp farming production by species (in MT)

Species	Scientific name	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000
Banana prawn	*Penaeus merguiensis*	30,473	32,211	33,491	39,201	43,522	44,994	44,994	41,497	43,109	37,150	45,717
Kuruma prawn	*Penaeus japonicus*	9,417	14,077	7,739	2,491	2,295	2,240	2,809	2,890	2,549	2,383	2,639
Blue shrimp	*Peaneus stylirostris*	8,080	11,582	12,741	9,739	11,973	9,796	10,758	14,787	15,773	12,338	-
Whiteleg shrimp	*Penaeus vannamei*	82,012	111,413	120,457	94,184	109,447	141,739	140,180	172,609	197,567	186,573	143,737
Black tiger prawn	*Penaeus monodon*	250,777	332,729	391,462	434,887	505,658	599,808	570,241	487,921	508,366	544,627	571,498
Eastern king prawn	*Penaeus plebeius*	0	0	0	0	0	1	1	0	0	0	0
Fleshy prawn	*Penaeus chinensis*	185,074	220,036	207,428	88,128	64,389	78,820	89,228	104,456	143,932	171,972	219,152
Caramote prawn	*Penaeus kerathurus*	0	0	0	0	0	1	1	1	1	1	1
Brown tiger prawn	*Penaeus esculentus*	7	0	0	0	0	1	1	0	0	0	0
Northern white shrimp	*Penaeus setiferus*	0	0	0	0	0	1	1	1	0	0	0
Indian white prawn	*Penaeus indicus*	1,060	1,350	1,500	1,874	2,244	3,429	3,124	3,209	3,201	3,672	4,370
Redtail prawn	*Penaeus penicillatus*	1,769	877	907	2,233	217	150	116	144	137	107	44
Penaeus shrimp nei	*Penaeus spp*	43,739	48,797	59,009	97,657	123,080	46,823	63,744	70,791	79,695	95,279	75,694
Eastern school shrimp	*Metapenaeus macleayi*	10	2	0	0	0	1	1	0	0	0	0
Endeavour shrimp	*Metapenaeus endeavouri*	5,619	4,249	1,640	9,490	1,843	-	-	-	-	-	-
Metapenaeus shrimp nei	*Metapenaeus spp*	23,641	21,92	22,747	23,907	25,894	26,193	28,422	42,090	22,017	20,575	20,916
Akiami paste shrimp	*Acetes japonicus*	1,389	3,735	104	228	200	1,392	673	328	264	93	544
Common prawn	*Palaemon serratus*	160	60	30	30	30	110	140	225	163	98	110
Nantantian decapods	*Nantantia*	19,091	19,612	21,319	31,066	29,775	429	330	323	329	904	605
Sum		662,363	822,700	880,619	835,160	920,617	955,928	954,764	941,272	1,017,103	1,075,772	1,085,027

