Thai aquaculture: lessons for shrimp farming

Gains and losses, rehabilitation, coastal cooperation and capacity building

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Summary

Thailand is one of the world's leading shrimp farming nations. Shrimps provide protein-rich food. With the depletion of the ocean fishery resources, shrimp and fish farming become an increasingly important activity.
The rapid development of shrimp farming in the vulnerable coastal zone is accompanied by degradation of the coastal environment and the abandonment of shrimp ponds. Rehabilitation is not always possible and if undertaken, can be very expensive. In order to minimise the negative impacts, it is necessary to protect the natural environment. This is not only important for people and the environment, but also for the continuity of shrimp farming itself. Sustainable shrimp farming should be based on integrated approaches of the coastal resource exploitation. Extensive shrimp culture may be combined with other kinds of land use, such as rice production and mangrove plantations. This demands increasing knowledge of coastal processes and strengthening integration between institutions and stakeholders. Capacity building at national and local level is important, some tools are provided and can be downloaded (see CCC V-1).

Black tiger shrimp *- Penaeus monodon.*
(photo: CORIN - Coastal Resources Institute, Hat Yai, Thailand)

1. Introduction

Coastal regions provide a rich and diverse natural resource. Fisheries are important providers of protein rich food for coastal inhabitants. However, intensive fishing has led to a situation where more than 30% of the world fish species are overfished. Commercial fisheries can no longer guarantee a sufficient food supply, certainly not in the future with a growing human world population.
Aquaculture such as shrimp farming is therefore an increasingly important coastal activitiy.
In 2002, the world shrimp farming production was about 1.6 million metric tons (Chamberlain, 2003). The majority taking place in South-East Asia: China, Thailand, Vietnam and India together produce more than one million metric tons of shrimps annually. The shrimp culture has developed exponentially.

Species

The dominant species is the giant black tiger shrimp (*Penaeus monodon*) with a relatively short growing period, great adaptability to salinity changes and a high market price. It is followed by the white penaeid shrimps, often less valuated, (*P. merguiensis* - banana shrimp, *P. indicus, P. chinensis*) and the dominant species in the Western hemisphere *P. vannamei, P. penicillatus* (like the white shrimp) and *P. semisulcatus* (green tiger prawn) are also farmed. The giant black tiger shrimp production worldwide peaked at almost 600,000 metric tons in 1995 and has since declined due to several diseases, as well as the decreasing quantity and quality of wild breeding stock.
The production per ha of the white shrimp (*P.vannamei*) is getting higher than that of the black tiger shrimp, as demonstrated in the 2000s by Wyban (2007).

Inefficient resource use

The rapid development of coastal aquaculture in the vulnerable coastal zone causes conflicts and inefficient resource use. Consequently the degradation of coastal environment increases, leading ultimately to abandonment of shrimp ponds. Rehabilitation is not always possible and if undertaken can be very expensive. The effects of rapidly developing shrimp culture are well documented in Thailand, and several lessons can be learned. This chapter shows how the boom-bust cycles in Thai shrimp culture developed, as well as some of the effects and integrated solutions for their sustainable shrimp farming in the future.

2. Shrimp farming in Thailand

Thai history

Shrimp culture has a long history in Thailand. About 60 years ago a sudden fall in salt prices, encouraged the coastal salt farmers to diversify their activities. They converted the saltpans into shrimp ponds and mixed several species of shrimp and fishes. Controlling production and larvae growth in the 70s put shrimp culture on a development path based on intensive and specialised production. In the 1990's, this intensification made Thailand the world's largest producer, with more than 25,000 farms, covering 80,000 ha and 250,000 metric tons of annual shrimp production. From 1972 to 1999, the area of Thai fish farms increased by a **factor of 8** and the production increased by a **factor of 200** (Figure 1). A maximum production value of 3.7 metric tons of shrimp per hectare was reached in 1994, followed by a stabilising or decreasing trend.

