
Aquaculture experiences of Thailand for Vietnam in an ICZM frame

(ICZM-Vietnam Training Module no. 8.)

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Black tiger shrimp (Penaeus monodon) *Photo: CORIN.*

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INTRODUCTION

1.1. ORIENTATION OF THIS MODULE

The Coastal Zone Management (CZM)-Centre in the Hague is currently engaged in producing an update of its generic Integrated Coastal Zone Management (ICZM) Training Module: " Coast in Conflict" (1996). This generic module has been used frequently in several vulnerable coastal countries by different Dutch institutions such as IHE and WL-Delft.
The fast increase of ICZM knowledge and experiences now justifies the production of an update of the generic ICZM Training Module.
ICZM experiences show that besides the common ICZM principles, there are many different coastal zone management practices based on the differences in the natural and socio-economic coastal processes in particular coastal areas, nations, and regions.
Therefore, the CZM-Centre decided to develop besides the update of the generic ICZM Training Module, "site" specific ICZM modules. The involvement of the CZM-Centre in Vietnam during the last ten years, is the reason to start developing a specific ICZM-Vietnam Training Module. This takes place within the Coastal Co-operative Program (CCP) frame and in close cooperation with the VN-ICZM project.
The ICZM-Vietnam Training Component, initiated, by Mr. Robbert Misdorp, consists of nine Modules, mainly to be written by Vietnamese and other Asian ICZM partners. Apart from the preface and the introduction, the modules treat the following subjects: Vietnam and ICZM strategies; Physical planning; ICZM and Mitigation of Hazardous flooding from an IFRC perspective; From river to coast and from sea to coast; Coastal wetlands; Aquaculture; Remote sensing applications.

1.2. AQUACULTURE

Aquaculture is a very important coastal resource especially in vulnerable (tropical) coastal regions. In some Asian countries (e.g. Thailand, Vietnam, Bangladesh, India) aquaculture areas are now very rapidly expanding in order to boost economic development of the region. However in many cases these activities are driven by generating short term huge profits, not taking into account the need for (long term) sustainable development. This may result in overloading the total environmental system, particularly by accumulated effects of small scale bad management practices. Sometimes this is leading to barren landscapes because of very expensive or even impossible restoration of the area. Unfortunately a lot of bad practices can be recognised today (e.g. in Thailand).
The tremendous Thai efforts to address the negative effects of these practices and restore the coastal resources, are well recognised. Their experiences can be used as a learning basis for the set-up of Good Management Practice in countries where the damage to the environment and to the farming community itself is not yet as severe as in Thailand.
To avoid negative (long term) effects aquaculture should be developed in a sustainable way and be treated as an important issue in ICZM development programmes. Obviously in vulnerable (tropical) coastal areas more attention should be paid to this issue. Therefore this module addresses the need for capacity building and knowledge transfer in order to support a sustainable development of aquaculture in ICZM context.

1.3. AIMS / OBJECTIVES

The aim of this part of the project is capacity building on sustainable aquaculture management in the context of ICZM. This training module is based on available information and expertise on good and bad practices in Thailand.
It will be used during hands-on workshops, courses and/or in a (interactive) website under NETCOAST.

1.4. TARGET GROUPS

This module is intended to provide basic knowledge to policy makers in the coastal zone, coastal zone managers, and (would-be) shrimp farm managers. After studying this module, they will know the principles of natural constraints for starting and running a shrimp farm; what kinds of impact a farm can have on its surroundings and landscape; how to avoid negative impacts; the ways and problems of mitigating negative effects; and the distribution of costs and net earnings for shrimp farmer as well as community, over the various phases of development of shrimp farming in an area.

1.5. APPROACH

There is already much information and expertise available on aquaculture management in tropical (Asian) regions.
However there is lack of structure regarding which information and expertise is needed (or should be developed) in which period.
This should be linked to the stages (and context) of the ICZM policy cycle: problem analysis, strategy formulation, identification of measures, implementation, monitoring and evaluation.
For the area considered involvement of all relevant stakeholders at national and local level (planners, decision makers, aquaculturists) is necessary in order to identify the problems, the needs and the possible solutions.
This will be elaborated through the development and implementation of training modules based on Thai experiences ('lessons learned', examples of good and bad practices). First results will be presented in Vietnam during a half-day inception workshop in Hue. In a later stage of the project involvement of Vietnam could be extended depending on their interests.

This module consists of six parts:

Part 1: Development of coastal aquaculture and its impact on environment and socio-economics.
Part 2: Future sustainable development of coastal aquaculture within an ICZM frame: the MFSCAD-Policy cycle
Part 3: Different scale levels of consideration - MFSCAD
Part 4: The Boom and the Bust cycle at a Thai, regional scale: Hat-Yai 300 *2 km
Part 5: Restoration of the Bust part of the cycle at Thai regional scale
Part 6: Recommendations how to prevent the Bust part of aquaculture and how to accommodate effects of the Bust

This will be rounded off with some conclusions, and completed with a list of used and useful literature.

2. DEVELOPMENT OF AQUACULTURE AND ITS IMPACT ON ENVIRONMENT AND SOCIO-ECONOMICS.

2.1. INTRODUCTION

The coastal region in the tropics is rich in its diverse natural resources that widely facilitated the coastal aquaculture development and contributed significantly to the national economy of many countries in the region. Coastal aquaculture has been expanding very rapidly in Thailand, Vietnam, Bangladesh and India by a wide variety of private sector groups, and there are many government agencies also involved in various aspects of its management in order to boost their national economic development. But still, the rapid development of coastal aquaculture activity in the vulnerable coastal areas is causing conflicts and inefficient resource uses. As a consequence the degradation of coastal environment increases, which subsequently leads to abandonment of ponds. This is considered an important issue in ICZM development programmes, because only in this way it is possible to reduce these conflicts and enable sustainable development of aquaculture sector. It is well recognized now that coastal aquaculture management studies in vulnerable (tropical) coastal areas are needed at the national and provincial levels. They can lead to specific recommendations for policies, regulations and programs, as well as to a detailed coastal aquaculture management framework and implementation processes for priority coastal development regions.

In order to obtain insight into the extent of the problem, it is important first to know more about the position of aquaculture in relation to other food protein producing activities.
This is addressed both on a world scale and on a regional scale (south-east Asia).
Next, this module focuses on one aspect of aquaculture: shrimp farming.
The situation and trends in the target countries (in this case: Vietnam and Thailand) are assessed.

To obtain insight into the extent of environmental and social-economic impacts of shrimp farming, information is collected about how much land has been converted to shrimp farms, and what the original use of that land was. The economic importance of the original uses will be assessed. This includes the value of land designated as "nature", because this does not only have an intrinsic natural value (including things like biodiversity, and beauty as an emotional value), but also economic value. Studies trying to identify and quantify the economic value of natural habitats must be discussed (see e.g. Cesar, 2000).

2.2. THE PLACE OF AQUACULTURE IN THE WORLD'S PROTEIN FOOD PRODUCING SECTOR

Fisheries products from the worlds' oceans are a very important food (protein) source for humanity. Moreover, about three quarters of humanity lives within a relatively short range from the sea shore and is dependent on coastal and marine production for their livelihood..
Table 1 shows the development of production from marine fisheries since 1975.

*Table 1. WORLD AND S.-E.ASIA MARINE CAPTURE FISHERIES PRODUCTION (METRIC TONS * 10^3)*

YEAR	**1975**	**1980**	**1985**	**1990**	**1995**	**1999**
World production	***58.6***	***64.3***	***76.1***	***83.6***	***94.1***	***97***
S.-E. Asia Production	***4.8***	***5.8***	***7***	***8.9***	***11***	***12.3***

It is well known by now that many fish populations are overfished, a situation that is still deteriorating. Fig.1 shows the development of the measure of overfishing, in terms of the percentage of fully, moderately, or overfished populations.

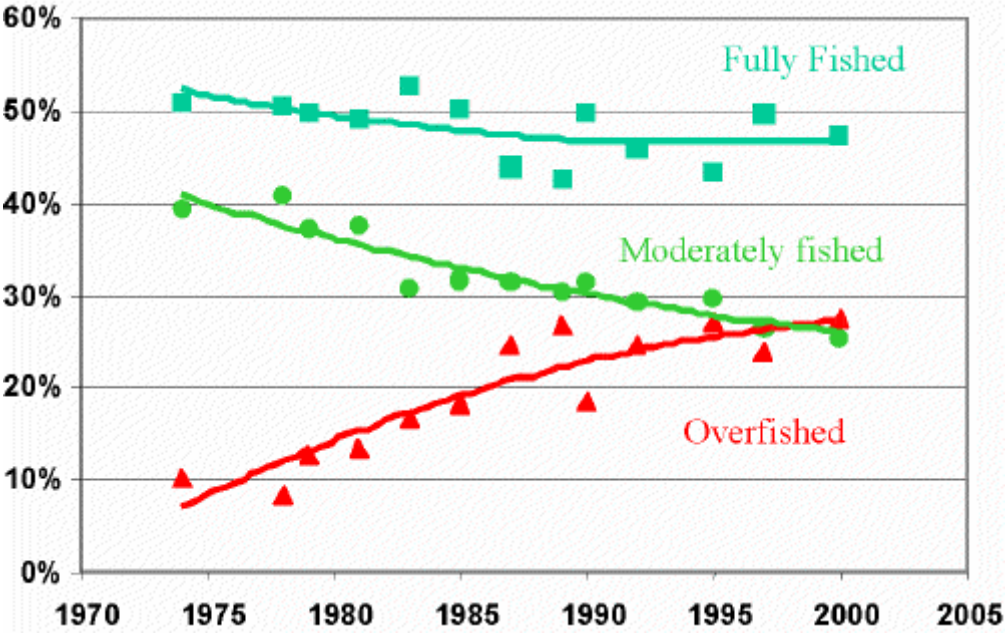


Fig.1. Development of the measure of exploitation of fish populations on a world scale (source: FAO, 2002).

Nearly half of the species (47%) is **fully fished,** meaning that at world scale the maximum yield (catch) in relation to a sustainable population has been reached. Fishing at this level can be continued (is sustainable), but growth is not advisable. It does not mean that at a smaller scale (ocean or sea) the populations are not overfished. 28% of all populations is **overfished**: the annual catch is higher than the level that is maximally acceptable to maintain the population in the sea. The populations have become so small, and the individuals don't reach a certain size any more, that it can only become smaller if fishing is continued at the same level. 25% is **moderately fished,** meaning that the maximum suatainable level has not yet been reached, and that there is some room left for growth of the catch. The overfished category is levelling off, but still increasing slightly. The number of fully fished populations is about stable for some years now, and the number of moderately fished populations is decreasing. This shows well the extent of the problem, and the fact that it is still becoming worse. Moreover, the illegal fisheries have not been taken in to account; this is estimated at ca. 25% of total fisheries.

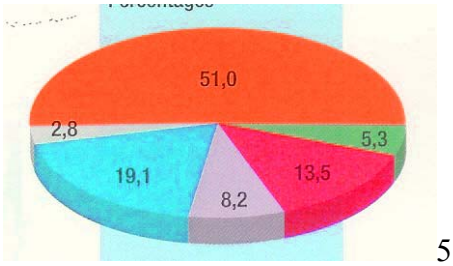
The trend in over-fishing the world's wild fish populations will probably continue for some time, although it appears to be levelling off now. The human population will not stop to grow for some time. The number of people living in coastal zones will not decrease – although the rising sea level may change this notion – in some regions even rather drastically.

The increase in capture fisheries production has been levelling off in recent years. A model calculation shows that the theoretical maximum exploitation level of natural marine fish populations if about the same as the present production level (84,000 * 10^3 metric tons). But the per caput fish supply is also levelling off, and at a faster rate than production (FAO-FIDI, 2000). This means that capture fisheries can no longer guarantee a sufficient supply; this

combined with the still growing number of overfished populations (happening in all oceans, see e.g. Pauly & Mc….., 2003) calls for a search for other sources.

Part of the food protein deficit can be compensated by aquaculture.

Nowadays aquaculture provides a growing share of the world's need for food protein, and the need for aquaculture products will continue to increase. Fig. 2 shows the ratio between different protein sources: meat (from cattle-breeding), fish (from capture fisheries), vegetables (from agriculture), and fish and crustaceans from aquaculture.



51%=cereals; 5.3%=roots; 13.5%= meat, fish, milk, eggs; 8.2%= fruits, vegetables, beans, nuts; 19.1%= oils, fats, sugars; 2.8%=rest

Fig.2. Main sources of human food protein. (source: FAO, 1995)

Table 2 shows the distribution over the important protein sources of total food protein intake per caput for the world as a whole.

Table 2. g/caput/day protein intake from various sources, averaged over 1997-1999 (source: FAO, 2002)

Total	75.1
Vegetable	47.5
Animal	27.6
Meat and offals	13.6
Milk and dairy products	7.2
Fish	4.4
Eggs	2.4

Figure 3 zooms in onto fisheries and aquaculture.

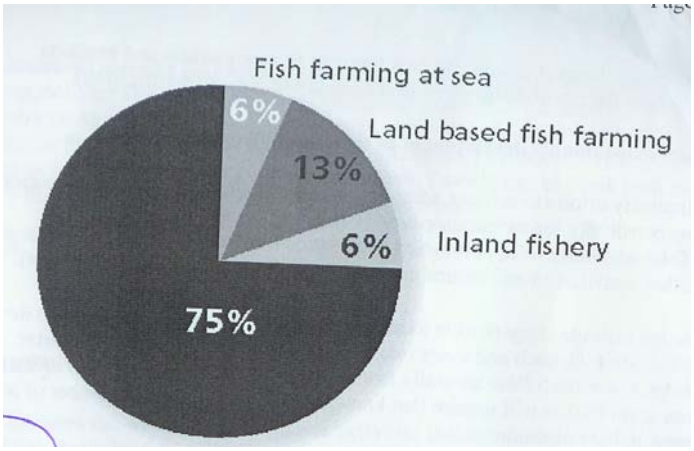


Fig.3.Capture and culture fisheries of the world (Source: FAO, 1997)

Table 3. Different types of aquaculture worldwide: production per species group in 2000 (source: FAO, 2002)

	Production (tons * 10^3)	Value (million US$)
Freshwater fish	19,801	20,794
Molluscs	10,732	9,497
Aquatic plants	10,130	5608
Diadromous fish	2257	6699
Crustaceans	1648	9372
Marine fish	1010	4072
Other aquatic animals	137	426

*Table 4. The world top 10 aquaculture countries in according to aquaculture yield in metric tons * 10^3 (source: FAO, 2002; figures rounded off)*

YEAR	1992	1995	2000	2001
WORLD	**15.400**	**24.400**	**35.500**	**37.800**
CHINA	8.200	15.800	24.600	26.000
THAILAND	400	500	700	700
VIETNAM	200	400	500	500
INDIA	1.400	1.600	1.900	2.200
INDONESIA	500	600	800	900
JAPAN	800	800	800	800
BANGLADESH	200	300	600	700
CHILE	70	200	400	600
NORWAY	100	300	500	500
USA	400	400	400	500

Table 5. Profit from aquaculture in million US$, for top 10 countries in 2000 (source: FAO, 2002).

China	28,117
India	2,166
Japan	4450
Philippines	730
Indonesia	2268
Thailand	2431
Rep. of Korea	698
Bangladesh	1159
Viet Nam	1096

In August 2003 the World Wide Fund for nature (WWF) stated, that it is very important to agree about an international code of conduct for fish farms. The damage to marine ecosystems is unacceptable. The business is good for an annual turnover of US$ 56 billion! But we risk

the extinction of wild populations if the escape from cages is not stopped (S. Cripps, director of the Threatened seas programme).