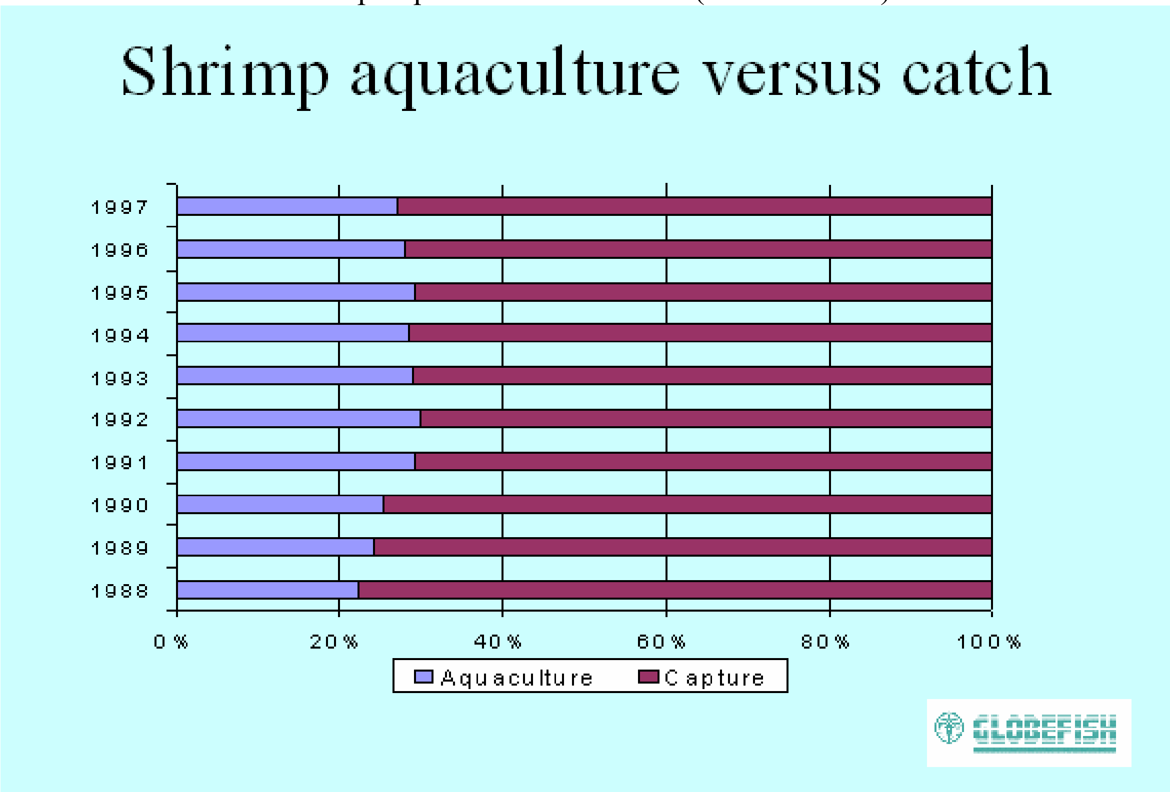
Source: FAO Aquaculture Statistics, 2001

In World Bank, NACA, WWF and FAO. 2002. Shrimp Farming and the Environment.

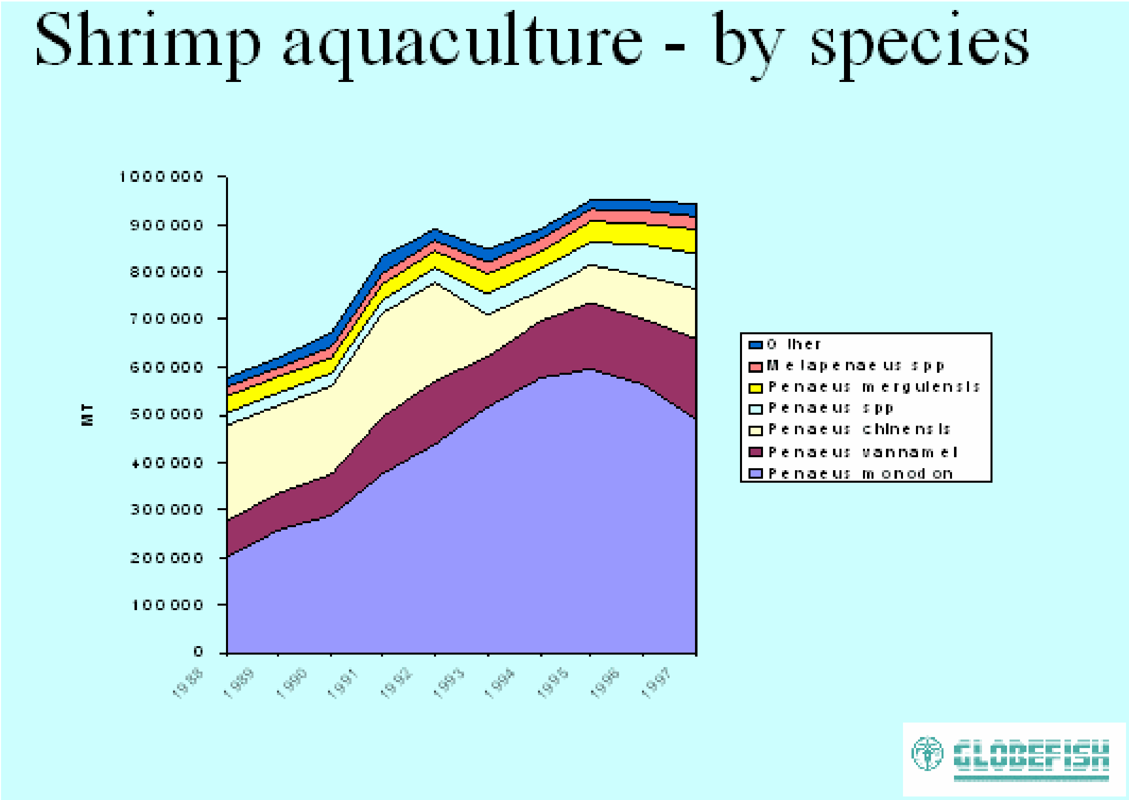
World Shrimp Aquaculture Production (GLOBEFISH)