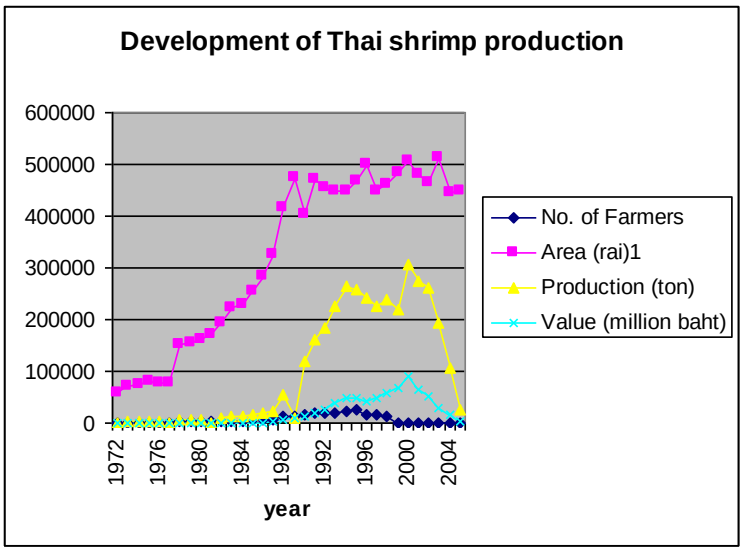

Figure 1 : ***Strong intensification of production of the cultured Black tiger shrimps****, during the 1990s ; 1000 rai = 1.6 km² ; 1 US$= 34 Thai Baht. (source: R. Leewis & S. Boromthanarat)*

This very high level of intensified shrimp production is unprecedented in the world and made Thailand the leading shrimp farming nation in the world exporting the most shrimp in terms of volume and value.

After 2000, the production of the black tiger shrimp decreased considerably, while the production of the pacific white shrimp *(P.vannamei)* increased. This reached such a level that Thailand became one the world's leading suppliers of the white shrimp. A key factor of Thailand's success with *P. vannamei* was their controlled brood stock imports to ensure sufficient supplies of true specific-pathogen-free white shrimp (SPF *P. vannamei),* (Wyban, 2007a). In the years following the introduction of the SPF *P. vannamei,* the production of shrimps exceeded the 1990's level. In 2006, *P. vannamei* represented over 98% of Thailand's total production and the production is nearly 400,000mt. (Wyban 2007b).

Intensive farming

About 95% of the shrimp farms in Thailand are now under intensive production. The majority of the intensive farms use the semi-closed system. Only a few extensive farms are still in existence and there are almost no semi-intensive farms (Huitric et al. 2000). The value of the Thai cultured shrimp production has increased considerably from 20 to 90,000 million Thai Baht during the period 1972 – 1999.

The contribution of the shrimp farming to the Thai GDP is about 2% (2002) and constitutes about 3% of the Thai export volume.

The Boom-Bust cycles in Thai shrimp farming during 1972 - 2000

Boromthanarat & Nissapa (2002) summarised the development of the shrimp farming industry in Thailand from the early 1970s, and distinguished three series of "Boom - Bust" cycles. The Bust (= abandonment) is followed by moving to the south and west migration of the shrimp farm waves (see Figure 2).