2.3. SHRIMP FARMING AND ITS PERSPECTIVE FOR THE NEAR FUTURE.

A very profitable form of aquaculture is shrimp farming. That is, if it is executed in the right way, i.e. sustainably. Shrimp farming must obey quite strict environmental and management rules, to be able to be continued during a longer time.

In 1995, about half of the total shrimp production in the world came from aquaculture; since then, the aquaculture share has increased markedly, and it is expected to go on increasing (FAO, 1995).
Only a few countries have managed to increase their production steadily, in spite of several wide-spread occurrences of diseases and other set-backs. Thailand is one of those countries. Table 6. shows the development from 1990-1994.

Table 6. World cultured shrimp production (source: Rosenberry, 1995)

Country	Production * 1000 metric tons				
Year	1991	1992	1993	1994	nog aanvullen
Thailand	**153**	**163**	**168**	**250**	
Ecuador	100	95	90	100	
Indonesia	140	130	80	100	
India	35	45	60	70	
China	145	140	50	35	
Vietnam	**30**	**35**	**40**	**50**	
Bangladesh	25	25	30	35	
Taiwan	30	25	25	25	
Philippines	30	25	25	30	
Other	45	46	54	63	
Total	733	729	622	758	

The vast majority of shrimp farming takes place in South-East Asia. The main shrimp producing countries are: China, Thailand, Vietnam, Taiwan, Indonesia, India, Ecuador.
In 2002 the world shrimp farming production was about 1.6 million metric tons (Chamberlain, 2003).
After the levelling off as a result of the white spot disease in the 1990s, it has grown by 10-20% per year over the last few years, and is expected to go on growing by 12-15% per year.

Development of yield and value thereof in $$ of the main shrimp species: *Penaeus monodon* (Black tiger shrimp): from a world production in 1993 of nearly 500.000 metric tons with a value of 3.2 million US$, the production has increased to more than 600.000 metric tons, with a value of 4.7 million US$ (FAO, 2002).

The biggest producers now are China, with an estimated 390,000 metric tons in 2003, and aiming at 400,000 tons; Thailand, with 250,000 metric tons in 2002, and an estimated 310,000 tons in 2003; and Vietnam, with 158,000 tons in 2002 and an estimated 205,000 tons in 2003. India is also rising: 127,000 tons in 2002 and 150,000 tons in 2003); other countries are smaller producers.

The production in China was mainly divided over three species: *Penaeus monodon* (the Black Tiger shrimp), *P. chinensis* and *P. vannamei* (White shrimp). This makes it easier for the country to switch between species, when one of them is hit by, e.g., a specific disease. And this is exactly what has happened in recent years: China's production is shifting to White shrimp.
Two important developments are worth mentioning – both in several Asian countries - : the survival of Black Tiger shrimp in the ponds is dropping. In 1998 it was 55%, in 2002 it was 49%, and the trend seems to be downwards. Secondly, the growth has dropped from 0,175 g/day to 0,140 g/day. In addition, several diseases are always present, and quality wild broodstock is becoming ever harder to come by (also much diseased). This is the reason that also in Thailand there is a shift to White shrimp. Pathogen free broodstock of this species is for sale now in Hawaii. Some other species cultured are: the Banana shrimp (*P. merguensis*), *P. indicus, P. penicillatus,* and *P. semisulcatus* (the Green shrimp). Thai production will probably not increase much any more, because most good sites are in use now. Total area of shrimp ponds now is 72,000 ha, and the goal is to freeze the area when it reaches 76,000 ha. Shrimp production in Thailand consists of cultivated and trawled shrimps. The former account for about 70% of total production.

Two more factors are important: operating costs, and market (demand).
As to **operating costs**: these are about the same all over the world, except for labour costs. The differences between the countries in labour costs will determine total costs for the farmers.
As to **market**: there are four important markets: domestic, Europe, USA, and Japan.
Domestic market in China consumes about half of all shrimp produced. In Thailand this is quite different: 90% of cultured shrimps is exported, and only 10% is used domestically. In 1999, more than 2 billion US$ was earned in the export of 200,000 metric tons of shrimps. In Vietnam probably a higher percentage is used domestically.
Import by European countries declined from nearly 40,000 metric tons to 15,500 tons when import tariff benefits for the southeastern Asiatic countries were abolished in 1999.
In the USA the demand is projected to increase by about 8% per year. The prices, however, have been declining since the 1970s.
In Japan demand decreases, and is expected to continue to decrease in the next few years.

Table 7. World marine shrimp farming by countries in 1999 (Source: World shrimp farming (2000), in: Boromthanarat & Nissapa, 2000)

Countries	Percent of Production	Heads-on Production (metric tons)	Hectares in Production	Kilograms per Hectares	Number of Hatcheries	Number of Farms
Thailand	24.6	200,000	80,000	2,500	1,000	20,000
China	13.5	110,000	180,000	611	2,000	10,000
Other	13.5	110,000	120,000	3,500	540	5,400
Indonesia	12.3	100,000	350,000	286	300	225,000
Ecuador	10.4	85,000	100,000	850	200	1,200
India	8.6	70,000	130,000	538	225	100,000
Philippines	4.9	40,000	60,000	667	120	4,000
Vietnam	4.9	40,000	200,000	200	1,000	6,000
Taiwan	2.5	20,000	5,000	4,000	220	3,000
Brazil	1.8	15,000	6,000	2,500	20	110
Malaysia	0.7	6,000	4,000	1,500	100	800
Nicaragua	0.5	4,000	6,000	667	5	130
Venezuela	0.5	4,000	2,000	2,000	3	12
Iran	0.3	2,500	4,000	625	10	150
Australia	0.3	2,400	600	4,000	8	45
Panama	0.2	2,000	3,000	667	11	35
New Caledonia	0.2	1,850	450	4,111	5	11
United States	0.2	1,500	400	3,750	10	20
Total	**100.0**	**814,250**	**1,251,450**	**32,972**	**5,777**	**375,913**

2.4. SHRIMP FARMING PRACTICE IN THAILAND AND VIETNAM

In Vietnam the vast majority of farms consists of small ponds with low densities of shrimps. Diseases spread fast because of the practice to use each other's effluent for the culturing ponds. In the Mekong Delta a lot of ponds now are aerated, which enables them to have higher densities of shrimps (without aeration, many shrimp die in the deeper parts of the ditches and ponds because of lack of oxygen. Total surface is ca. 700,000 ha of ponds (including abandoned ponds). The trend in yield is decreasing, mainly because of diseases. In 1990, it was estimated that the potential area available within the coastal provinces is about 180.000 ha (Roozen & Rosenboom, 1997).

Tabel 8. 7 main types of shrimp farms can be distinguished (Roozen & Rosenboom, 1997)

Area in the **Mekong delta**:	Area	production (kg/ha/y)
► extensive shrimp farms	160,000	395
► improved extensive shrimp farms	1,100	357
► semi-extensive shrimp farms	800	1670
► intensive shrimp farms	?	?
► combination shrimp/rice	?	?
► combination shrimp/salt	6,000	100
► combination shrimp/(mangrove)forest	25,000	342

Extensive:
This is the traditional system. In Vietnam the vast majority of farms are extensive. With the rising tide sea water is let into the ponds and kept there for some time. The shrimps living in this water are growing, and are harvested by letting the water out again at low tide and placing a net or other construction in the outlet. No larvae are added into the pond, and no extra food is provided. Productivity is between 70 and 250 kg/ha/crop cycle, but it is declining: less post larvae are caught with the incoming water, because less shrimps grow up in the wild as a consequence of he loss of breeding places: mangroves (Koopmansschap & Vullings, 1996).

Improved extensive:
In this system, larvae of a certain size are added to the pond, in low densities. These must be purchased at a hatchery, or caught in the wild. 30-60% of such larvae survive in the ponds. After 3-5 months they are harvested. Production is 200-300 kg/ha/crop cycle. The tides are the driving forces behind the water exchange, and no extra food is provided.

Semi-intensive:
Smaller larvae are added to the pond, in higher densities. These must be bought from hatcheries. Water intake is by using the high tide, water outlet is by pumps. Algal bloom is stimulated before stocking, by adding fertilizer and lime. Extra food (minced molluscs, trash fish, and the like) is provided twice a day. After 4-5 months the shrimp are harvested. Potential production if this system is 500 kg/ha/crop cycle.

Intensive:
Bigger larvae are added to the ponds, but now in high densities. Water intake and outlet is completely regulated by pumps. Extra food is added, and this is all high quality food, mostly imported. This system, which is common in Thailand, is not very successful in Vietnam because of the high management costs. It can, however, produce ca. 3000 kg/ha/crop cycle.

Shrimp + rice:
In the rainy season rice is cultured, and in the dry season shrimp is culture in the same paddy fields.

Shrimp + salt:
In the rainy season shrimp is cultured, and in the dry season salt production takes place in the same paddy fields.

Shrimp + forest:
This system needs large ponds that are used for shrimp culture; in the middle mangrove trees are planted, and cut after 12-15 years.

Table 9. Thai Cultured Shrimp Production, Number of Farmers, Area and Value : 1972-1999 (source: DOF = Thai Department of Fisheries)

year	***No. of Farmers***	**Area (rai)**[1]	Production (ton)	Value (million baht)
1972	1,154.00	56,602.00	991.00	20.50
1973	1,462.00	71,678.00	1,635.00	35.30
1974	1,518.00	75,576.00	1,775.00	43.20
1975	1,568.00	80,422.00	2,538.29	81.80
1976	1,544.00	76,850.00	2,533.33	79.45
1977	1,437.00	77,567.00	1,589.54	56.09
1978	3,045.00	151,055.00	6,394.83	349.16
1979	3,378.00	154,222.00	7,064.07	460.59
1980	3,572.00	162,727.00	8,063.50	458.91
1981	3,657.00	171,619.00	10,727.87	657.26
1982	3,943.00	192,453.00	10,090.77	765.68
1983	4,327.00	222,107.00	11,549.85	950.37
1984	4,519.00	229,949.00	13,006.75	1,024.01
1985	4,939.00	254805.00	15,840.56	1,348.42
1986	5,534.00	283548.00	17,885.83	1,373.57
1987	7,264.00	325929.00	23,576.47	3,449.32
1988	11,838.00	417071.00	55,632.84	7,900.55
1989	14,253.00	474551.00	9,3191.50	11,072.19
1990	15,072.00	403787.00	118,227.10	14,365.36
1991	18,998.00	470826.00	162,069.70	19,834.11
1992	19,403.00	454975.00	184,884.30	25,500.14
1993	20,027.00	449292.00	225,514.00	37,842.00P[2P]
1994	22,197.00	448000.00	263,446.00	49,156.00P[2P]
1995	26,145.00	468386.00	259,541.00	49,785.00P[2P]
1996	16,000.00	500000.00	241,816.00	43,405.00P[2P]
1997	15,500.00	450000.00	227,000.00	47,183.86
1998	12,800.00	460000.00	240,000.00	58,353.32
1999	n.a.	n.a.	220,000.00	n.a.
2000	n.a.	n.a.	n.a.	n.a.

N.B.: 1 ha = 6.25 rai; 1US$ = 43 bath
N.B.: wordt nog vervangen door grafiek

Within the category “intensive” several different systems are distinguished: open, semi-closed, closed, and super-intensive. The main differences are in the amount and times of water exchange. Further sub-division is based on the soil type. Four main soil types constitute the bottoms of the farms – dependent on where they are: clay, laterite, mangrove clay, sand. This

is important for the later effects of shrimp farming. On the one hand, clayey soils make good ponds, because they leave very little water through. On the other hand, mangrove soil is very clayey, but also contains many stubbles that can reduce the impermeability of the pond bottom. And even more important: the mangrove soil contains a lot of pyrite, which will turn the soil very acid if exposed to air (oxidation). This is the main effect of concern in many areas where shrimp ponds have been abandoned, following a decline ("bust") in production, for whatever reason it occurred. It is the driving concern behind the restoration project discussed in chapter 6 of this module.

About 95% of shrimp farms in Thailand now are of the intensive type. The majority of these use a semi-closed system; open systems are becoming rare. Only a few extensive farms are in existence, and nearly no semi-intensive farms. (According to Huitric *et al*. (2000), the percentage of intensive farms is decreasing again since 1995, and was only 25% in 1999).

Also, about 95% of all farms is located in the coastal regions; 5% are inland farms, although this percentage may rise a little, in spite of the existing ban on inland shrimp farming.

Only about 60% of the shrimp farms in Thailand is registered, the rest is illegal.

It is important to note that the pond surface necessary for extensive shrimp farms to yield the same volume of shrimp as intensive farms, is enormously larger.

2.5. IMPACTS OF SHRIMP FARMING

2.5.1. Land use before shrimp culture

In 1995, there were about 26,000 shrimp farms in Thailand (Patmasiriwat *et al*., 1998). 40% of coastal land area in southern Thailand was covered by shrimp farms. Preferred area is land with low agricultural value, because this keeps costs low (Funge-Smith & Stewart, 1996).
Shrimp farms have to be located not farther than 2 km from the shore, because otherwise the exchange of water with the sea becomes too difficult (= too expensive). The large part of the coastal area occupied by shrimp farms reflects the relatively good income from this profession. In 1994, of the total coastal area of 372448 ha, 168676 ha was mangrove forest, 64992 ha was shrimp farms, 4961 ha was inhabited area, and 133813 ha was in use for other purposes (Office of Envrinmental Policy and Planning, 1998..

Table 10. Previous land use before shrimp farming in the south of Thailand (Lindberg & Nylander, 2001)

Previous land use	Percentage of farms surveyed
Rice paddies	49
Fruit, vegetable, or other agriculture	27.5
Mangrove and wetland	13.7
Uncultivated/Wasteland	5.9
Extensive shrimp farms	3.9

Within the mangrove areas, concessions for mining and wood cutting have been granted by the authorities. A large area is also illegally occupied, for several purposes, as shown in table 11.

Table 11. Land use type in mangrove forest areas in 1996 (source: Office of Environmental Policy and Planning, 1998)

Legal occupying mangrove forest	140550 ha
Mining concession	909
Harbour	107
Other legal uses	15876
Illegal aquaculture and others	35724
Illegal residential area	3133

2.5.2. Impacts of shrimp farming

The impact of shrimp farming on the mangrove forests gets a lot of attention mostly. It is therefore sometimes thought that this constitutes the biggest impact. This is not altogether true. There are several other important impacts of shrimp farming, and the mangrove forests are threatened by several other developments. Platong (1998) showed that between 1961 and 1996 about 50% of Thai mangroves were destroyed. Causes were conversions to shrimp farming, mining, forestry and agriculture. The shrimp farms took only 30% of the destruction (Tookwinas, 2001, pers. comm.;). Globally, this is somewhat less: between 10 and 25% (Tobey *et al*., 1998).Tookwinas (1995) mentions that, on the basis of satellite photograph analysis, it can be concluded that even less, about 17.5% has been destroyed by shrimp farm invasion of the mangroves. Total destruction, however, is larger, because mangroves also suffers from pollution from the shrimp farms, i.e. the water pollution with nutrients and other substances, and the dumping of sludge from the shrimp ponds into the mangrove stands.