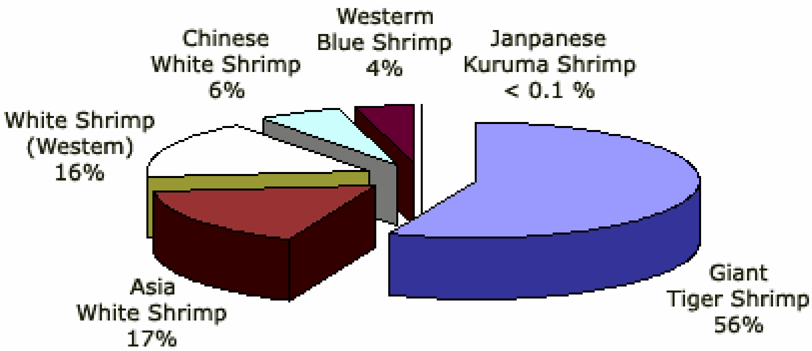


Shrimp Aquaculture vs Catches (GLOBEFISH)



Shrimp Aquaculture by Species (GLOBEFISH)





CP Group (Thailand) Shrimp Culture Newsletter March 2000

Appendix 2: Technical Typology of Production Systems:

The goal is to define a farm typology that could be read whatever the country or region, allowing to gather and keep the information that usually disappears at the international level (feeding as an energy cost, etc.). Two main entries can be proposed: a technical one and an extra one based on farms organisation mode.

1. The technical entry:

This entry is proposed for section 2 (economics of production - CBA) according the statistics gathered in each country. Three main techniques can be usually described: Traditional, Semi-Intensive and Intensive. An additional one, called Traditional +, is often quoted as an "improvement" of the traditional. Characteristics of these techniques are described in the following table:

Table 1 Official and real technical criteria

	Traditional		Semi-intensive		Intensive	
	Official	Real	Official	Real	Official	Real
Stocking density	<2/m2	2-5/m2 average3/m2	4-6m2	until 15/m² average 10/m2	>10 m2	<50/m2 average 20-30/m2
Feed (artificial pellets)	no	after 1 month < 100kg/ha	yes	yes	yes	yes
Usual FCR	-	-	-	1-1,5	-	> 1,5
Liming	yes	<500 kg	<1t/ha	-	yes	yes
Fertilizers	100-150 kg/ha	-	yes	yes	yes	yes
Pesticides	yes	yes	yes	yes	yes	yes
Other input	no	corn, rice brain...	no	no	yes	feed complement, fertilizers...
Paddle-wheel	no	no	no	sometimes 1-2/ha<10h/day	yes	>20h/day
Size at harvest	-	10-30p/kg	-	30-35p/kg	-	>35p/kg
Pumping	no	sometimes	yes	yes	yes	yes
Number of crops per year	2-3	2-3	2	2	2	2
Duration of crop	<120 days	< 120 days	120 days	120 days	120 days	120 days
Comments		nursery ponds for post-larvae				