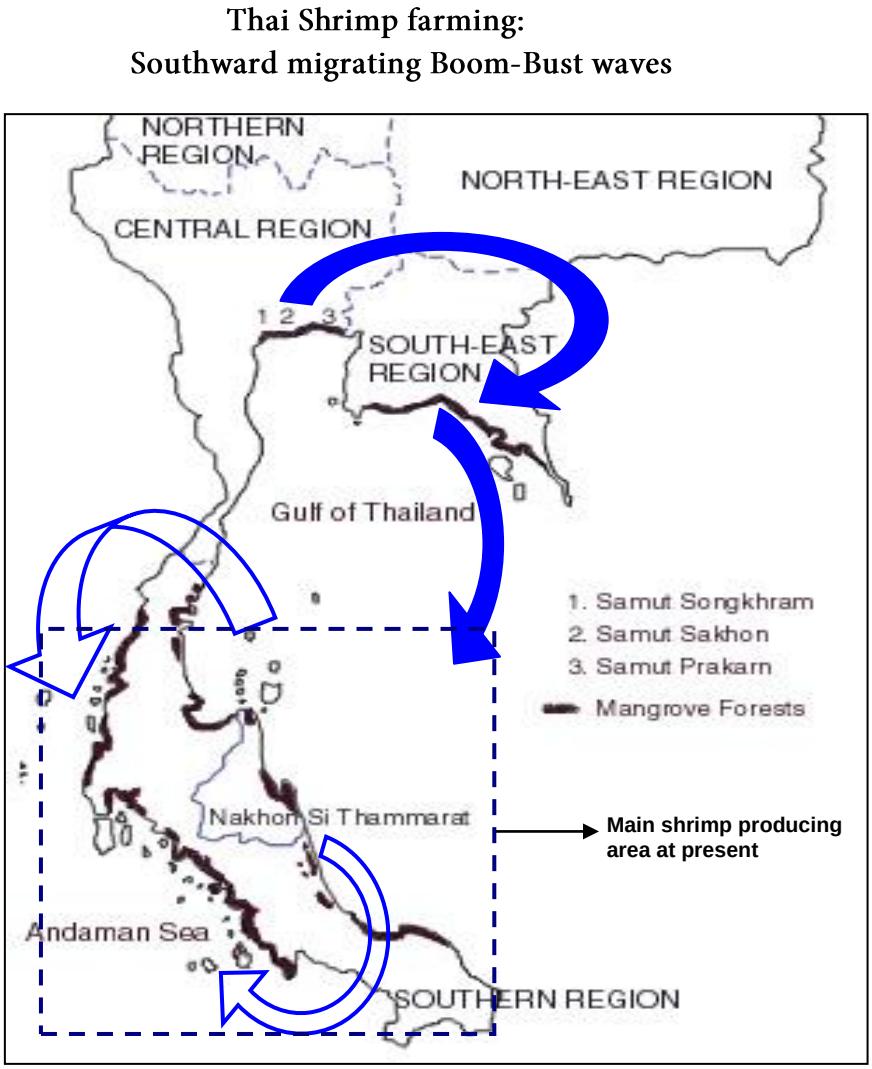

*Figure 2: **Shrimp farming development** in Thailand with southward migrating Boom-Bust waves, reaching the southern province of Nakhon Si Thammarat along the Gulf of Thailand and the coastal areas of the Andaman Sea. (source: S. Boromthanarat)*

The following Boom-Bust observations were made:

1) The Thai national shrimp farm statistics show only small changes in the periods of 'local' cycles of Boom and Bust. This is due to the quick response of the shrimp farm industry: boom, bust and move to the south of Thailand. This short cycle provides large economic return but is accompanied by severe resource depletion. Three periods can be distinguished in the mid 1970s, the 1980s and mid 1990s;
2) The astonishing rate of intensification during the end of the 1980s and first half of the 1990s, and the first part of the 2000s, resulted in a high production level per hectare (reaching almost 4 ton/ha by the end of the 1990s and is rapidly increasing again). Severe negative consequences have been observed: long lasting, detrimental environmental impacts, and social disruption in the abandoned pond areas;
3) The Thai awareness of the consequences of this very high level of intensification of shrimp farming, led to experiments with modern, more extensive farming at beginning of this millennium;
4) The abandoned, barren and contaminated shrimp farms are difficult to restore. It is easier to initiate a new, short cycle by 'simply' moving to new, southern coastal areas.

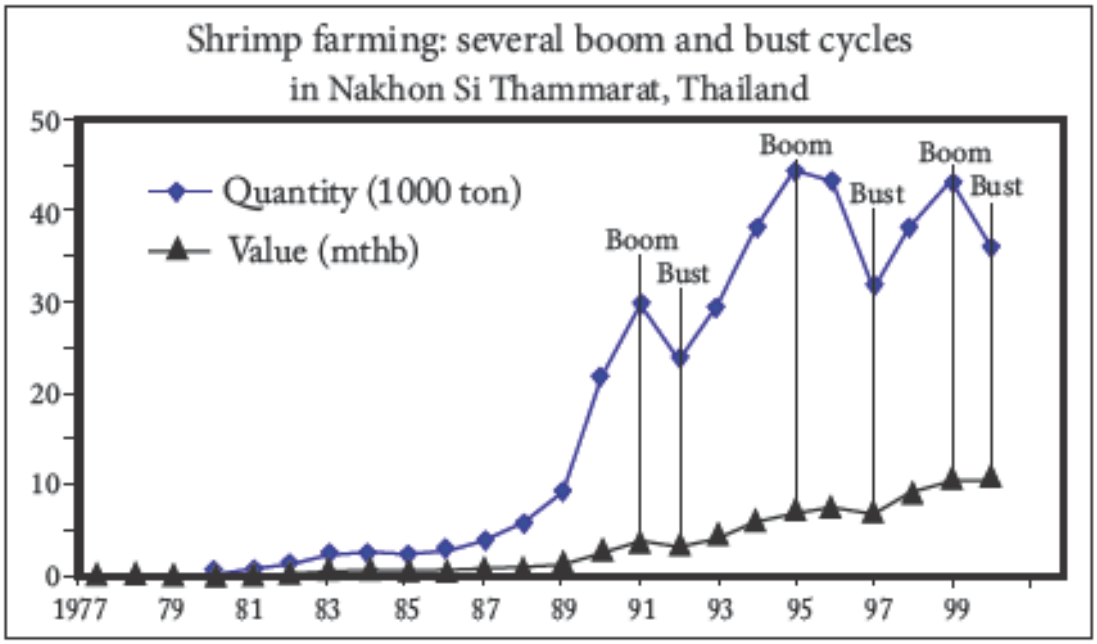

Figure 3: ***Several boom and bust cycles: shrimp farming development in the province of Nakhon Si Thammarat*** *(qty = quantity). The smooth increasing value curve (mthb = million Thai Baht) is also influenced by external world market prices. Major causes of the bust are often environmental degradation and subsequent diseases threatening the exploitation of the shrimp ponds. (source: S. Boromthanarat)*