Other impacts are listed by Tookwinas (1995). They were connected with the use of fresh water from groundwater deposits and aquifers, but this practice nowadays is replaced by the use of full strength seawater directly from the sea. This brings other problems, mainly during water exchange and harvest. But the main other impact is from chemicals. Although the pollution potential from shrimp farm water is considerably less than from domestic or industrial water, the effects of excess feeds, fertilisers, chemicals and antibiotics is not at all negligable. Macintosh and Phillips (1992), cited by Tookwinas (1995), give the following table:

Table 12. Shrimp farm effluent compared with other types of waste water (mg/l)

	Shrimp farm	Domestic water	Domestic water after primary treatment	Fish processing waste water
BOD	4.0-10.2	300	200	10,000-18,000
Total N	0.03-1.24	75	60	700-4530
Total P	0.011-2.02	20	15	120-289
Solids	30-225	-	500	6880-6475

Table 13. The main problems associated with effluents

Waste material	Primary effect	Secondary effect
Uneaten food, faeces and dissolved excreta	Increased nutrient loads and reduced oxygen in ponds and water supplies; increased sedimentation	Environmental changes; Reduced carrying capacity
Chemicals and drugs	Eco-toxicological impacts	Mortality and sublethal effects on Organisms; water quality changes
Antibiotics	Increased antibiotic resistance among micro-organisms	Increased problems in treating bacterial diseases; residues in marketed shrimp

One of the main problems with shrimp ponds in mangrove areas, however, is the potential acidity of the soil. The soil contain sulphuric compounds like pyrite. When exposed to oxygen (air) these soils tend to become highly acidic. This of course happens every time when ponds are set dry (in the belief that undesirable substances will be baked out by the sun), but even more when ponds are abandoned and fall dry.

Applying this knowledge about impacts of shrimp farming any coastal region, however, it must be realized that other causes of impacts may be just as important. E.g. in Vietnam, there is no primary mangrove forest left at all! In 1943, there was still 400.000 ha of mangroves in Vietnam. By 1950, cutting for timber, firewood and charcoal production had reduced that to 290.000 ha. In 1971, another 105.000 ha was lost, mainly as a consequence of the use in the war of defoliation agents by the Americans; the majority of this loss occurred in the south of the country. After the war, the deforested area was rapidly occupied by agriculture, salt production, and aquaculture, which also took care of the loss of the rest of the original mangrove forests.
In the meantime, however, a replanting programme had already started. The present mangroves are all secondary (Hong, 1995)!

2.6. THE INTRINSIC AND ECONOMIC VALUE OF NATURAL COASTAL HABITATS AMONG WHICH MANGROVE FORESTS

Coastal zones anywhere in the world, are richly endowed with natural beauty and biodiversity, but also with natural resources: mangrove forests and fertile soils on the land side, coral reefs, sea grass beds and many fish stocks on the marine side.

Fig. 4. A pristine mangrove forest

South-east Asia is known as the epicentre of marine biodiversity. The area has about 30% of the world's coral reefs and mangrove forests (Chou, 1997; UNEP, 1998). The ecological functions of several habitats are strongly interconnected. Mangroves act as nursery areas for many kinds of reef fish. The enormous diversity can only stay intact if the natural connections between mangrove forests, sea grass beds and coral reefs are unharmed (Nagelkerken, 2000; Morinière, 2002).

Mangroves are economically valuable in terms of the use by local people for firewood, charcoal production, fishing and hunting, and the production of a host of direct and indirect items. Lindberg & Nylander (2001) give a list. But also for coastal protection, waste recycling, and as a basis for offshore fisheries. Sathirathai (1998) thus estimated the annual return from mangroves to be between US$ 3200,-- and US$ 4090,-- per ha/year.

For comparison: a commercial shrimp farm can bring in more than US$ 23,000,-- per ha per year.

Other functions that change or suffer when mangroves are cut, are: protection against saline water intrusion, making the land unsuitable for agriculture; draining pattern of agricultural land; tidal current patterns; and protection against coastal erosion.

The economic return from **healthy** coral reefs in the area (fisheries, tourism) is of the order of US$ 230,-- to US$ 2700,-- per ha annually (Burke *et al*., 2002).

The waste recycling function of mangroves, and actually of the whole coastal region, in the South-east Asian countries has not yet been quantified in economic terms. This should be done, however, to provide a better basis for the management of the coastal zone. The same goes for "free" functions like carbon sequestration, climate regulation, genesis of rainfall,

protection against erosion and floods, etc. As to the protection against floods and erosion, it must be realized that the land behind the mangroves is heavily used by humans for habitation, agriculture, and industry. The protection value therefore is a kind of insurance policy. A world analysis by Costanza *et al*. (2002) showed that these services and protective functions for the world as a whole may be valued at US $ 12.5 trillion per year!

3. FUTURE SUSTAINABLE DEVELOPMENT OF COASTAL SHRIMP FARMING WITHIN AN ICZM FRAME

3.1. SUSTAINABLE SHRIMP FARMING

Sustainability for shrimp farming means three things:

1. a reasonable economic return form the activity, so that farmers, supporting and dependent industries can be provided with a good living standard, not only now, but also in the future;
2. minimal negative influence on other aspects of the socio-economic environment;
3. minimal impact on the natural assets by the activity.

It is very important to be aware that the latter is not only meant as a protection of those natural values and their "services" for humanity (like protection; waste recycling; etc.), but also essential for the continuity of the shrimp farming itself. The basis for the farming possibilities lies in the quality of the water and soil, and in the possibility to catch larvae or adult specimens in the wild (except when larvae are bought from abroad)**, w**hich means the quality of the habitats in the sea in front of the coastal area under consideration**.**
This means that shrimp farming, like other activities, should be incorporated in an integrated approach to coastal planning and management, called Integrated Coastal Zone Management (ICZM).

Sustainability not only pertains to the farming itself, but as much to the environment, the economical conditions, and the social circumstances. These must be brought in accordance with each other, and the sustainable aspects of their respective goals maximized.

The main factors for the future sustainable development of aquaculture will also be related to specified carrying capacity factors of coastal waters and lagoons .

Environmental Impact Assessment (EIA) should be a part of any judgement of an application for an activity like shrimp farming. Determination of the "Ecological footprint" is often enlightnening.
Kautsky *et al*. (1997) calculated this for a semi-intensive shrimp farm in Colombia, and found that for the farm to be sustainable, the ecological support system should be 35-190 times as large as the farm area itself!
Ideas about the best method to proceed differ. Primavera (1993) stated that semi-intensive shrimp farming would be the most sustainable, from both an ecological and an economical point of view. Funge-Smith & Stewart (1996) thought that technical measures like pond lining materials and improved biological filtration would constitute the solution.
Probably, in the context of the economic situation of the countries concerned, a labour-intensive system will be better than a capital-intensive system.
If a sustainable development of aquaculture in ICZM context is to succeed in Thailand, or any country for that matter, it is clear that there is a need for human resource capacity building and knowledge transfer to implement the MFSCAD integrated plan.
As there is no existing ICZM-aquaculture training module at hand, therefore the module development based on the design and testing of a provincial level coastal aquaculture program should be undertaken. Subsequently the gained experiences would be incorporated into policy development and planning for the national integrated coastal zone management program.

Thailand has a long time experience with boom and bust cycles of coastal shrimp farming development since 1985. From such experiences, the Royal Thai Government attempts to integrate coastal resources development into the mainstream of coastal aquaculture development, in particular shrimp farming, by using appropriate methods and mechanisms. This approach is in line with the generic principles for ICZM.

3.2. ICZM AND MFSCAD

There is an increasing awareness of the importance of ICZM in many countries in the world, probably partly driven by the threat of sea level rise.

What does it mean to practice ICZM?
The following diagram shows the main principles of ICZM.

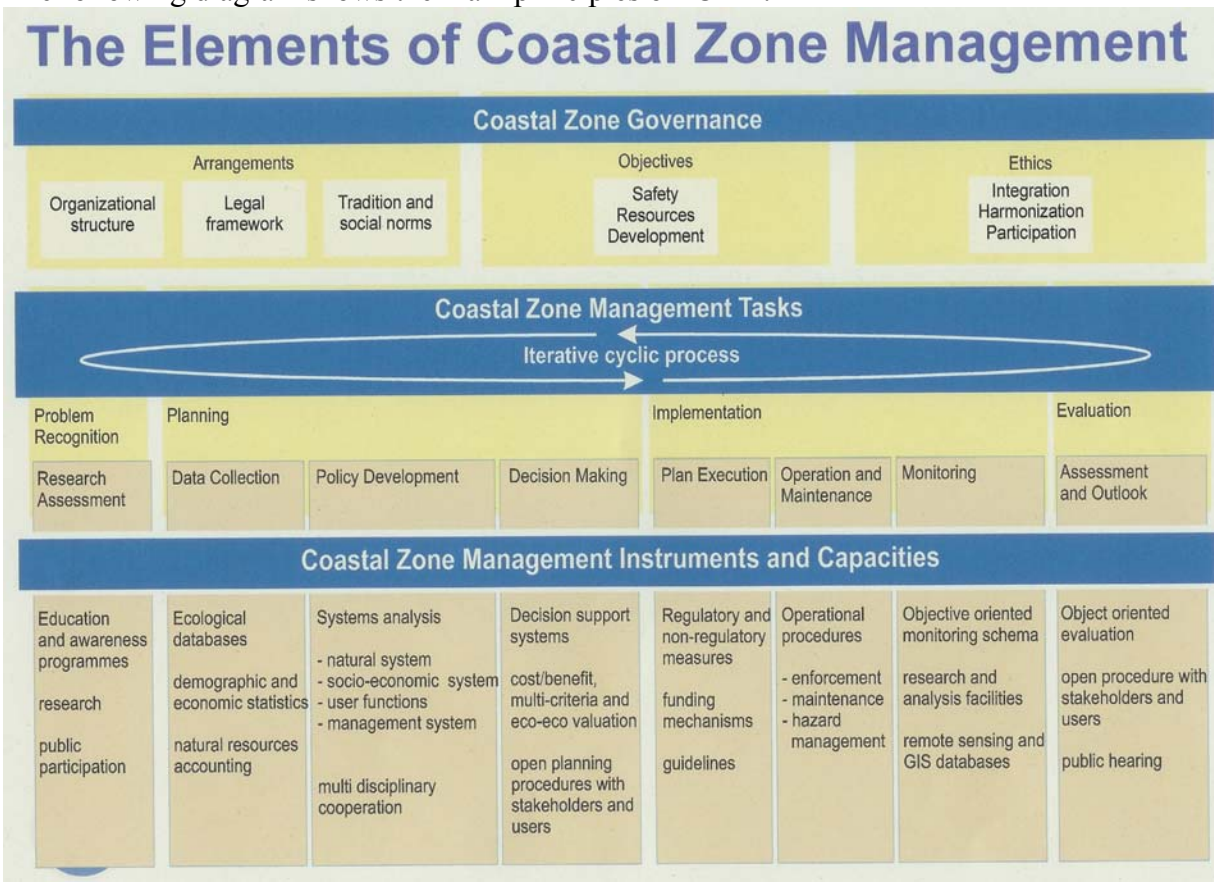


Fig. 5. The elements of Integrated Costal Zone Management (CZMC, 1998)

In the context of aquaculture, the key principles to be adhered to are:
(1) a basic **Management Framework for Sustainable Coastal Aquaculture Development (MFSCAD)** should be formulated to manage coastal resources comprehensively; this is actually nothing else than a specific case of integrated coastal zone management (ICZM). Sustainability of aquaculture is here the motive to use ICZM.
(2) **systematic and integrated (spatial) planning** following MFSCAD at different levels (**local level:** pond/farm; **provincial level:** shrimp farming impacts to the coastal zone; **national level:** shrimp farming and the other sources of impacts to the coastal zone--ICZM) should be emphasized; and
(3) **plans should be put into practice for the benefit of local people**. Co-ordinating systems and instruments are of prime importance. They will be required first if mechanisms for

managing coastal resources including aquaculture are to conform to the preceding principles. Local (farmer) organizations, being closer to natural resources, should be encouraged to paicipate (more) in coastal resources management programmes by using instruments created specifically for the purpose.

These instruments include MFSCAD tools and information systems concerning:

- environmental impacts
- mitigation strategies
- factors affecting sustainable aquaculture development
- guidelines for management

These instruments can be organized into complete and compatible systems, adapted to the specific characteristics of each locality of the coastal areas.

MFSCAD is strongly related to the 'Policy cycle' (problem analysis, strategy formulation, identification of measures, implementation, monitoring, evaluation).

What is MFSCAD?

- An MFSCAD is a Coastal Zone Management planning system, mostly prepared at the provincial level. It includes the formation of a Multisectoral Coastal Aquaculture Committee (MCAC), employs GIS information, and aims at integrating policies and local needs by employing Public Participation Techniques (PPT).
- It defines a system of zoning for multiple resource uses to guide the selection of location and approval of all public and private coastal aquaculture development projects, to move the industry more effectively towards sustainable development.

What are the Aims of MFSCAD?

- To encourage the development of aquaculture while minimizing conflict with other uses of coastal resources
- To contribute to integrated planning in the coastal zone
- To contribute to the process of site selection of aquaculture facilities

How is it prepared?

- It identifies the problems and opportunities facing the coastal zone
- Describes vision and goals for the future of the area
- Defines objectives for each sector, reflecting sustainable aquaculture development and national policies
- Seeks consensus to eliminate resource use conflicts arising from overlapping sectoral objectives
- Develops strategies and management guidelines to achieve objectives, and
- Formulates broad project and program concepts that can be elaborated in detail in action plans for each aquaculture facility.

The steps in the MFSCAD process consists of:

1. Identification of the problems facing the management of the coastal zone
2. Classification of the coastal environment of aquaculture in terms of sensitivity to organic loading and nutrients;
3. Assessment of the natural capacity of each category to tolerate organic loading and nutrients;
4. Assessment of total existing loading/inputs;

5. Estimation of the maximum acceptable additional organic loading, which is converted into aquaculture production equivalent;
6. Assessment of the physical area available for aquaculture development (by subtracting all unsuitable areas and all areas currently occupied from the total area).

These items can be elaborated as follows, into:

- Problems and opportunities
- Objectives / criteria / targets (supported by EIA, C/B-analysis, …)
- Strategies and zoning guidelines
- Farm operation plans
- Monitoring (what, how, where to go) (e.g. making use of remote sensing information)
- Evaluation

Management Advice should address at least the following issues:

- Introduction
- Sustainability and responsibility
- New concepts towards sustainable development
- Management issues for aquaculture development in ICZM context
- Regional and international instruments for management of coastal aquaculture
- management arrangements at international, national and local level

Incorporation of existing guidelines and links to relevant background information is always essential, so as not to create unnecessary conflicts with existing practices.

The contribution of ICZM towards sustainability in an area, whether from an economic, social or environmental point of view, can be tremendous. It is also obvious that pro-active ICZM – i.e. avoiding possible future negative effects of developments in an area, is better, and a lot cheaper, than just repairing damage afterwards.

The following diagram shows the expected effects of pro-active coastal zone management, for any economic activity in an area that is (negatively) affected by that activity.