In addition to these three main techniques, there is another and more officious one named traditional plus. It is statistically and administratively accounted for the semi-intensive. In fact it concerns traditional with supply of artificial feed. This technique has been developed by Cepia, who trains or delegates also technicians on farms. Presenting good results at the beginning and favoured by international agencies for precautionary motives (avoid more intensive techniques with high environmental pressure), it encountered many problems due to a trend to overstock in pond designed and managed for lower density and to a lack of knowledge required for a higher level of intensification.

But as illustrated in the above table there's a gap between official and practical criteria, mainly due to an intensification trend. Some authors talk about Traditional for less than 1 PL/m², Traditional plus from 1 to 3 PL/m², S-I from 3 to 10 and Intensive from 10 to 30. Techniques appear rather as a continuum from Traditional to Intensive with no superior limits (water recirculation, plastic liner to separate the substrate, etc.) leading to some kind of mismanagement in case of countries comparison. For instance semi-intensive techniques today are rather close to former intensive criteria in Indonesia and Vietnam. At international level, most of extensive systems and sometimes improved extensive systems are often neglected.

Then, even if the real technical criteria is the stocking density (SD), this criteria doesn't allow a complete and detailed comparative analysis of production systems beyond of national and sometimes regional scope. But the SD will be helpful to position the different countries segments according the T, T+, SI and I techniques.

At least, this typology is not based on yields (that doesn't take into account the risk attached to the technical choice: collapse rate, etc.), neither on farm area as it can change a lot from a place to another one.

Regarding this basis of techniques and according LR's objective we can propose the following typology:

Beyond of T, T+, S-I and I, we have to take into account extensive and small improved extensive systems such as those you can encountered in Vietnam or Philippines. In addition to SD, one of the most important difference is based on energy-giving that can be translated into costs (as well as technical choices are also translated into costs). This is another interesting parameter as it also illustrates the technical choice. Paddle Wheel could be also used (and figure in table 1) but is quite correlated to SD and feeding.

Then a typology based as well on qualitative and quantitative criteria can be illustrated in table 2. SD are given in table 1 (we propose to group the T+ with the improved extensive as these techniques are very close today and to avoid too many groups).

Table 2: Farms typology

0 **Stocking Density (PL/m²)** 50

<table>
<tr><th colspan="2">Extensive</th><th colspan="2">Improved extensive / traditional</th><th>Semi-Intensive</th><th>Intensive</th><th>Super-Intensive</th></tr>
<tr><td colspan="2" rowspan="2">Monoculture (shrimp only)</td><td rowspan="2">Monoculture</td><td>Organic feed</td><td rowspan="2">Organic feed</td><td rowspan="4">Artificial feed</td><td rowspan="4">Artificial feed
Concerete ponds
Complete plastic linner</td></tr>
<tr><td>Artificial feed</td></tr>
<tr><td rowspan="2">Polyculture</td><td rowspan="2">Shrimp/paddy/fish
Shrimp/mangrove
Shrimp/salt
Shrimp/fish/crab
Alternate or not</td><td rowspan="2">Polyculture</td><td>Organic feed</td><td rowspan="2">Artificial feed</td></tr>
<tr><td>Artificial feed</td></tr>
</table>

Feeding

0 Organic Artificial

It is then possible to go more in depth by looking at seasonal management for instance, especially concerning polyculture systems, but it should be difficult to gather this kind of information at the province, region or country level.

This is not a fixed typology but just a frame to position national or regional statistics about shrimp farming in order to characterise groups of farms.