3. Impacts of Shrimp Farming on Coastal Resources

Land conversion & habitat degradation

In 1995, about 40% of coastal land area in southern Thailand was covered by shrimp farms. The preferred areas are the low-cost lands (Funge-Smith & Stewart, 1996). Shrimp farms have to be located near the sea to facilitate the exchange of water with the sea.

The previous land uses before shrimp farming in southern Thailand are rice paddies (50%), fruit and vegetables, mangrove and wetlands (15%), waste land and extensive shrimp farms (Lindberg & Nylander, 2001). Shrimp farms are responsible for an estimated 30% destruction of the Thai mangroves (Tookwinas, 2001, pers. comm.).

Pollutants

Pollution from the shrimp farms largely involves water pollution due to excess use of food, fertilisers, antibiotics, pesticides, and the dumping of sludge from the shrimp ponds. Although the pollution from shrimp farm water is considerably less than from domestic or industrial water, the effects are important. Another problem with shrimp ponds

in mangrove areas is the potential acidity of the soil. The clayey soils often contain sulphuric compounds like pyrite, which become highly acidic when exposed to air. This happens every time ponds are allowed to dry out (in the belief that undesirable substances will be baked out by the sun). It is even more significant when ponds dry out after abandonment.

Large scale abandonment

The explosive development of the highly intensified and profitable venture (shrimp farming) has left a large number of abandoned ponds in Thailand. In 1994, there were 20,800 ha of abandoned shrimp ponds (Anon, 1995). A later report (Kaosa-ard and Wijukprasert, 2000) stated that around 40,000 ha of shrimp farming areas in the Upper Gulf of Thailand alone became abandoned during the second bust period, which forced 90% of the local farmers out of business. In the Upper Gulf of Thailand (Hossain, 2001; Hossain & Lin, 2001) some abandoned areas were restored to extensive shrimp farms, salt farms and rehabilitated mangrove, at great cost and effort, and with varying success.

Large-scale abandonments leave behind barren land without livelihoods for the coastal people left behind and have severe environmental and social consequences.

Social impacts

The conversion of mangroves and rice paddies to shrimp farms is often accompanied by a sequence of social degradations: breakdown of traditional livelihood support systems, leading to the marginalisation of the rural poor; increase of landlessness and poverty; and transfer of land and wealth to local and national elites, strongly benefitting from shrimp culture. Small-scale shrimp farmers, however, are often afraid to invest in shrimp culture due to diseases, debts and other social constraints. Conversion without sufficient knowledge or access to capital is often a source of failure in shrimp culture.

Saltwater intrusion from shrimp ponds and brackish water aquaculture to agriculture land such as paddy fields is also an important source of conflict: Rice yields decrease too such an extent that farmers have either to abandon their land (and often leave the area) or to convert it into shrimp ponds. The salinisation of ground water is another consequence of uncontrolled discharge of saline pond water (Primavera, 1998), reducing domestic and agricultural fresh water supply.

4 . Sustainable Development and ICZM

Sustainability for shrimp farming mainly requires two things:

1. Obtaining a reasonable economic return from the activity, enabling farmers and supporting industries to attain a reasonable standard of living and incentives for making long term investments;
2. Minimising the negative social and environmental impacts of shrimp farming is not only necessary to protect the natural values and their "services" for humanity, but is also of vital importance for the continuity of shrimp farming itself. The basis for this lies in the quality of water and soil, and in the continuing prospect of being able to catch larvae or adult specimens in the wild. This means that the quality of the habitats in the sea is important too.

ICZM

During the last decade, it has been realised that not only having adequate resources, but also institutions, management and stakeholders are integral to successful shrimp farming activities. Sustainable shrimp farming development using integrated planning tools has become the main concern in the new millennium. These efforts are directed at integrating public participation, policy dialogue and international networking within the context of Integrated Coastal Zone Management (ICZM).

ICZM now faces two important issues related to shrimp farming:

- In areas that already have shrimp farms: restore the abandoned shrimp ponds, the surrounding landscape and the natural values into the 'natural' situation; restore basic conditions and original 'environmental services'.
- For new shrimp farms: avoid the degradation of farming practices; maintain the equilibrium between the various land uses, including the natural biodiversity.