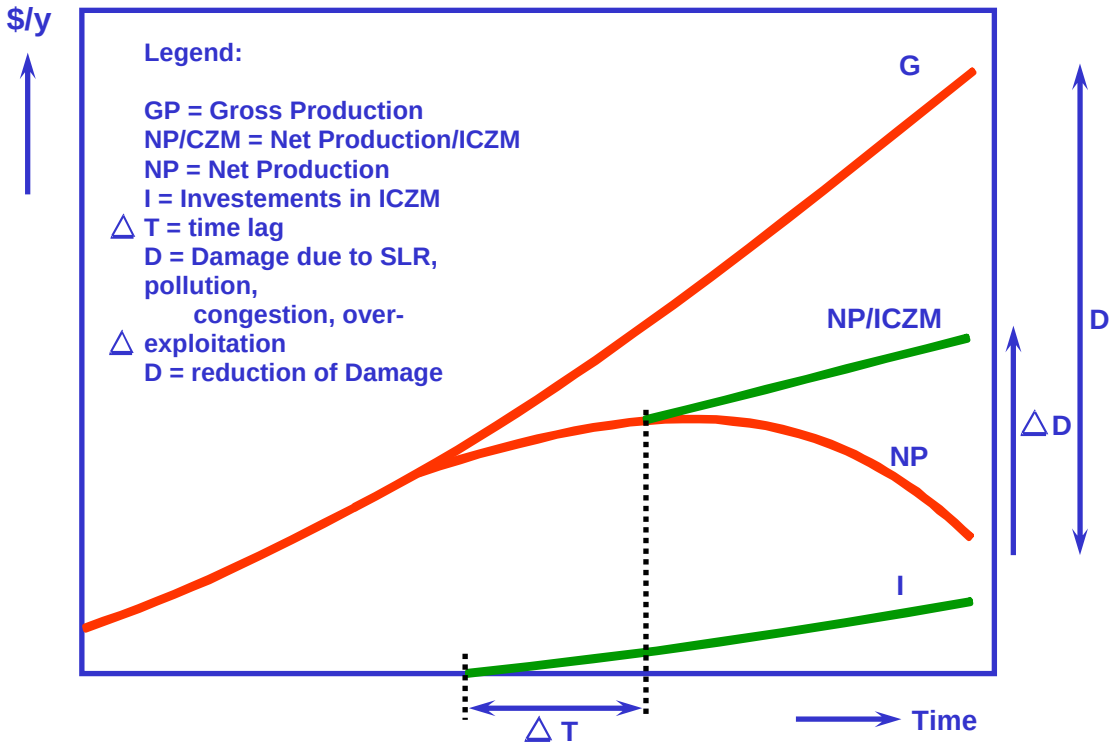


Fig 6. Pro-active ICZM is better and cheaper.

4. DIFFERENT SCALE LEVELS OF CONSIDERATION

4.1. INTRODUCTION

Several different levels of consideration of aquaculture are distinguished. Each geographic level has its own effect on the carrying capacity and impacts on environmental, social, legal, policymaking and institutional issues.
These different geographic scales are: international, national, provincial, district and local (= the aquaculture farm level).

At **the local level** the construction and management of shrimp ponds are the main concerns.
At **the district level**, questions will mostly pertain to the (technical) management of the farms themselves: where to put the ponds, how to construct them, combine them with other functions, how to avoid influence on, as well as from, the environment, water exchange, feed, use of chemicals, and so on. Actors are the farmers, maybe also proprietors of secondary industries, and local authorities.
Also, division of space between functions is important. Here district authorities are the most important actors. They are mainly instructed by the provincial, but also by the national; authorities. Infrastructure is also a determining factor.
At **the provincial level**, shrimp farming impacts to the coastal zone are the most important management issues. It is important to determine which part of the province can be developed in which way. The presence of facilities like harbours, mines, large industries, as well as larger cities determines the degrees of freedom for new developments. Actors are mainly provincial authorities, important industrial managers, and co-operations of shrimp farmers and other pressure groups.
The national level involves the government. Political considerations become more important at this level.This is the level where generic decisions are made about Integrated Coastal Zone Management(ICZM). The government decides in what way the different claims to space in the coastal zone, including their impacts to the coastal zone, will be handled.
The national authorities have to decide about general rules for the siting and management of shrimp farms – and any other activity as well. They also have to ascertain control on the application of the rules. They have to tell the provincial authorities what to do.
The national and provincial authorities are the most likely levels at which research can be carried out or commissioned.
At **the international level** it is important to comply with international notions about the way things (i.c. shrimp culture) should be executed. There are international agreements about the way countries should handle environmental issues.
Also, the market for shrimps is mainly international. This involves many issues, like competition and import tariffs; currency questions; transport; etc. Actors are governments, diplomats, industry and transport managers.

- Key issues in aquaculture management at all levels
    - Environmental issues
    - Social issues
    - Legal issues
    - Policy and institutional issues (institutional failure)
    - Incorporation of existing guidelines and links to relevant background information

4.2. THE MULTI-STAKEHOLDER ANALYSIS

4.3 THE LOCAL LEVEL

The shrimp pond (Thai experiences)

- Problems and opportunities
- Vision, goals and objectives
- Implementation
- Monitoring
- Evaluation

Incorporation of existing guidelines and links to relevant background information.

Main requirements for a successful shrimp farm:

- good climate
- space for rearing basins and hatcheries
- good soil, or lining of the ponds
- nutrients (for algae as food) and/or prepared food
- pesticides
- hormone preparations
- ……

N.B.: it must be realized that there is an important difference in the sort of impacts caused by **inland** shrimp farming, and the kind of farms that we're looking at here, i.e. farms in the coastal zone, where saline water is an intrinsic factor of the environment. In inland farms the effect of salination of the surrounding agricultural fields is much more profound. **See Szuster & Flaherty, (….) for more information.**

4.4. THE DISTRICT LEVEL

The shrimp farm (Thai experiences)

- Problems and opportunities
- Vision, goals and objectives
- Implementation
- Monitoring
- Evaluation

- Checklist of environmental impacts and mitigation strategies for a shrimp culture project
    - on site selection
        - Conflicts / hazards / problems
        - Environmental quality
        - Impacts
    - on farm operation and management
        - Solid waste disposal

        - Waste water
        - Feed management

- effects from the density of ponds & shrimps on the productivity, nutrients and physical planning - landscape design.

- Factors effecting sustainable aquaculture developments
    - Extrinsic – off farm factors
        - Pollution
        - Habitat loss
        - Socio-economic impacts
        - Policy and legislation
        - implementation
    - Intrinsic – on farm factors
        - Eutrophication and water qualities
        - Culture techniques
        - Seed supply
        - Availability of artificial and natural feed
        - Disease problems

- Incorporation of existing guidelines and links to relevant background information

In the shrimp farm development consists of shrimp ponds and other kinds of ponds necessary to run the shrimp farms, i.e., water-intake ponds, water settling ponds and sludge storing ponds. These ponds are connected with the management of farms leading to an involvement of economic, trade and social components of the farmers.

4.5. THE PROVINCIAL LEVEL

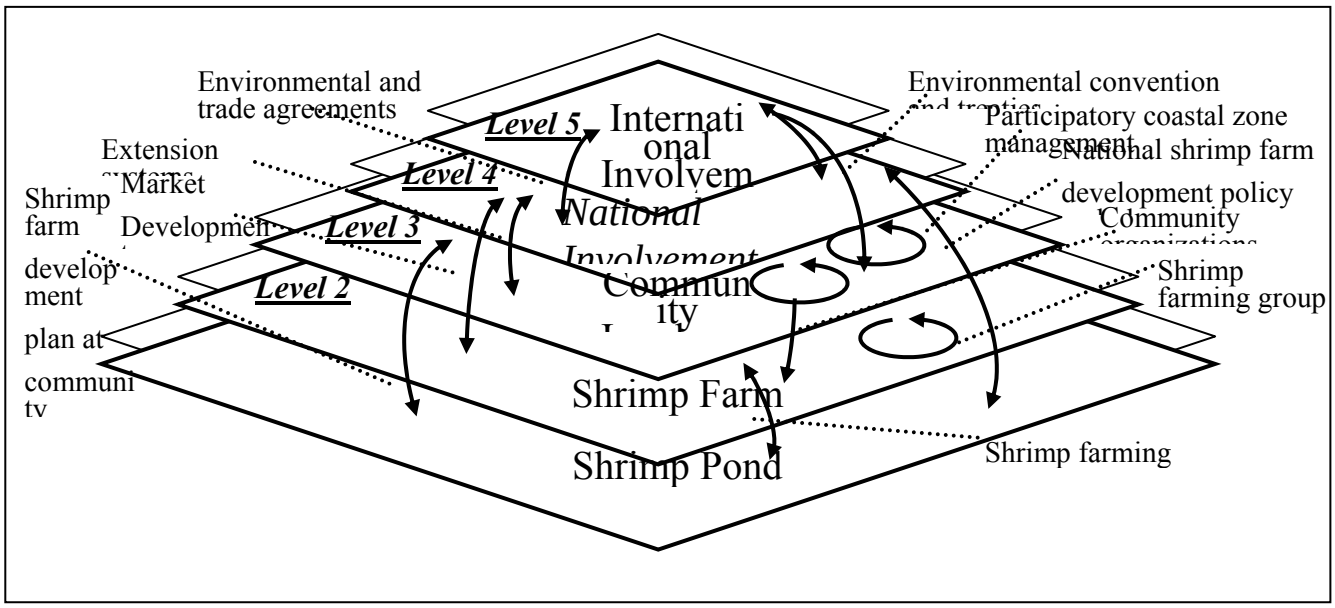
At this level Community Involvement (Provincial and Sub-district) becomes more important. All shrimp farms and their environmental impacts are connected with each other, and their impacts to the coastal ecosystem. The system is thus increasingly more complicated, therefore it involves some more components of the system. The components enter to play an important roles such as institutional, legal, as well as policy components counterbalancing with the biological, environmental, economic, market and social components.

4.6. THE NATIONAL LEVEL

The most complete system is the national level. A National Development Plan for shrimp farm to mitigate the impacts of shrimp farming to the coastal zone, but also impacts from other sources are involved. Impacts from industries, households, tourism, infrastructure development and agriculture are taken into account, which complicate the system spatially as well as temporally. Institutional, legal, policy and planning, and conflict resolutions play a prominent role in paving ways for the desirably sustainable shrimp farming industry.

4.7. THE INTERNATIONAL LEVEL

It is inevitable that shrimp farming has to link with international trade and agreements. Competition to increase market shares in a few importing countries, i.e., Japan, United States of America, and European Union has been stiff. Various trade negotiation techniques are forcefully used by both exporting and importing countries to control the shrimp trade in line with the countries' policies. Trade restrictions ranging from product quality control, environmentally sound label, specific trade preferences and privilege to genetically modified products are increasingly implemented. The need to have access to information on trade movement, its analysis and proper strategic planning is constantly urgent.
Fig.7. shows the interrelationships between the 5 levels distinguished.



4.8. A THAI MODEL

A model incorporating important institutional settings in all operational levels 1-5 of sustainable shrimp farming process has been developed.
It is emphasized that, no matter what maximum level any model is operating at, sustainability in each level is necessary for an overall achievement of the goal.
Below the important features of such a model are analysed.
The objective is : "To develop and maintain sustainable shrimp farming practices as an **economic** enterprise for the production of **internationally recognized** shrimp products with adequate **social** and **environmental** responsibilities."

There are at least four key issues/fields of interest: Economical, International, Social, Environmental. The essence of these issues has been elaborated below.

1. **Economic Enterprise.** An economic enterprise seeks economic returns to cover the costs and normal profit. The costs involve not only financial costs, but also social and environmental costs. Hence, the economic objective is:

To maintain and increase economic returns to shrimp farming entrepreneurs at all levels, and
To integrate shrimp farming development plan into the national plans and policies.

With respect to value of cultured shrimp, the value has been increased from a small mount of 20.50 million baht in 1972 to more than 58,000 million baht in 1998. The export exchange earnings from shrimp have substantially contributed to the Thai economy as the value of export in has been in the top ten list following computer parts, textile, circuit, rice, rubber, jewelry and canned seafood. Income from cultured shrimp export is expected to remain its significance in the national economy in spite of stiff competition from neighboring countries, increasing trade barriers of the importing countries and domestic production problems.

2. International Recognition. In the present trade globalization, products recognition is important for international trading advantages. The recognition is in a form of product differentiation via standardization, positive attitudes toward the products, acceptable production process and products delivery systems. The objective here is formulated as follows :

To adopt and implement the FAO of the United Nations' Code of Conduct for Responsible Aquaculture.

3. Social Responsibility. In the shrimp farming process, many social aspects are involved. These aspects are, for example, exploitation of child and alien labour, equitable distribution of benefits, conflicts among stakeholders who have and care for different occupations and interests, and human migration and resettlement due to polluted waterways, coastal erosion and soil contamination. The objective is developed as :

To minimize social problems accruing from the development of shrimp farming.

Social issues form a livelihood core of the people benefited and/or affected by the shrimp farming development in terms equity distribution, employment opportunity and social well-beings.

In southern Thailand, a larger proportion of shrimp farms are developed by small business people from towns, government officials, local influential people and big business, either in cooperation with the local rice farmers or fishermen or on their own. In a short term, these investors gain a majority of the benefit from sale of shrimp, but when the farming industry is bust, the negative consequences are put as a burden on the local who actually have their livelihood there. In addition, increases in road accidents, major and minor crimes, drugs and unwanted forms of entertainment have entered into the shrimp farming locality and, while the big investors have fled, the local people are the ones who are suffering from the shrimp boom.

Positive social benefits from shrimp farming are employment which creates socio-economic security and opportunity to the farmers and their families. In 1998, there were 15,800 registered shrimp farmers who are directly engaged with this industry. Each farmer had approximately five dependent members in a family, and he/she employed on an average of one hired laborer to help in his/her farm. The shrimp farming, therefore, generated about 32,000 direct jobs with 63,000 dependencies. There were also some related industries such as shrimp processing factories, shrimp export companies, shrimp feed industries, middlemen and others that create an additional employment of more than 200,000 people. In total, there were about 300,000 people who depend on the viability of shrimp farming in Thailand (Sethsirote, 1995 and Department of Fisheries, 1993).

4. **Environmental Responsibility.** There have been various studies on environmental impacts from shrimp farming. These impacts can be divided into two main categories: those arising from the destruction of mangrove forests, and those produced by the day-to-day operation of the shrimp farming industry. The apparent impacts are mangrove degradation, water and soil contamination by chemicals and salt, farm pollutants, eutrophication and loss of aesthetic values of landscape. Hence, objectives are formulated as :
   To minimize environmental impacts from the shrimp farming industrie, and
   To restore environmental quality of the locality where shrimp farming is situated, and larger areas.

In 1961 Thailand had 3,679 sq. km. of mangrove forests; by 1993, it had about 1,687 sq. km. – a decline of more than 50 percent in about 30 years. The area of mangrove forests had declined along the eastern seaboard, in the Upper Gulf region and in the south in relation to the movement of shrimp farming development. Although mangrove forests have been under pressure of encroachment from many activities such as charcoal timber concessions, mining, salt ponds, household settlement and even tourism development, the main chief cause of mangrove forest decline has been the one associating with the development of shrimp farms. Not that mangrove areas are ideally suited to shrimp pond development because the tangled mass of mangrove roots are difficult to clear and there is a tendency for pond to leak where remaining root structure penetrate the impoundment walls. The soils are often acidic requiring extra expenditure to neutralize and the complete drainage of the ponds and drying of the pond bottom is difficult to achieve within the tidal zone. But mangrove forests have been common property resources supporting subsistence livelihood of the local poor; and state's forest reserves that their boundaries have been unclear, and implementation of the forest reserve principles has not been sufficient. Therefore they have been considered vacant, and subject to being converted into shrimp ponds. Even though the mangrove forest reserves are protected by laws, their protection has in the past been compromised by the Thai authorities' willingness to grant concessions for mining and shrimp farming, as well as the harvesting of the forest for charcoal wood on a supposedly sustained yield basis. Illegal encroachment for all purposes of economic benefits, particularly for shrimp pond development, has also largely been ignored. However, the present lift of new mangrove forest concession is an attempt to preserve the remaining forest. The forthcoming community forest law is expected to encourage the local people to help protect their own forest resources.