2. Organisational typology:

This "typology" is proposed in order to describe the relevant information for sections 1, 4 and 6. Public policy is not only relevant for environment but also in terms of social and development issues. These topics cannot be described from the solely technical point of view. The organisation modes can be a second entry to study these issues: familial or private farms (local employment and fall out), farm area, integration level (the added value will be different), etc.

Farm area	Farm's ownership and management	Global environment & consequences
As an indicator of local dvpt.	Familial Single private owner, investor State cooperative Real estate etc.	Access to knowledge and inputs (land status, credit, labour, etc.) Level of integration Markets

The value chain concept could be useful to illustrate section1 (flow charts).

Applying this kind of qualitative typology could lead to the two extreme following samples (and only samples):

<u>Sample1</u>

<u>The familial farm based on extensive or traditional technique</u>

These farms are characterised by a local endogenous development. This is typical of a rapid and unorganised development in which all the local resources have been invested. This development has been induced by the high profitability in shrimp culture in case of successful crop compare to other activities such as rice culture.

This development has to face several main problems:
-the access to capital
-know-how and lack of knowledge
-an ecological environment less favourable to shrimp farming compared to other coastal shrimp farming area in Asia
-a difficult access to production factors
-distancing of the main infrastructures
selling and processing places
PL transportation and quality
Training place, energy, etc.
-land tenure system and compliance to environmental regulations

(It can be completed with information on technical and economic performances as well as local fall out)

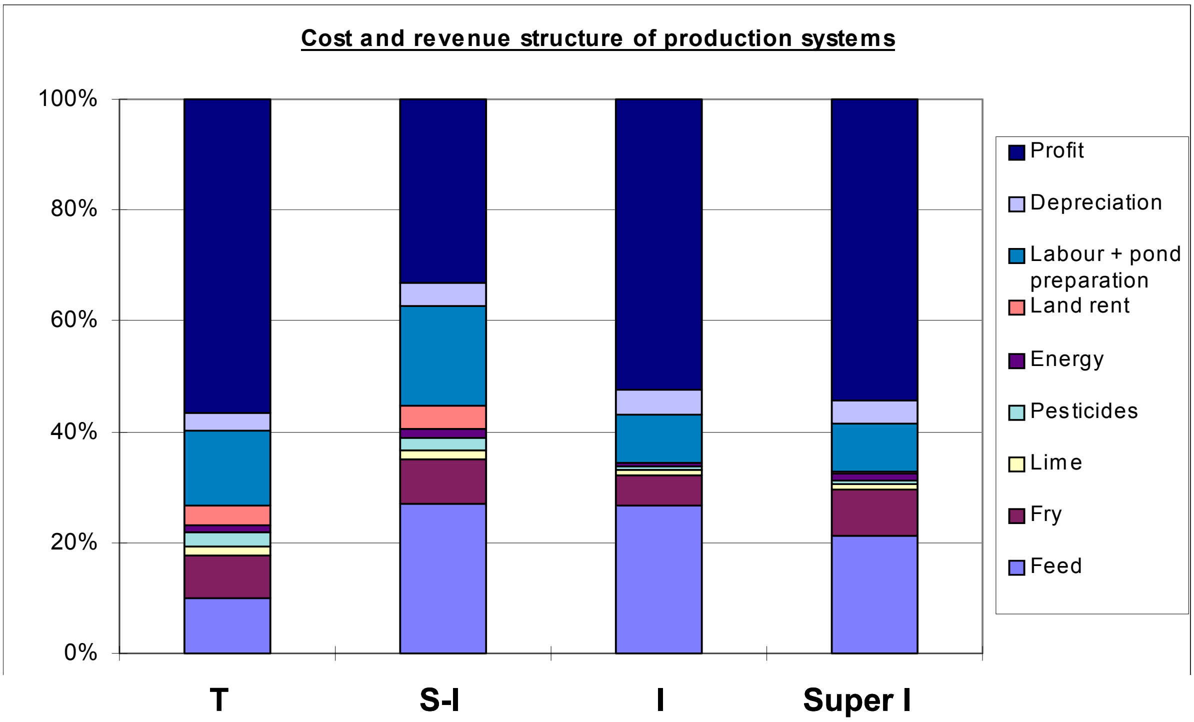
Sample2
NESS: Nucleus Estate Smallholders Scheme
This system is based on huge areas developed by an external single investor providing technology, inputs and market outlet to single small farmers managing 1 or 2 ponds under a lease system.
By having the same objective of maximising the profit per ha and benefit from the high profitability of the shrimp farming under well controlled systems and technologies, the nucleus estate try to avoid the problems related to the other organisation modes