5. Some examples of integrated approaches

Pak Phanang Royal Project

In 1997, the King of Thailand ordered the restoration of the devastated aquaculture area of the second phase of decline, in the Pak Phanang basin in the province of Nakhon Si Thammarat. The King's order made it possible to give thoughts, manpower and money to achieving this. The Pak Phanang River Basin Development Project is initiated not only to solve the problem of seawater intrusion into the Pak Phanang River and its tributaries during the dry season but also to supply fresh water for the people by functioning as a fresh water storage reservoir to support agriculture uses and daily consumption as well as to prevent the flooding. Moreover, the Project offers solutions for solving the conflicts between shrimp farmers and rice farmers, and in turn, promotes the harmonious co-existence among the people and nature so as to bring about sustainability.

The project is located in the Nakhon Si Thammarat province (see Figure 2) covering about 2,000 ha., which is only 5% of the 40,000 hectares of abandoned ponds in the Upper Gulf of Thailand, as estimated in 2000. The project uses the surplus fresh water from the river Pak Phanang. This surplus water is collected by the construction of a large barrier in the mouth of the river. The actual execution of project started in 1999 and cost about 100 million $, excluding the construction of additional waterways .The water is subsequently diverted to the devastated areas of former aquaculture, and washes out the polluting substances, which are fixed to the clayey sediments of the bottom aquaculture ponds. The outflow then enters the sea. In some areas, proper drainage presents a technical problem, which will take several years to resolve.

Lastly, in the consolidation phase, social structures will be repaired, marginalised families helped and mangrove systems replanted. The rehabilitation costs are high in comparison to the extent of the rehabilitated area.

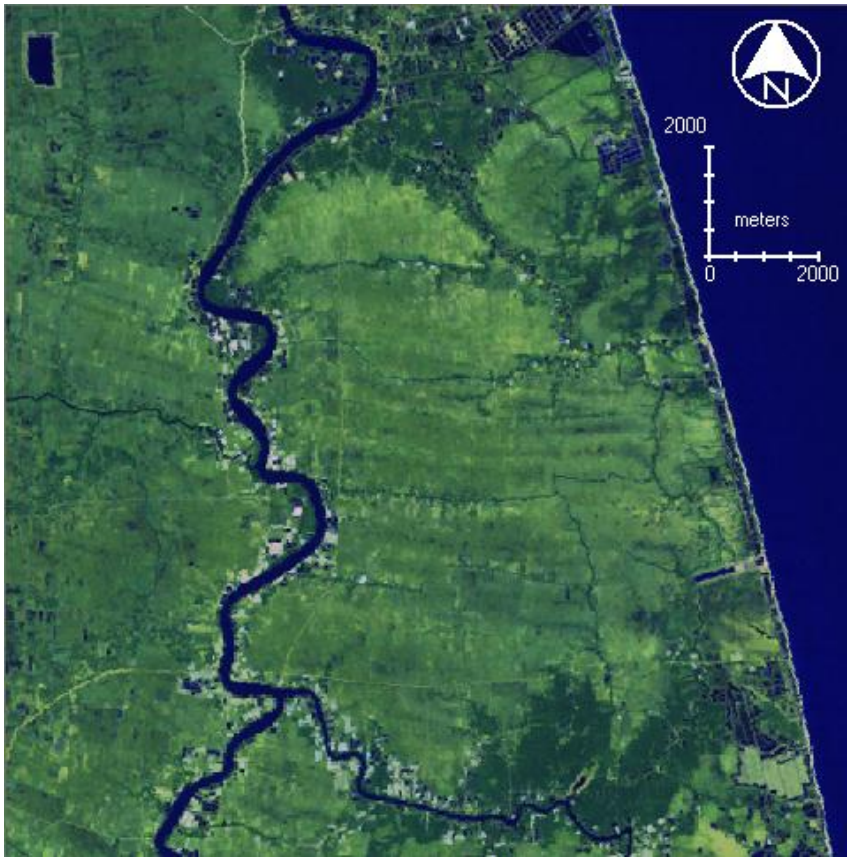

*Figure 4: A part of the **Pak Phanang area, before the very intensive shrimp farming** started (photo: Processed Landsat TM Image , 1994 – GLCF)*

Figure 5: ***Image of partly abandoned shrimp farms****, Pak Phanang area (district Rawa, 60 km north of Songkla), Nakhon Si Thammarat Province. (photo: Google Earth: Image ©2008 DigitalGlobe Image ©2008 TerraMetrics ©2008 Tele Atlas ©2008 Europa Technologies)*