The impacts of shrimp farming development to mangrove forests are not only in terms of area encroachment, but also sludge disposal. As the mangrove forests are considered vacant, many shrimp farms have disposed the sludge from shrimp pond cleaning directly into the forest causing mangrove trees die off. A considerable vast area of mangrove forests has been affected.

The growth of shrimp farming has led to the generation of large amounts of wastes. From an annual crop of 150,000 tons, based on the Food Conversion Ratio (FCR) of 2:1, 250,000 tons of organic matters, 17,400 tons of nitrogen and 5,600 tons of phosphorous wastes are produced. The waste water (more than 2000 tonsday/ha) in which these materials are to be found with other inorganic matters and antibiotics is normally drained into the sea or public canals without proper sedimentation and treatments, causing water pollution and planktonic eutrophication. This wastewater may be suitable for fin fish, molluscs and seaweed culture because of the abundant plankton, organic solids and

nutrients. Surprisingly, little research and practical experiments leading to such a promising secondary aquaculture system has been conducted to date in Thailand.

The institutional matters involved with this approach are elaborated in Annex 3.

This model can be implemented in various situations:

1. Coastal area where marine shrimp farming is predominant and bands of coastal areas along the Gulf of Thailand, inner Gulf and Andaman Sea.
2. Existing and potential areas for freshwater shrimp farming
3. Abandoned shrimp farms in coastal and freshwater areas. These can be located in both (1) and (2) above, but because of its special characteristics it could be treated separately.

In every situation an analysis must be made with respect to water supplies, water quality, topographic properties, socio-economic characteristics, existing institutional arrangements, and problems and opportunities.

Special attention must be paid to the location where abandoned shrimp farms in both coastal and freshwater areas are numerous.

Expansion of shrimp farming area must be avoided at all costs, but in the existing areas, and particularly the abandoned shrimp farms the use must be optimized.

5. EXAMPLE: THE BOOM AND THE BUST CYCLE AT A THAI SUBNATIONAL, REGIONAL SCALE: HAT-YAI 300 *2 KM

(Illustratie: casus Hat Yai.)

5.1. INTRODUCTION

This chapter deals with Thai experience as an example of development of shrimp farming and its influence in a (complex?) coastal zone, and **in the absence of ICZM**.

The development of Thai shrimp culture is characterized by what is tentatively called the "boom and bust cycle". It is particularly evident in the Hat Yai area, and this is therefore used here as an example. The factors determining this development are discussed below.

The Hat Yai area is part of a larger stretch of coast in the south-east of Thailand. Here intensive shrimp farming is concentrated in a 1 to 2 km wide section of coastal plain, with a length of 700 km.

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5.2. HISTORY OF SHRIMP FARMING IN THAILAND

Lindberg & Nylander (2001) gave a short review of the development of shrimp farming in Thailand.

Extensive shrimp farming in Thailand started around 1935 in the area east of Bangkok. Salt water intrusion into the rice paddies caused bad rice crops, and this induced the farmers to start harvesting shrimp under low tide conditions, at first only for domestic use and the local market. But soon this proved good business, and many rice paddies were converted to shrimp ponds.

In 1947 a second phase started. Salt prices fell sharply. It proved profitable to convert salt fields into shrimp ponds (Flaherty & Karnjanasort, 1995).

In the 1970s hatchery technology made it possible to adopt semi-intensive production methods. The Department of Fisheries (DOF) stimulated this by constructing its own hatchery of mainly Black Tiger shrimp.

Then, in the 1980s Taiwan took the lead in intensive shrimp farming. Many countries followed, stimulated by support from the World Bank, the Asian Development Bank, and other financial institutions. In the mid-1980s intensive shrimp farming became abundant in parts of Thailand. This had four main causes: increasing export prices; decreasing wild catch; and the collapsing production in Thailand caused by diseases (CORIN, unpublished); and the increasing willingness of Taiwanese farmers to share their expertise and knowledge.

Fig 8. Thai intensive shrimp farm near…. *Photo: Tom Bucx*

5.3. THE BOOM/BUST CYCLES IN THAI SHRIMP FARMING

Bormthanarat & Nissapa (20002) summarized the development of the shrimp farming industry in Thailand from the early 1970s, and distinguished a series of "booms"and "busts".

START Shrimp farming in Thailand was accidentally discovered as a by-product from salt fields along the seacoast of the Inner Gulf of Thailand. The conversion on salt fields into shrimp ponds was convenient, as these fields are well linked with the sea through a network of canals facilitating shrimp farming operations.

POLULAR Only in the 1970s shrimp farming became popular among some groups of investors with financial opportunities.

BOOM Around 1980, shrimp farming started to become booming business, concentrating on coastal lands in the upper Gulf of Thailand provinces close to Bangkok (i.e., Samut Sakorn, Samut Songkram and Samut Prakarn). The main stimulus for this growth was the rapidly increasing export price for shrimp particularly into the Japanese market. The farm operation intensity and the species cultured changed from an extensive system (with the species being the banana prawn *(Panaeus merguiensis)*) to semi-intensive or intensive systems, the cultured species being the Black tiger prawn *(P. monodon)* . The latter fitted better with the Japanese taste and requirements. Several factors contributing to the boom of the shrimp farming are a regional decline in the shrimp catch from wild source, a massive decline in Taiwanese production, and the gradual willingness of the Taiwanese to share some of the technology and expertise that they have developed over time. By 1989, Thailand had some 80,000 hectares of shrimp farms, with an output of 90,000 tons, and held 16 percent of the world market.

Thailand was the world's third largest producer of tiger shrimps after China and Indonesia, and its position moved to the second largest tiger shrimp producer in 1990, only after China. In 1992, foreign exchange earning from shrimp export represented Thailand's ninth largest sub-sector. In 1999, Thailand was the largest producer in the world.

Much of the land converted to intensive shrimp farming was in former areas used for extensive and semi-intensive operation, mangrove forests, nipa palm forests and coconut groves.
Many people, from various trades and professions, but all with little knowledge of or expertise in shrimp farming, decided to try their luck in poorly protected public lands. There was no planning of farm lay-out, some critical mangrove forests were encroached and some farms discharged their effluents into public canals or directly into the sea. Overstocking of ponds and poor feeding efficiency added to the nutrient level of discharge water, and the high concentration of farms caused the recycling of contaminated waters back into ponds.
The combined effects of these actions saw the tiger shrimp farming in the Upper Gulf Provinces have some signs of environmental degradation as the expansion was without proper controls coupled with government encouragement. Death of many shrimps, severe infestation of old and new diseases and lower shrimp prices forced many farmers to leave the industry.
BUST The shrimp farming in the Upper Gulf Provinces of Thailand was over.

MOVE Shrimp farming then moved to the eastern provinces toward the Cambodian border (Chantaburi, Rayong, Trat and Cholburi), **and southern provinces along the Gulf of Thailand (Nakhon Si Thammarat, Surat Thani and Songkhla). Public mangrove forests and extensive areas of low lying poor paddy land along the coast were available and local land owners (Farmers, fisherfolks and local business people) entered the industry.** Small commercial investors began to buy up land, and larger companies (national and transnational) either bought up land or entered into agreements with local farmers to develop contracted or co-operative shrimp farms. **In 1991 it was estimated by the Department of Fisheries that nearly three quarters of Thai shrimp production came from the south.**
BOOM The development of the shrimp industry was strongly promoted by the national government and by provincial governors. For example in Surat Thani province, the policy became one of making Surat Thani the biggest shrimp producer in the south, and authorities organized "Shrimp Day" as an annual celebration.

BUST As had occurred in the Upper Gulf Provinces, the expansion was badly controlled, exceeding the nature's carrying capacity, and poorly managed, leading to a collapse of the industry. Along with the devastation process, some of the farmers and larger private companies continued to experiment the new alternative practices, only to fail or gain some marginal success. Nevertheless, some new shrimp farming models (closed, semi-closed, alternate closed systems) were developed. But on a larger scale, the shrimp farming in the eastern and southern provinces was almost over.
MOVE Shrimp farming shifted to other areas to Upper Southern Provinces (Chumphon, Phang-nga and Phuket). Because of favorable environmental and weather conditions, and open-access space, these areas became the new investor hub of shrimp farming industry.

INLAND While the traditional shrimp farming practices continued in the eastern and southern parts of Thailand, inland or freshwater shrimp farming has been developed in the central plains around Bangkok (i.e., Suphan Buri, Ratchaburi, Nakhon Pathom, Ayutthaya). These areas are thought of as the rice bowl of Thailand. There were calls to put off the inland freshwater shrimp farmers for fear of ecosystem and crop farming damages, the Thai government (after several debates, studies and protests by parties affected), announced a Cabinet Resolution to ban the practices, dated July 7, 1998. The inland shrimp farming and

the imposition of ban had generated conflicts not only between shrimp farmers and rice farmers, but also institutional conflicts among the government departments. Fishery officials as well as interior officials had declined to enforce the ban because they had promoted the aquaculture business (fishery officials) or they fear confrontation with the shrimp farmers. There have been arguments for the ban's flexibility and many shrimp farms refused to comply with the ban.

Fig 9. shows schematically what happened during a period of more than 30 years.

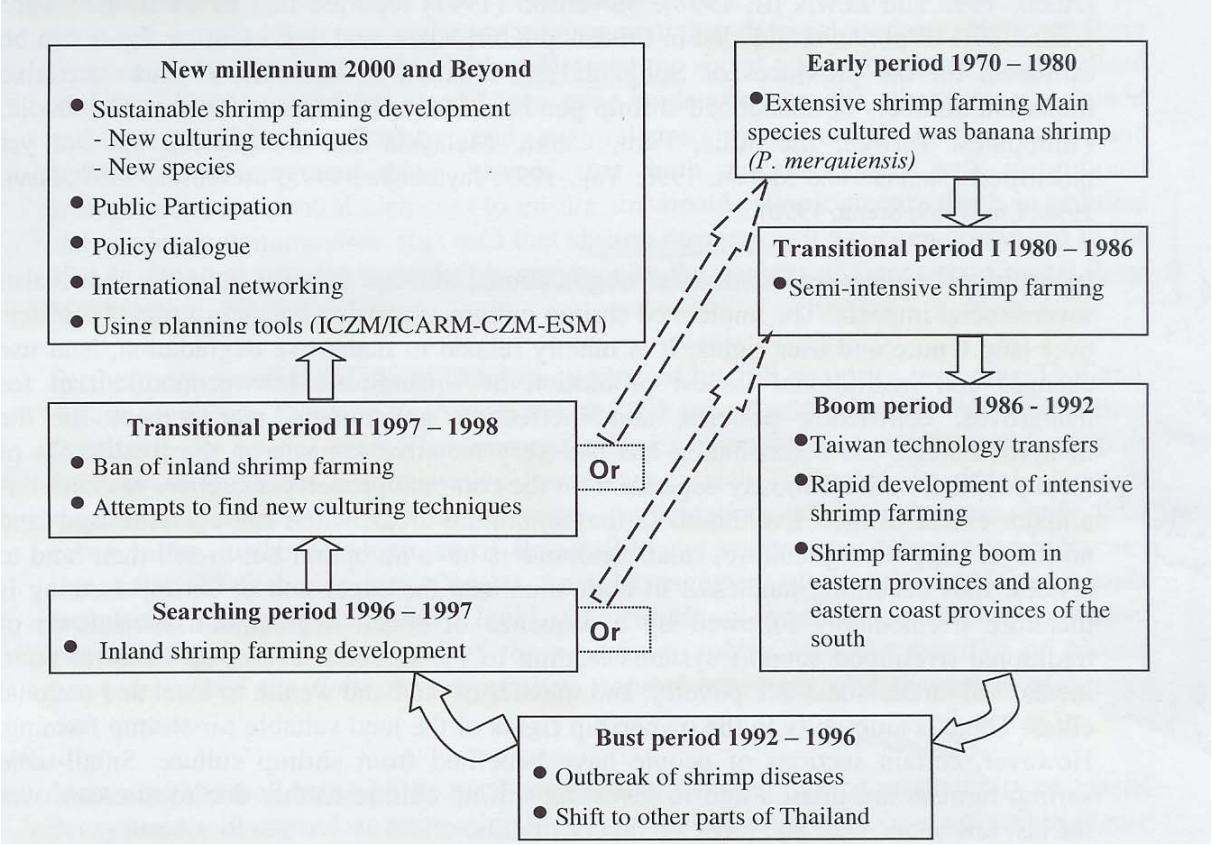

Fig 9. Boom and bust cycle of Thai shrimp farming

RESEARCH Meanwhile there have been attempts to develop new culturing techniques, modern disease control methods and new substituting species in the areas that the operation was ceased. Some farmers and private companies have learnt from their experiences about their failure and attempted to correct it by several means such as lower stocking density, careful screening of incoming water, constructing water storage and treatment facilities, and closed/semi-closed culturing systems. Many old shrimp ponds are currently operating with increasingly intensive system (or extensive in some aspects). There has been a satisfactory degree of achievement, which encourages shrimp farmers from other parts of the world to visit.

It is obvious that shrimp farming development in Thailand has gone through several stages of learning-by-mistake. An analysis of the historical shrimp farming development in Thailand shows that one thing is a returning phenomenon: the abandonment of the ponds in an area, after which the shrimp farming industry moves to another part of the country. This has caused a barren abd devastated landscape in several parts of the country.

To obtain a better insight into these matters, it pays to look at them as several cycles of developing land, receiving profits, destruction of basic conditions for the shrimp culture (along with various aspects of the natural inheritance), **and leaving of the ponds**.

This is what this chapter is about! As long as the ponds stay in use, there are other problems to solve, like the use of each others' effluent water to feed the ponds → fast spreading of pollution and diseases. The farmers and the local authorities are the responsible actors here. But as soon as the ponds are left, the problem is one concerning the whole region, and impacting the lives of many people at once. This also means that the responsible actors here are no more the farmers, but the authorities, even up to the national level.

This cycle in effect is a one sinusoid cycle… after bust no boom of aquaculture! And also not of any agricultural use.

Referring to the general figure given in chapter 3, this is a clear example of the correctness of this economical theory. The following figure shows this once more: investment in ICZM at first doesn't show any dividend, but on the longer run it's well worth it!