- high technical level: try to master the environment and reduce risks ("technique is able to bridge any gap")
- very intensive system and smallholders scheme to balance bad technical efficiency
- centralised management
- Integration of all the process (control the uncertain)
- previously inhabited wetland

It can be repeated for others groups such as small scale intensive farms depending of their ownership and logic (speculative attitude or not, insiders versus outsiders, etc.). Then in addition to the technical typology, it should give several entries to describe relevant farms groups according LR's sections.

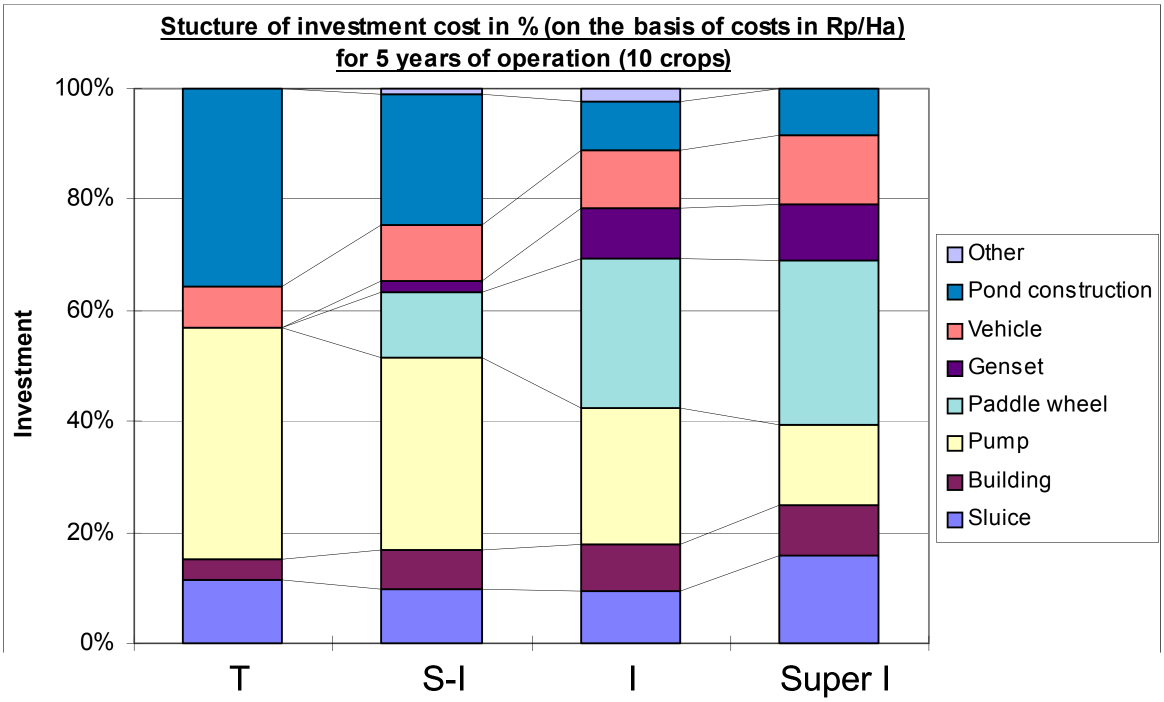
Economics of production systems:

Cost and revenue structure of different production systems – Part 1



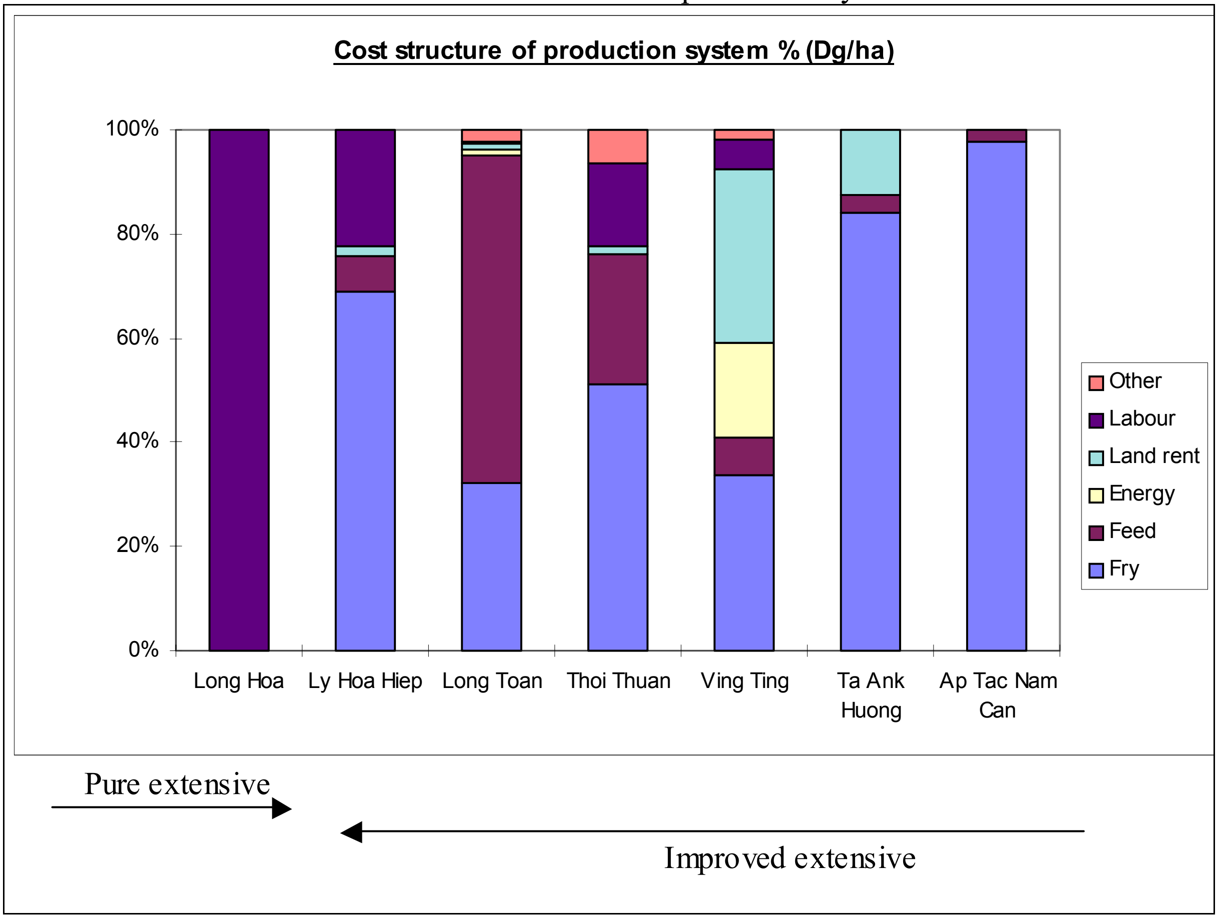
Source : Bailly et al. 1997

Cost and revenue structure of different production systems – Part 2



Source : Bailly et al. 1997

Cost and revenue structure of different production systems – Part 3



Source : Bailly et al. 1997