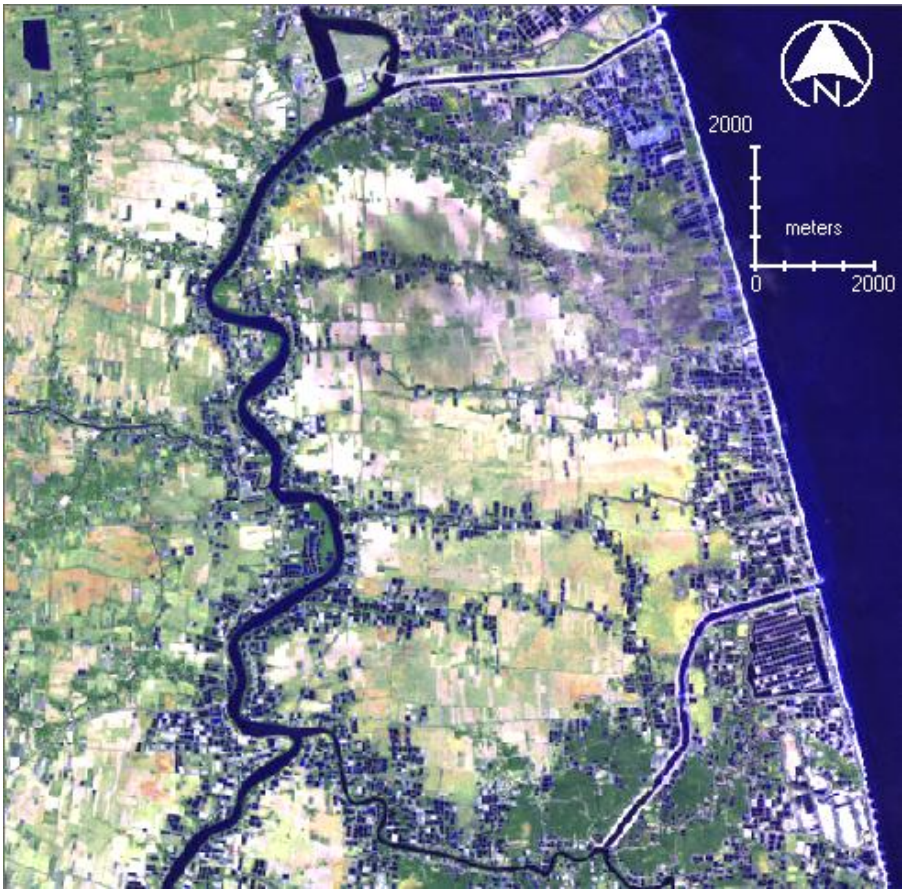

Figure 6: ***The river Pak Phanang and the coastal zone.*** *Areas after abandonment of the no longer productive shrimp farms in the coastal zone: the barren coastal plain is not providing any livelihood for the orginal coastal inhabitants. (photo: Processed Landsat TM Image, 2002 – GLCF)*

Seawater Irrigation Projects

These projects support the key policy for sustainable shrimp farming put forward by the Thai Department of Fisheries (DOF). Its primary purpose is to manage seawater supply and farm effluent discharges. The tiger shrimp farms under the responsibility of this project are given good quality seawater and the system collects effluents from each farm for further physical and biological treatment.

Four operating seawater irrigation projects provide models for improved farm management (see a.o. Tookwinas and Yingcharoen, 1999). The Kungkrabane Royal Project in the east of Thailand is the best example. The success of such projects is based on (i) original acquisition of land, (ii) sense of ownership of the farmers in the project, and (iii) communal leadership. The DOF supports project implementation in terms of both investment and operating costs.

Shrimp-mangrove experiments

Attempts have been made to integrate shrimp farming and mangroves into an ecologically robust system, such as incorporating the mangrove buffer zone in Kanchanadit district, Surat Thani province . This coastal province is the largest of the southern provinces of Thailand and located on the Gulf of Thailand north west of the Nakhon Si Thammarat province (see Figure 2). The contribution of mangrove to shrimp farming lies in its capacity to act as a bio-filter for shrimp farm effluents, which improves water quality. The filtering capacity of mangroves can only be successful if the density of shrimp ponds is low and the ratio of mangrove area to shrimp ponds is high. Only in this way it is possible to filter the nitrogen and phosphorous loading adequately from an intensive shrimp farming system (Robertson and Phillips, 1995). The positive findings regarding the bio-filtering capacity of mangroves are confirmed by Gautier (2002) along the Caribbean coast of Colombia.