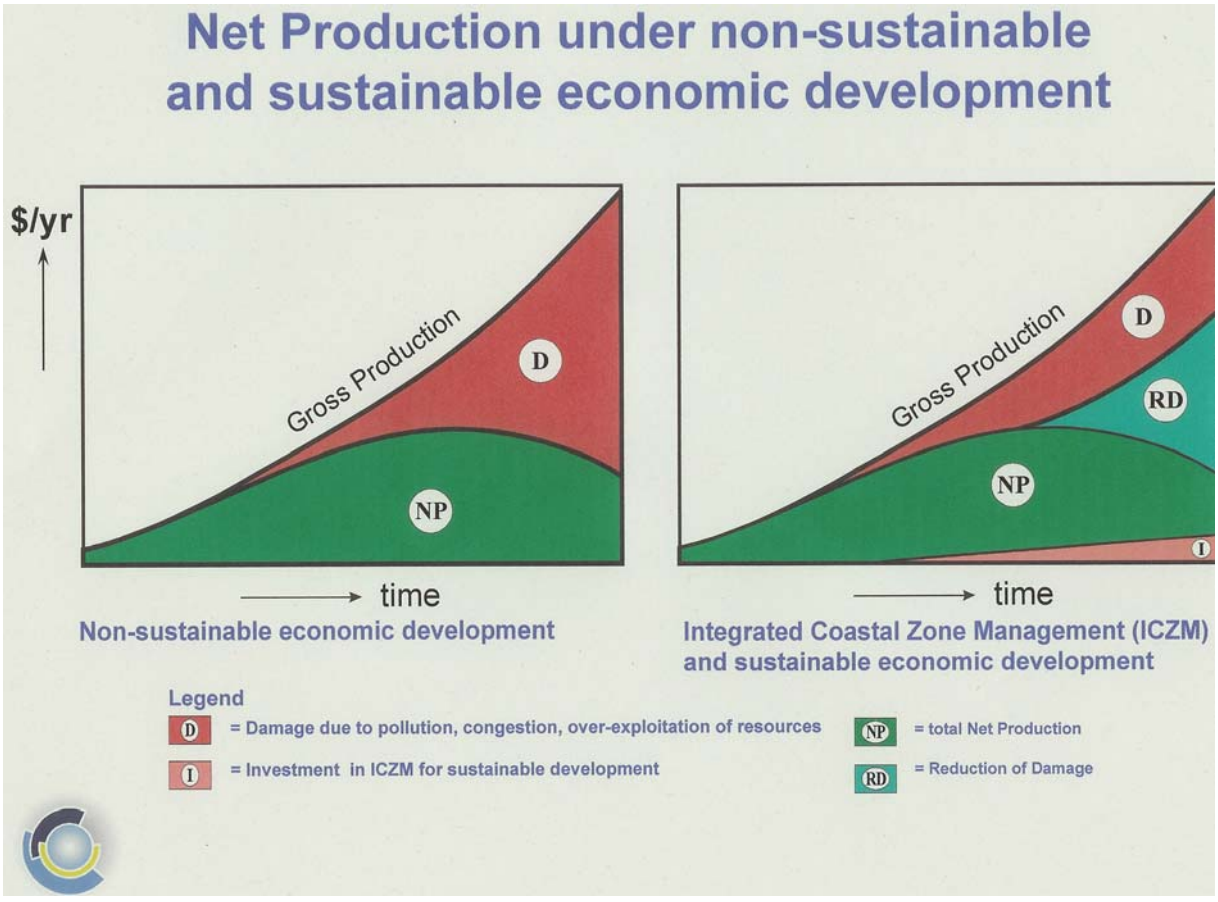

Fig 10. ICZM is a cheap tool to obtain sustainability.

Although the cause for the decline is different in the various cycles that can be distinguished, the results are the same every time: a desolated landscape, with only scarce means of existence for the local people, and an enormous area of abandoned shrimp ponds, the bottom of which is heavily polluted.

Lang (2001) indicated that the problem in Vietnam is rather the same.

In the last 40 years, the area of mangrove forest in Vietnam has shrunk dramatically. Causes include defoliation during the American war, logging, expansion of rice farming as a consequence of government agricultural policies, and influx of people, especially in Ca Mau province. In the last decade, ***government-promoted shrimp farming has increasingly become a major cause of mangrove loss***. The role of mangrove forests in providing thatching for roofs, firewood, charcoal, medicinal plants and honey, as well as mangrove's role in protecting the coastline, has been lost in many places.

Shrimp farming tends to be a short term activity. Many farmers moving into shrimp farming without sufficient technical skill or money for the necessary infrastructure have found the land is useless after as little as three years. Shrimp farming is also at risk from disease. In 1994-95, a virus wiped out almost the entire shrimp harvest in Vietnam.

Although in Vietnam most shrimp farming is extensive, the Ministry of Planning and Investment has recommended intensifying production. Intensive shrimp farming uses antibiotics and chemical additives to increase production. Eventually the shrimp ponds and surrounding water systems are so poisoned that the land can only be abandoned.

It appears that many occupants appear to be well aware of the need for reforestation as illustrated by individual and voluntary tree planting activities which can be observed at various locations.

Yet, many families are to be evicted so that mangrove trees can be planted. The people to be moved are not only shrimp farmers but include farmers, forestry workers, salt producers, tailors, mechanics, handicraft producers, shopkeepers, fishers, and labourers. Many of these people were encouraged to move to the area in the first place by local authorities, to grow shrimp or as forestry workers. The Vietnamese government faces a complicated problem: on the one hand they're required to stimulate replanting of mangrove forests and protecting the environment, on the other hand loins (from a.o. the World Bank) have to be repaid. This requires foreign exchange. To raise this the government will promote the export of cash crops --such as shrimp. **In February 2001, Vietnam's aquaculture industry announced a five-year plan, a key aim of which is to increase the area of shrimp farming in the country from 226,000 hectares to 330,000 hectares.** Deputy Minister for Fisheries, Nguyen Viet Thang, promised governmental financial assistance for shrimp farms of over 100 hectares.

Governments in Southeast Asia have promoted shrimp farming as a means to earning foreign exchange. The beneficiaries of this expansion are mainly private companies such as the Thai agribusiness company, Charoen Pokphand.

In Thailand, the World Bank, the Asian Development Bank, Charoen Pokphand and the Thai government worked together to set the scene for expanding the shrimp industry. Companies setting up shrimp farming operations in Thailand were offered generous subsidies including tax breaks, tariff-free imports, tax holidays and export credits.

During the 1990s, Charoen Pokphand expanded its operations to Vietnam. In 1993 Charoen Pokphand exported shrimp from Vietnam worth US$96 million --about 40 per cent of Vietnam's shrimp sales that year. Charoen Pokphand also operates shrimp-feed plants in Vietnam.

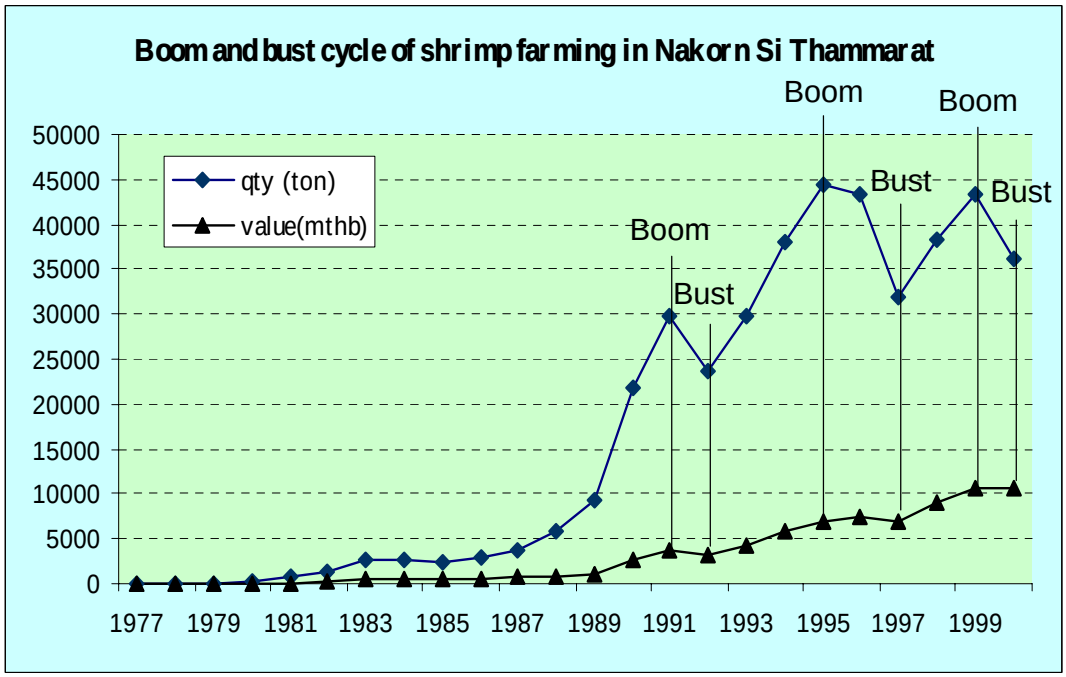

Fig 11. The boom and bust cycles in Thai shrimp farming development

The major causes of the bust are not necessarily the same as the worst effects on the environment. It would appear that the most important environmental effects are:

a. Decrease of mangrove area;
b. Acidification of ponds. This is caused by the substances accumulating in the bottom; when a pond is deepened, the bottom clay is put onto dikes separating the ponds. By contact with the air this earth will acidify, and when it rains the acid earth will be washed off the dikes into the ponds, causing the water to become acid. This is no good environment for shrimps;
c. As a consequence of bad farm management many substances accumulate in the bottom of shrimp ponds and ditches. Among them particularly sulphur, nutrients, pesticides, possibly hormones, disease agents and organic material causing BOD. These substances are easily dispersed through the many canals, to other farms and to the general environment;
d. When the farms are abandoned, many ponds dry out. The substances in the exposed bottom become oxidized or react in another way. The bottom material can be dispersed by winds or by flooding, which is not unusual in the coastal areas, particularly when mangroves, formerly being the protection against flooding from the sea, have been cut – e.g. to make room for shrimp farms.

These are the most important effects in Vietnam, too!

ICZM now is faced with two important tasks:

- In the affected area: restore the abandoned shrimp ponds, the surrounding landscape and the natural values into something that resembles the original situation; restore basic conditions and original "environmental services".

- For new shrimp farms: avoid the degradation of farming practices, yield from the farms, and at the same time the environment; maintain equilibrium between the various uses of the land, including the natural biodiversity .

The development of shrimp culture caused extensive degradation of the environment. In the area north of Hat Yai, a great restoration effort was also performed. The extent, costs and effects are discussed in chapter 6 of this module.

6. RESTORATION OF THE BUST PART OF THE CYCLE AT THAI REGIONAL SCALE

6.1. INTRODUCTION

Statement: without ICZM there is a realistic chance that the (coastal eco-)system will crash. Remediation then will require enormous investments – if it is still possible.

Restoration requires first looking at the T-zero situation: how was the landscape, what was the extent of mangrove forests and where (under what conditions) were they; how many persons were living and working in rice fields; and how much was earned in subsistence and in export of rice.

An illustration of how a deteriorated landscape can be restored again – and what this will cost, is presented by the case of the area north of Hat Yai. This is an area of 300 km long and 1 to 2 km wide, along the south-eastern coast of Thailand (see map). It is to be born in mind that this is only one example. The possibilities are sheer endless, because the starting situations and the causes of deterioration can both be very different in different regions. This example, however, can be useful in the Vietnam situation, because the general environmental circumstances are comparable: climate, soil types, land habitats (coastal, deltaic) and adjacent sea habitats.

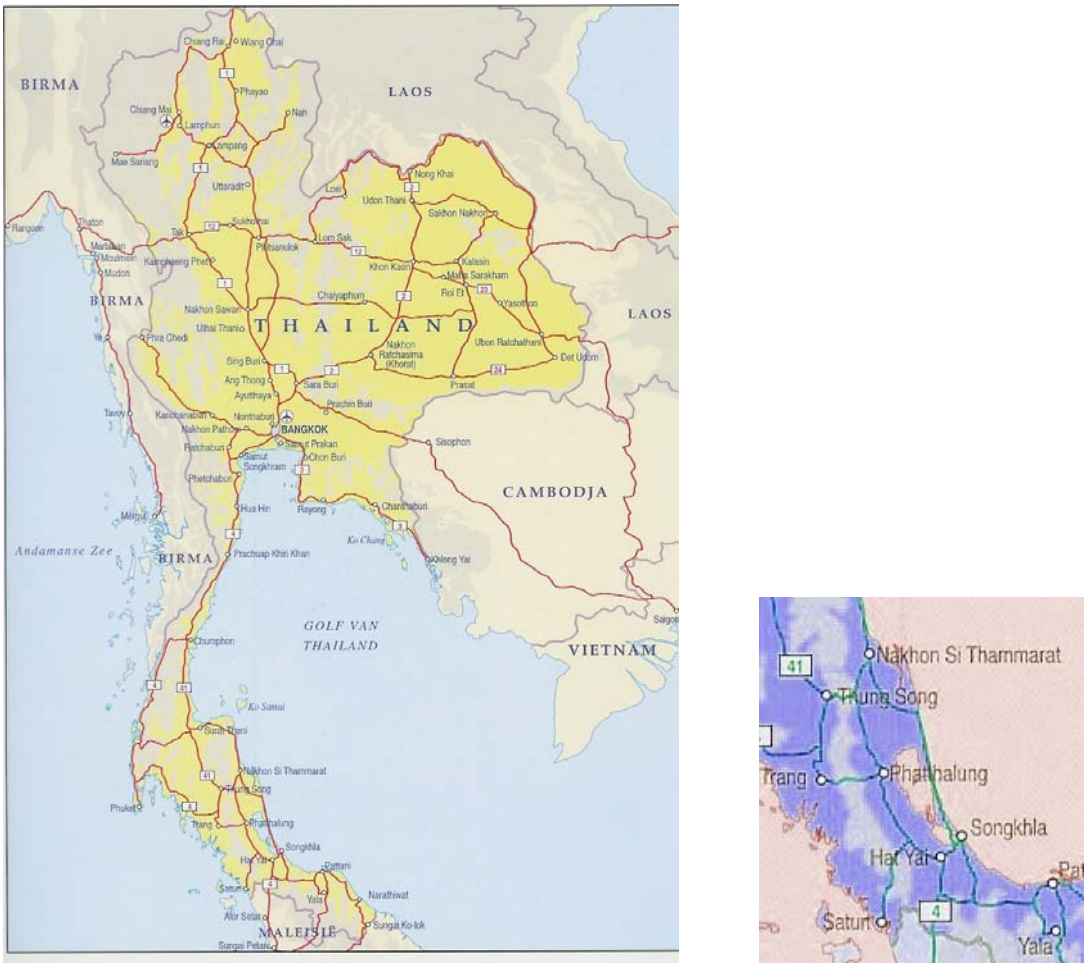

Fig 12. Map of Thailand. At right, the study area

The next two satellite photographs show the area before intensive shrimp farming development, and after.

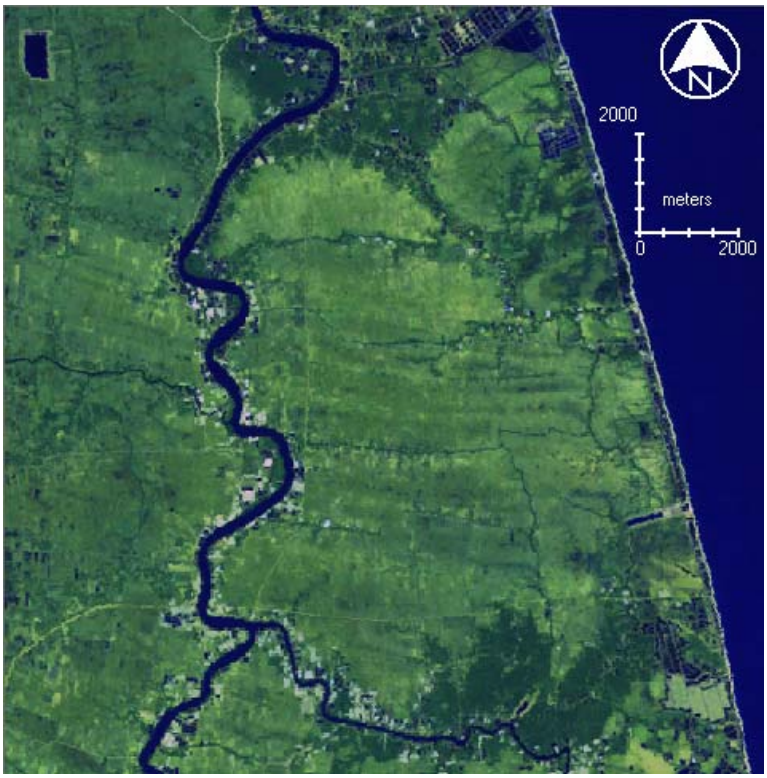

Fig 13. Pak Phanang area before intensive shrimp farming

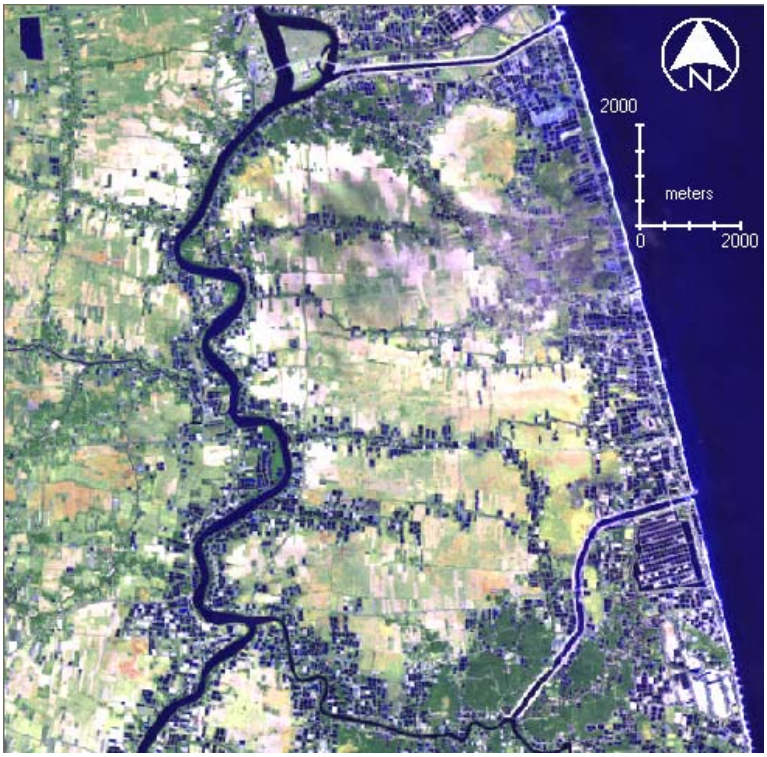

Fig 14. Pak Phanang area after abandonment of the no longer productive shrimp farms

6.2. THE KING'S PROJECT AT HAT YAI

In 1997, the King of Thailand has ordered to restore the devastated aquaculture bust area north of Hat Yai, by means of a remarkable measure! The King's order made it possible to direct a lot of thinking power, manpower and money to this effort. The King's project is directed at using the surplus of fresh water of the river Pak Phanang. This surplus is collected by the constructing of a barrier in the mouth of the river. It is subsequently diverted to the devastated areas of former aquaculture, and used to wash out with fresh water the polluting substances which are fixed to the clayey sediments of the aquaculture pond bottoms. The outflow will enter the sea, and therefore pollute the coastal waters even more than was the case beforehand, but that is another problem.
It is imperative that in the new situation an equilibrium is created between the various kinds of land use – among which (intensive) shrimp farming – and the environmental assets, like mangrove forests.
Therefore, the restoration demands more than restoration of the water and soil quality. It will also demand restoration of landscaping and return of vegetation in this barren countryside. It will also mean that the damaged social structure must be repaired, and many families who's income has shrunken dramatically must be assisted financially until they are able again to earn sufficient income on their own.

This is a vast project, that will take a number of years to complete.
Afterwards, maintaining the situation in equilibrium will demand constant watch, and a set of precautionary measures, as well as sanctions for when things threaten to get out of hand.
This will also require an authority or (institute) whose task this is.

All this has cost a lot of money, and will continue to do so for a number of years.
In table 15 these costs are summarized (rough estimates).

Table15. Remediation costs of the devastated area north of Hat Yai

Preparation phase	$
Implementation of the plan:	
Building of the dam	
Adapting canals to divert the water	
Applying the wash-out	
Consolidation phase	
Repairing damaged social structure	
Helping economically marginalized families	
Replanting former mangrove areas	
Lost income through lying fallow of the area	
Unforeseen	

These costs are to be taken as negative income from the shrimp farming industry.
Furthermore, they must be mainly made after the shrimp farms have stopped earning anything.

Eventually, the shrimp farming industry has brought wealth to only a few people (the investors), but the negative effects cost the community a lot of money.

The lesson to be learnt here is, that it would be wiser to invest beforehand in spatial planning, environmental protection and conservation. The money has to be spent anyhow, and it is

better to plan it. Better still, if you spend it beforehand, much less is needed, because keeping the system in equilibrium is much cheaper than repairing it afterwards.

An extra problem surfaced during the implementation of the plan.
The building up of the water level was a success, as was the deviation. But then the water did not flow to the sea as intended. It was retained in the soil of the area. This created a vast marshland. Which is totally unfit for exploitation in any way. Resolving this problem will cost years again, not speaking of the extra amount of money it will take.

In short:
Good environment →small to medium investment (by individuals and the community/government) → sustainable shrimp farming + protected environment = financial and social security for he people.
OR:
Good environment →small investments (by individuals)→unsustainable shrimp farming →bad environment →no shrimp farming→large investments necessary (by the community/government)→outcome???

The choice is easy, I would think!

7. RECOMMENDATIONS HOW TO PREVENT THE BUST PART OF AQUACULTURE AND HOW TO ACCOMMODATE EFFECTS OF THE BUST .

7.1. IS THERE A WAY OUT?

To acquire SUSTAINABILITY, one much reach and maintain EQUILIBRIUM between

- shrimp farming
- other human uses of the coastal area
- safety (against flooding) ("coastline conservation")
- landscape conservation
- biodiversity conservation

This can only be reached by timely **planning**, and rigorously **maintaining** the planned activities.
Such planning requires **knowledge**.

- knowledge of the interrelationships between shrimp farming and other human activities, and the natural conditions that make those activities possible.
- Knowledge about the ways in which those natural conditions can be changed by those human activities.
- Knowledge about the economic feasibility and consequences of different combinations of functions in the area.
- Knowledge of modelling techniques, necessary for the calculation of the effects of scenarios.

ICZM, and more specifically MFSCAD, are frameworks showING managers and planners how to proceed.

7.2. RELEVANT KEY ISSUES

Joe Schittone of UNEP Netherlands, summarized 10 relevant key issues for coastal aquaculture for minimizing coastal and nearshore physical alteration, destruction of habitat, and sediment mobilization:

a. Aquaculture activities should be part of an Integrated Coastal Management and/or Watershed Programme. Planning and \operations should not occur in isolation from other important economic and social interests in the coastal zone (fishing, agriculture, tourism, navigation and ports, etc.).
Integrated management can avoid or resolve conflicts between different economic or socoal needs.
b. Other user groups and interested parties should be able to participate in decisions pertaining to coastal aquaculture activities.
c. Authorities should employ a variety of economic instruments to encourage the aquaculture sector to select options that promote environmental quality and social equity.
d. Aquaculture operations should respect traditional users and foster good community relations.
e. Plans to construct and operate aquaculture facilities should undergo prior EIA (Environmental Impact Assessment) to evaluate potential adverse ecological and social impacts, and, if possible, prevent and minimize them.
f. Siting of aquaculture activities should avoid degradation to coastal and marine biological diversity ans habitats. Aquaculture developers should attempt tp locate their operations in areas already developed.

g. Construction of aquaculture facilities should minimize mobilization of sediments, especially to watercourses.
h. Design and operation of aquaculture facilities should avoid disruption of water flow and circulation.
i. Operations of aquaculture facilities should avoid release of pollutants and not degrade the water quality of receiving water bodies. The goal should be to develop sustainable aquaculture systems with zero release to the environment.
j. Prevent release of exotic species to the natural environment.

To each of these key principles a set and check list of guidelines can be given, to ensure that everything is done to obey the principles, without forgetting some important point of attention.

Ayut Nissapa has formulated the kind of research that is needed to be able to develop, introduce and disseminate cleaner technology methods for shrimp aquaculture, to manage shrimp farming operations in an environmentally sustainable way in terms of reduced total loading of discharge water and reduced salinity of agricultural land and fresh ground water resources.

Research components needed for this:

- Design and construction of test ponds with pollution prevention water treatment system
- Test of technology and equipment in real life shrimp production conditions in the research stations
- Re-design and/or adaptation of the waste cleaning/reducing technology
- Demonstrate economic viability of the adapted waste cleaning/reducing technology
- Train private shrimp producers in operation procedures of the technology
- Dissemination of the technology

7.3. <u>TOOLS.</u>

SAMPAK

SAMPAK is a member of the COSMO-family of models, developed by Resource Analysis in Delft and CZMC in The Hague, The Netherlands and CORIN in Hat Yai, Thailand.
It is a modelling tool that can be used to evaluate the consequences of certain sets of decisions that policy makers may take about the location and extent of functions to be established or changed in a given area. Functions may include agriculture, aquaculture, industry, habitation, nature reserves, etc.
The tool allows to construct a map of the area under consideration.
The user can instruct the tool to use certain interrelations between functions.
Then scenarios are constructed about possible developments within the area (e.g.: the shrimp farming area doubles in the next 10 years; or: a new harbour will be constructed; the imagination of the policy maker is the limit to the possibilities).
The model is then instructed to calculate the consequences of the scenarios. These may be shown as nature area lost or gained (nature conservation), rice paddy area increased (spatial planning), peoples income changed (economy and welfare), the kind of profession that people may aspire in this area (is there opportunity to be fisherman, farmer, industrial worker,….), etc.

This way, a policy maker can form an idea, however imprecise, of the consequences of his decisions **before he takes them**. Although the outcome of the model cannot be a prediction, it shows the direction into which the development of a region may go.

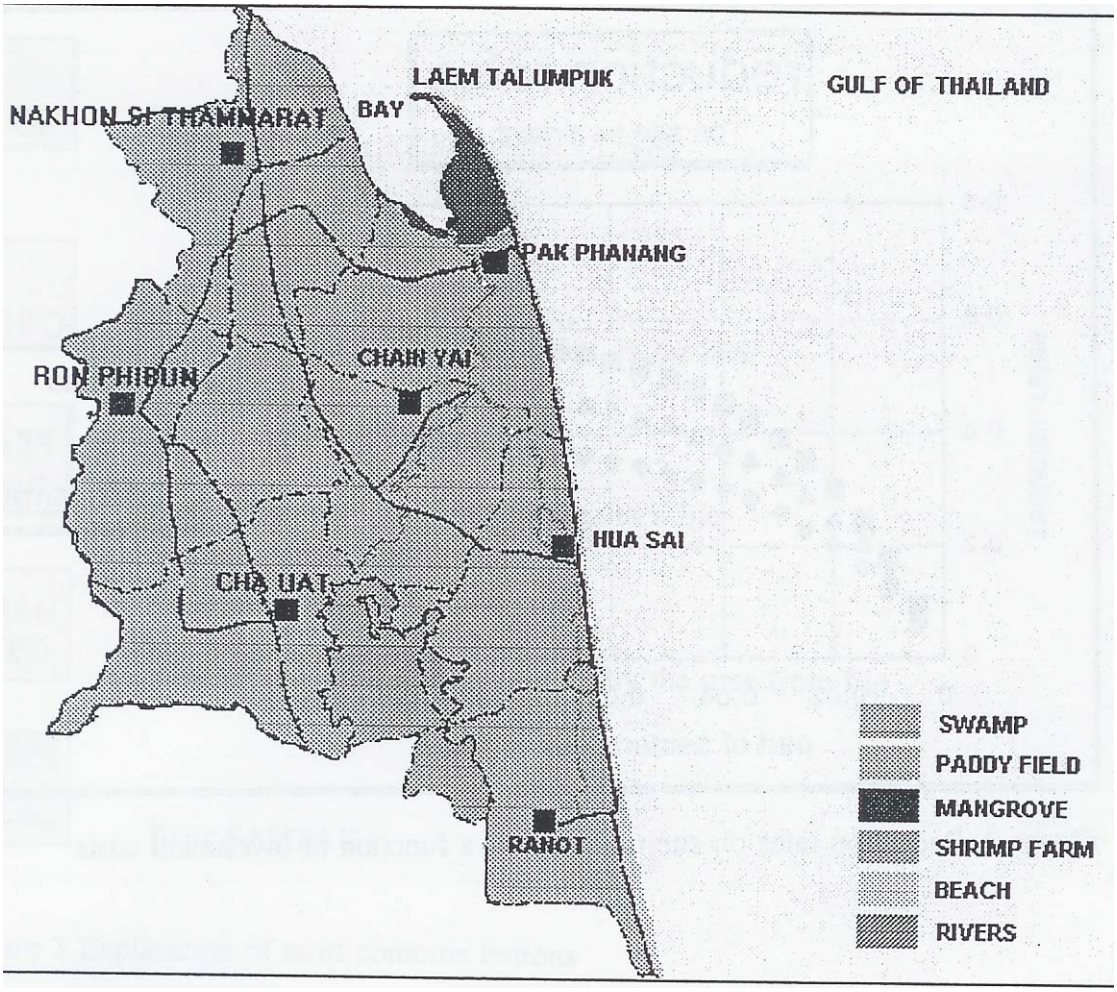

Fig. 15. The Pak Phanang area.

SAMPAK was developed for, and used in the area north of Hat Yai. i.e. the area where the King's project is situated. The name of the area is Pak Phanang. The meaning of the acronym is: Special Area Management Pak Phanang.
Pak Phanang has long been a rice producing wetland area with large mangrove stands. In 1992, the WCMC (Groombridge, 1992) put the area on a list of the most threatened wetlands in Asia, based on information compiled by Scott and Poole (1989). Only two more areas in Thailand were on that list: Gulf of Thailand, and Pa Phru.
It is located on the eastern side of Thailand's southern inthmus. The Pak Phanang river discharges from the south into the bay, which is protected by a small peninsula: Laem Talumpuk. The larger part of this peninsula is covered with mangroves, which provide a natural fish nursery and fishing and crabbing grounds, as well as protection against storms. There is much fishing in the bay, from boats and with standing gear. Inland, just behind the shoreline, there are many shrimp farms, rice paddies, small human settlements, and mangrove protectorates competing for space.

The main problem in the area is constituted by lagging economic development and (consequently) unemployment. The rice farming is not as lucrative as it was in the past. Improved technology, like high intensive farming and more crops a year are only possible

when there is sufficient unpolluted fresh water available. The technology is there, but the water in the area is scarce, polluted, or brackish. Also, because people have left the area for lack of employment, there is a shortage of labourers. This makes planting and harvesting problematic, and therefore farmers have turned to less labour-intensive forms of culture, like vegetables, fruit, and shrimps.

The decision maker using SAMPAK to has to go through 7 steps, thus forcing him

- to think of every conceivable variant in the planning at hand, and
- to make clear choices on the basis of criteria and scenarios

The 7 steps are:
1. Issues and problems
2. Objectives and criteria
3. Formulation of strategies
4. Specification of scenarios
5. Selection and analysis of cases
6. Overview of all cases
7. MCA-ranking of cases

The objective of application of SAMPAK is:
TO ENHANCE ECONOMIC GROWTH THROUGH A SUSTAINABLE USE OF NATURAL RESOURCES OF THE PAK PHANANG AREA.

The program leads the user through a series of screens giving him information about the area and its problems.
Each problem is accompanied by suggestions for solutions.

Three main objectives are distinguished: economy, environment, and living conditions.
(The sustainability of) all three can be measured by a number of criteria. The user may selct criteria from a given list. He may then add weights to the different criteria.