Shrimp Central Markets

Before the 1990s there was only one privately-owned shrimp central market in the Mahachai district of the province of Samut Sakhon in central Thailand. In late 1990s two new shrimp markets in the south of Thailand were approved by the Thai Cabinet: one in the Pak Phanang district of the Nakhon Si Thammarat province (government-shared), and one in the Phun Phin district of the Surat Thani province (privately-owned). The establishment of these new markets reduced transportation time and costs, facilitating preservation of the freshness of the shrimps.

Bringing the markets nearer to the production and processing sites may also serve to guarantee that financial benefits will eventually be equally distributed among all stakeholders in the shrimp industry (Nissapa and Boromthanarat, 2002).

Residues Inspection & Shrimp Product Certification

The Department of Fisheries has coastal aquaculture centers and stations in all 22 coastal provinces. These have as one of their responsibilities the monitoring of the coastal environment in marine shrimp farming areas. The data obtained are utilised for designing technical advice to farmers. Shrimp, water and sediment in culture ponds are checked regularly for antibiotic residues. In addition, the harvested shrimp are also inspected for antibiotic residues and hygienic checks in order to be able to issue a product safety certificate before export.

6. Integrated Planning Tool: SAMPAK

Special Area Management Pak Phanang (SAMPAK) is an integrated simulation tool, GIS based, that can be used to evaluate the consequences of coastal management measures, prepared and determined by policy- and decision makers. The objective in the application of the tool is to enhance economic growth through sustainable use of natural resources of the Pak Phanang area.. SAMPAK is a member of the COSMO-family of GIS simulation models, (see CCC III-3-2-2) a co-production of the Netherlands (RA & CZM-Centre, the Netherlands) and Thailand (Coastal Resources Institute, Prince of Songkla University, Hat Yai, Thailand).

The user of SAMPAK has to go through 7 steps from identifying issues and problems to ranking results using MCA (Multiple Criteria Analysis, see Figure 7) and is thus forced:

* To think of different ways of looking at planning opportunites, and
* To make clear strategic choices on the basis of criteria and scenarios.

The tool allows the construction of a map showing the results of the model in the area under consideration. This very visual aspect makes it a strong tool (see Figure 7).