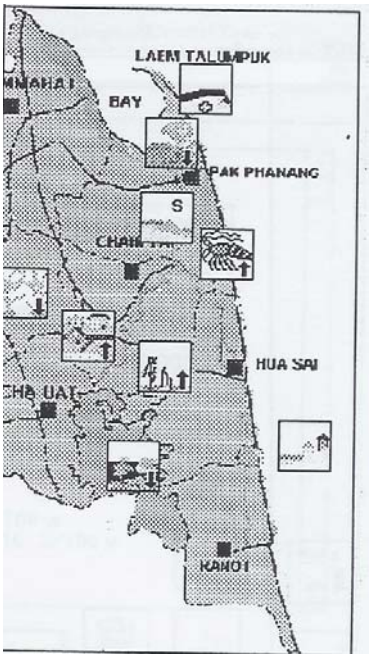

Fig. 16. The Pak Phanang area with the symbols for the distinguished functions

Formulation of strategies means choosing between goals for the three main objectives.
The next steps serve to narrow the strategies down to scenarios and lastly to specific cases. These are defined by attributing quantitative measures to each of the aspects of the three main objectives.

The model then calculates the consequences of the decisions and choices made.
The result is given in a table showing the effects on different aspects of the three main objectives.
All cases considered can then be ranked into a table, showing which case gives the best results for each and all of the objectives.

This result, as well as the results of the other steps, can also be shown in a map of the area. This is a very strong point of the model (and of all related, COSMO-type models): the decision maker may directly see what the consequences of his choices are in a spatial sense. It tells him in which part of the area there will be more mangrove, in which part will the fishermen or the shrimp farmers earn more money, and where is the best place to concentrate industrial activities, build or extend a harbour, or build houses. The very visual part makes it a very strong tool. The description and manual of SAMPAK are part of this module.

8. SOME CONCLUSIONS

LESSONS LEARNED FROM THAI EXPERIENCES

The pattern

1. The main pattern in Thailand has been that shrimp farming moved into an area, mostly coastal because of the easier physical circumstances, shrimp culture boomed, and within a few years fell down again. The consequence was a subsequently abandoning of the farms, which lead to barren and devastated countryside, virtually useless to the people living there and dependent on it.
2. In the process, natural resources as well as potential livelihood for the people were destroyed.
3. Only some investors earned a lot of money.
4. This saddled the authorities up with vast restoration problems, while at the same time social and economic issues had to be addressed.
5. Restoration is expensive – and mostly has to be executed when the financial returns from the shrimp farming had stopped coming in.
6. Good planning, using ICZM and MFSCAD principles, can prevent the bust of the industry, and ascertain sustainability. Moreover, it is much cheaper than restoration.

"Preventing is better than cure".

The planning

1. The main management problem usually comes from the appointed managers themselves (Key Stakeholders) rather than the undisciplined users.
2. Causes are dependent on the institutional system structure more than the technical issues
3. The shrimp farm development should be the demand driven and should support institutional reform through upgrading public functions in order to understand and meet those demands.
4. The conflicts between mangrove foresters and shrimp farmers must be solved by shifting the approach from conservation to sustainable use. The mangrove conservation will be closer to economic needs of the farmers.
5. ICZM and more specifically MFSCAD, is an essential planning tool both at the provincial (national) and district (local) levels. In both cases, bio-physical, spatial and social analysis is required to determine suitable areas for promotion.
6. The emphasis of integrated science and coastal policy researches should be subjected to identify in the MFSCAD plan as essential for rapid and sustainable development of the industry

The tools

Apart from the other tools, SAMPAK, adjusted for any other area, is a very useful way to aim and concentrate efforts to visualize a possible future for the area under consideration.

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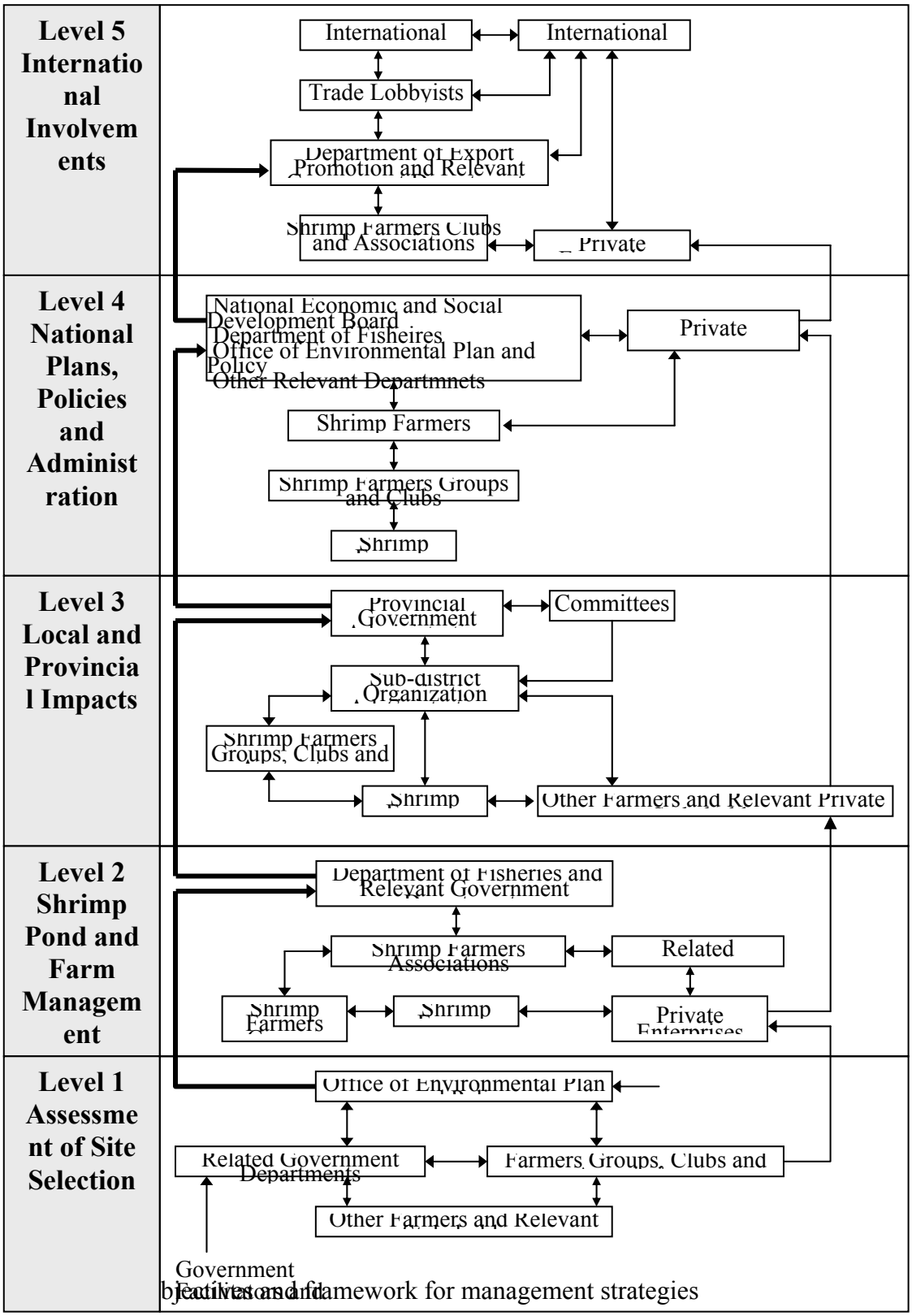
ANNEX 1

Relationships between the 5 levels of MFSCAD, also indicating the proposed actors



bjectives and framework for management strategies

Objective	Framework for Management Strategies
1. To maintain and rightfully increase economic returns	**Level 1** • Site selection criteria • Limitation of growth of fresh water shrimp farming

to shrimp farming entrepreneurs at all levels	**Level 2** • Appropriate water management techniques • Emphasis on economic efficiency (not technical or financial) • Managed stocking density, and uses of others inputs • Chosen closed, semi-closed or open systems according to pond, farm and environmental conditions • Controlled uses of chemicals (fertilizers, antibiotics, additives)
	Level 3 • Increased roles of local administration to impose appropriate taxation system (direct, social and environmental taxes)
	Level 4 • Amendment of laws to support shrimp farming • Clear policy, measures and plans
	Level 5 • Quality assurance (HCAPP, ISO, Green labelling) • New market within Asia and Oceania • Establishment of international cooperations
2. To integrate shrimp farming development plan into the national plans and policies	**Level 1** • Shrimp farming zoning based on physical, socio-economic and environmental considerations • Proper EIA
	Level 2 • Correct estimation of financial, economic and environmental cash flow**.**
	Level 3 • Local administrations' participation in plan and policy setting • Trained local personnels in particular topics relating to shrimp farming • Local monitoring and evaluation of activities related with shrimp farming • Coordination with private enterprises
	Level 4 • Provision of clear channels to integrate shrimp farming development plan into the national plans and policies • Provision of personnel and financial assistance to local administration for the preparation of plans
	Level 5 • Shrimp farming development plan in terms of environmental, social and health concerns is in the national agenda for international market promotion
3. To adopt and implement the FAO of the United Nations' Code of Conduct for Responsible Aquaculture	**Level 1** • Following the Code of Conduct, but adjusting it to fit well with local conditions
	Level 2 • As in Level 1
	Level 3 • As in Level 1

	• Increased local supports to implement the Code of Conduct • Development of specifically local Code of Conduct
	Level 4 • As in Level 1 • Development of specifically national Code of Conduct
	Level 5 • As in Level 1 • Campaigning to show the international community that Thailand takes the Code of Conduct seriously
4. To minimize social problems accruing from the development of shrimp farming	**Level 1** • Social factors are taken into account when performing the tasks (EIA, zoning, landscape design) • Improve pond and farm designs
	Level 2 • Improved pond and farm management to minimize social conflicts • Salinity, water drainage and sludge controls • Social parity management (conducting social functions, social benefit distribution, participation in social events)
	Level 3 • Improved local administration involvement in conflicts management • Increased local authorities to manage the occurred conflicts
	Level 4 • National policies supporting social harmony via informative and informal education • Decisions to conflicts with national benefits as the main goal
	Level 5 • Exhibition of social conflict resolution, perhaps using the Thai ways to the international community • Showing that social harmony is the Thai way of life.
5. To minimize environmental impacts from shrimp farming industries	**Level 1** • Improved aquaculture landscape design • Proper aquaculture engineering (water intake and drainage) designs • EIA is inclusive of every components (economic, social, financial, natural and environmental valuation)
	Level 2 • Constant monitoring of water effluents and sludge from shrimp

	farms • Water intake and settling ponds • Timing of water intake and drainage
	Level 3 • Increased local authorities to monitor and control environmental impacts • Penalties due to violation go to local administration.
	Level 4 • Assisting local administration to monitor and control environmental impacts • Training on the monitoring and control techniques to local personnel • Counterbalancing the enforcement of local authorities
	Level 5 • Showing that Thailand is serious about the environmental impacts from shrimp farming • Showing that local communities are involved in the environmental impact minimization process.
6. To restore environmental quality of the locality where shrimp farming is situated, and larger areas	**Level 1** • Positioning of coastal areas for mangrove rehabilitation programs • Mapping of coastal areas (waters) with varying degrees of environmental quality (endangered species, chemical concentration, mangrove depletion and succession)
	Level 2 • Participation in environmental restoration programs (mangrove rehabilitation, fish and shrimp seed enrichment, dugong, dolphin, sea turtle conservation) • Promoting the environmental restoration programs
	Level 3 • Creating and supporting mangrove rehabilitation programs • General public announcement and encouragement
	Level 4 • Promotion techniques (reward) • Environmental quality restoration is the national policy • Encouragement of research and education programs
	Level 5 • Showing the national policy and its achievement to restore Thailand's environmental quality to the international community. • Using the above strategies as Thai brand names

ANNEX 3
Institutional matters

It is important that in each level of the "Hierarchical Stakeholders" structure, vertical and horizontal integrations of institutions and people involved in the institutions are necessary for the achievement of the goal and objectives.
Shrimp farming development has generated many kinds of institutional involvement such as institutional arrangements concerning rights and rules, and organization arrangements dealing with management of rights and implementation of rules. The shrimp farming industry has created conflicts among economic, environmental and social issues. Economic benefits accruing from shrimp farm operations are on the expenses of deleterious environmental impacts related to the destruction of mangrove forests; the excessive pumping of groundwater in areas farmers prefer freshwater or brackish to salt water shrimp farming; the pollution surrounding farmlands, freshwater rivers and canals; and the dumping of pond sludge in mangrove forests and other inappropriate places. In addition to those environmental hazards, changing traditional beliefs and ways of life; increasingly aggressive consumerism society; increased accidents, drug usage and crimes; unequal distribution of wealth; and social conflicts among the residents have changed the face of Thailand's peaceful and relaxing inheritance. It is clearly that the roles of the institutions and its legal tools to solve the problems, minimize the conflicts, distribute the benefit equally, as well as restore peace to the society are in urgent needs.

Clearly some forms of regulations are required. Initially, the Royal Thai Government (RTG) adopted a benign option by promoting public awareness and advice on environmentally sound farming practices. This approach clearly was having little effect, and in November 1991, the RTG introduced regulations for shrimp farming that the shrimp farmers were to be registered with the Department of Fisheries; farms over 50 rai (8 ha) must be equipped with wastewater treatment or sedimentation pond(s) covering not less than 10 percent of the pond area; water released from shrimp farming areas must contain BOD not more than 10 mg/l (ppm); mud or silt must not be released from the shrimp farming areas into natural water sources or public areas; and salt water must not be drained into public freshwater sources or other farming areas. These regulations were designed to protect local rice farmers and villagers, and shrimp farmers against themselves. It was believed that by reducing the spread of pollutants to the surrounding areas and waters, ideally the problem could be solved. However, unless these direct regulations are enforced, compliance will not be the result.

The Governor of Songkhla province paved the way to solve the environmental problems from shrimp farming by calling on several discussions with representatives of the industry, including the Charoen Pokphand (CP) and Aquastar, and fisheries researchers from the Department of Fisheries and National Institute of Coastal Aquaculture (NICA) to draft more specific provincial guidelines which added to the general Thai regulations. The extra requirements that there be no pumping of artesian well water into shrimp ponds; that drainage pipes must extend at least 10 meters into the ocean; that ponds must be no more that two kilometers from the shoreline and no closer than 100 meters from a fresh water canal; and that there be no digging of ponds in the vicinity of Songkhla Lake. In future permits were to be required from the Harbors Department to install intake or drainage pipes in the ocean, and from the Highways Department for pipes to pass under the coastal roadbed. These provincial regulations show an attempt to get involvement from at least three departments for the issuing of permits. But these regulations are unlikely to be enforced rigorously, as evidences of these regulations violations have been obviously seen. As long as these regulations add an extra

cost to the shrimp farming investors whose motivation of getting short-term profit is prominent, unless these regulations are enforced rigorously and in a manner not hitherto known in Thailand, these regulations will be largely ignored. Certainly, large companies will comply, not only because they are more visible, but also because their investments are such that they are more likely to be planning on long occupancy. The problem is more serious in the case of “hit-and run” investors, who are trying to minimize their costs for the highest profit. Certainly, these regulations must be effectively enforced. Some forms of subsidized assistance may be necessary to untangle the web of water inlet pipes and drainage channels that have resulted from uncoordinated, unregulated piecemeal and shrimp farms development. The public investment, however, should claim the polluter-pay principles.