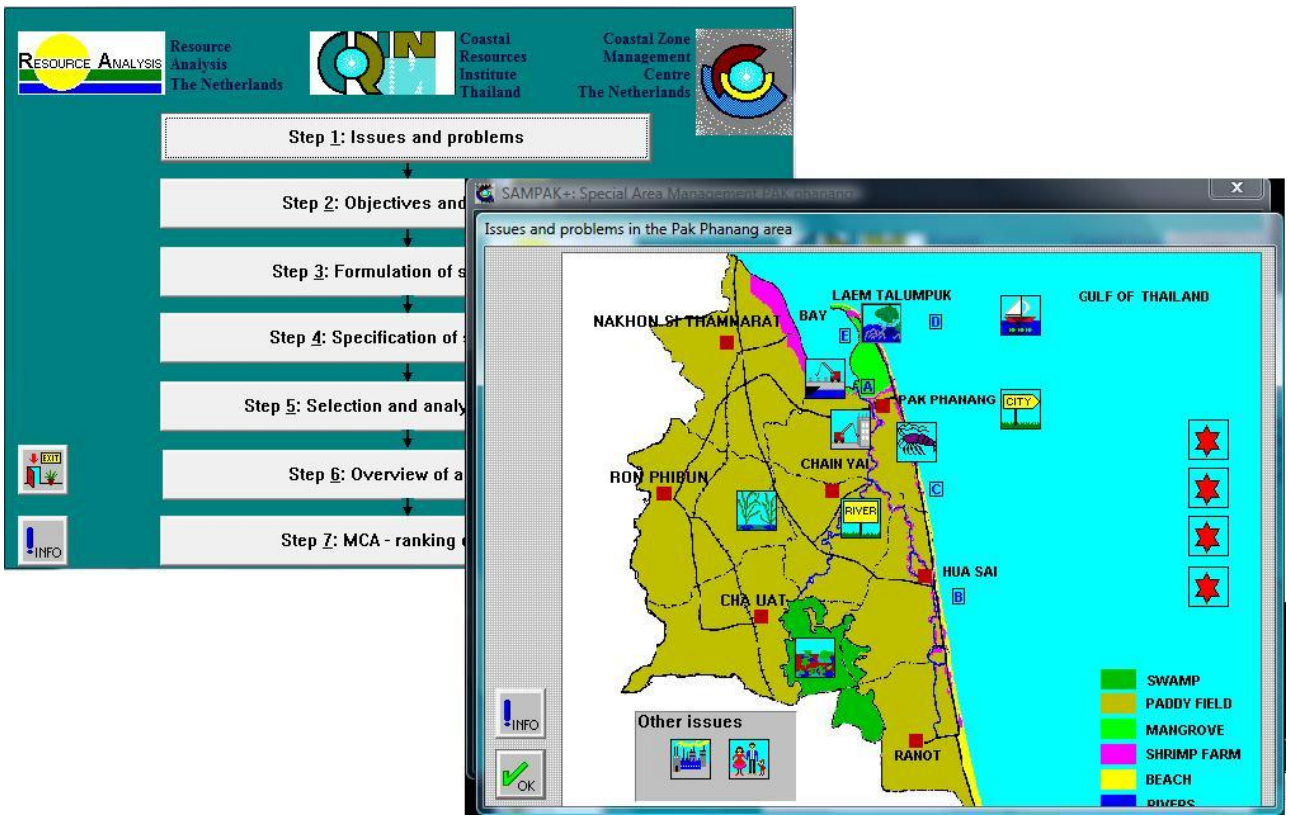

Figure 7: ***Screendump from SAMPAK***

Using this, a policy maker can have a rough idea of the consequences of a decision during the planning phase before the decision is taken! The outcome of the model is not a prediction; it shows however, the direction the development of a region is likely to go.
A Demo-SAMPAK application (see CCC III-3-2-2) can be free-of-charge downloaded as member of the COSMO – (Coastal Zone Simulation Model) family see CCC V-1-2-1.

7. Capacity building: Lessons learned – training manual

The experience of more than 70 years of shrimp farming in Thailand constitutes a very valuable learning school for other Asian shrimp farming nations.
This awareness formed the basis for developing an ICZM-aquaculture training module, based on the design and testing of a provincial level coastal aquaculture programme. This Training Module was developed by Leewis and Boromthanarat (2003) for the Coastal Cooperative Programme in Vietnam (CCC II-8) and can be downloaded, see CCC V-1-1-2.
It shows the position and development of Thai and other Asian countries shrimp culture against the background of world production figures. It then illustrates the detrimental effects on ecology and (local) economy of mismanaged shrimp culture ponds. Some rehabilitation projects are shown, but the most important part of the module is the identification of the measures that have negative effects and hence should be avoided , if a sustainable shrimp farming industry is to be achieved.

8. Conclusions

Shrimp farming provides protein-rich food. With the depletion of the ocean fishery resources, aquaculture becomes increasingly important. Thailand has more than 70 years of experience with shrimp farming and thus has much to offer in developing an environmentally sustainable industry.

In summary the main developments of Thai shrimp farming are:

- It adds to economic development and constitutes: 2 % of GDP, 3% of the Thai export;
- Most of the farms are of the intensive type with an average annual production of more than 4 metric tons of shrimps per hectare;
- A cycle of intensive shrimp farming in a particular coastal area can only be carried on for a short time: after only a few years it moves from: boom→bust→abandonment of barren ponds→move to exploit new coastal areas;
- Abandonment encompasses large coastal areas: more than 40,000 ha of coastal zone in the southern Gulf of Thailand alone and includes long lasting, detrimental environmental impacts and social disruption in the abandoned areas;
- Rehabilitation undertaken by the state is complex and costly, and not always successful;
- The production level of more than 4 tons of shrimps/ha/year can be considered as a non-sustainable resource exploitation, because of the large scale damage. Rehabilitation is costly, while the gains of short term, intensive shrimp farming production are modest expressed as contribution to the Thai Gross Domestic Product;
- Experiments are being explored by the Thai government in new ways of cultivation, which stress integrated approaches to management (applying ICZM principles);
- These 'new ways' demand an improving knowledgebase of natural coastal processes and socio-economic conditions as well as strengthening integration between relevant national and provincial institutions and local stakeholders;
- Capacity building at national and local level is important, some tools are provided: SAMPAK and Training Manual with lessons from Thailand.

The shrimp farming industry has brought wealth to a few people (mainly the investors), but the negative effects cost the local communities and national government large sums of money.

The main lesson to be learnt is, that it would be wiser to invest beforehand in spatial planning, improved farm management and environmental protection.

By extensive shrimp farming, in combination with other land uses such as rice production or mangrove forests, the destruction of coastal ecosystems can be avoided. The experiments in Thailand help increase our knowledge of sustainable shrimp farming based on integrated approaches to coastal resource exploitation.

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- **GLCF – Global Land Cover Facility :** http://glcf.umiacs.umd.edu/index.shtml

Relevant powerpoint presentations - see CCC-V-1-1-2:

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- **Leewis, R.J. and S. Boromthanarat:** Shrimp farming experiences in Thailand.