UPTEC W10 008
Examensarbete 30 hp
Februari 2010

Sveriges
lantbruksuniversitet

Trans-disciplinary evaluation of mangrove plantations in Pak Phanang Bay, Southern Thailand

Transdisciplinär utvärdering av mangroveplanteringar i Pak Phanang, Södra Thailand

Peter Larsson

"Where else can one find trees
which walk out over the water
and grow roots upwards,
seeds which germinate
before they fall from the parent tree,
fish which hop about in the mud
and climb trees,
and monkeys which eat crabs?"

Thom Henley, 1998

ABSTRACT

This study was conducted within the EU MANGOVE project in the spring of 2009. The aim of this report was to uncover the effects, both physical and social, of mangrove plantations in Pak Phanang Bay, South East Thailand. Another aim was to identifying important organisations and groups active in the process. The information presented in this report is based on interviews, GIS remote sensing, literary study and field observations. Extra focus was put on three coastal communities that are dependent on mangrove recourses.

The study showed that the increased focus, since the mid 1990's, on mangrove and its positive effects has led to a number of mangrove plantation programmes in Pak Phanang Bay. Areas that have been planted are abandoned shrimp ponds, riversides and previously unvegetated mudflats in the delta. This has resulted in an increased mangrove area in Pak Phanang Bay during the same period. Plantations have been performed with one or few species of mangrove. This has likely induced a shift in mangrove species composition on a local scale. Plantations have also likely changed the inner coastline morphology of the bay. The water mangrove edge on the western side of Pak Phanang Peninsular has gone from a rugged coastline to more smooth, as a result of mangrove plantations.

A number of organisations have been active in mangrove plantations in the study area. Organisations active in plantations differed between the three communities. The awareness of the benefits with mangrove was rather unanimous amongst people and participating in mangrove plantations on all levels. For local communities these were mostly secondary benefits. Products associated with mangrove, for local villagers, are increased area for finding shrimp, crabs and fish. There was no possibility for communities in Pak Phanang to legally cut mangrove as a sustainable resource of wood. According to this study the way mangrove plantation projects were performed was found to be similar regardless of the intention or goal of the project.

Key words
Mangrove, plantation, rehabilitation, Pak Phanang, trans-disciplinary, CATWOE, stakeholder, remote sensing

Environmental Communication, Urban and Rural Development, Swedish University of Agricultural Sciences, SLU, Ulls väg 28 A-B, SE-756 51 Uppsala, Sweden

Referat

Denna studie genomfördes inom projektet EU MANGROVE under våren 2009. Målsättnigen med rapporten var att visa effekter, både fysiska och sociala, av mangrove planteringar i Pak Phanang, Sydöstra Thailand. I undersökningen har också organisationer och grupper aktiva inom eller påverkade av planteringar identifierats. Informationen som presenteras är baserad på intervjuer, fjärranalys och litteratur. De lokala intervjuerna genomfördes i tre byar vars befolkning var beroende av produkter associerade med mangroveskog.

Studien visar att de senare årtiondenas ökade fokus på mangroveskog och dess positiva effekter lett till flertalet planteringsprojekt i Pak Phanangbukten. Planteringar har genomförts i övergivna räkodlingar, i kanterna av vattendrag samt tidigare obevuxna tidvis översvämmade gjyttjehällar. Detta har lett till att arealen mangroveskog har ökat sedan senare delen av 1990-talet i Pak Phanangdeltat. Planteringar har skett med en eller få antal arter av mangroveträd. Detta har troligtvis påverkat artsammansättningen samt artrikedomen på platser där planteringar har genomförts. Studien visar att sättet mangrove planteringar utfördes på var oberoende av målsättningen med planteringsprojektet. Mangroveplanteringar har även troligen ändrat kustlinjen i Pak Phanangbukten. Insidan av Pak Phananghalvön har blivit kortare med mindre nodulerad som ett resultat av mangroveplanteringar.

Flera organisationer var aktiva inom plantering av mangrove i Pak Phanangbukten. Vilken roll organisationerna spelade skiljde sig mellan de tre byarna. Uppfattningen om fördelarna med mangroveskog och plantering av nya träd var relativt lika i de tre byarna och bland aktiva organisationer. Lokalbefolkningen har ingen direkt vinst av mangroveskog utan nyttan för bybor är i första hand sekundär. Ökad yta mangroveskog ger ökad area där bybor kan samla fisk, krabbor och räkor. Det kan här påpekas att det finns ingen möjlighet för bybor att lagligt avverka mangroveskog för kommersiella syften.

Nyckelord
Mangrove, plantering, rehabilitering, Pak Phanang, trans-disciplinär, CATWOE, stakeholder, fjärranalys

Miljökommunikation, Stad och Land, Sveriges Lantbruksuniversitet, Ulls väg 28 A-B, SE-756 51 Uppsala

PREFACE

This Master thesis (30 ECTS) was conducted as part of work package 5 and 8 of the EU MANGROVE programme entitled "Reconciling Multiple Demands on Mangrove Resources". This portion of the EU MANGROVE project was managed by Stockholm Environment Institute (SEI). The field work was performed with staff from the Stockholm Environment Institute, the Coastal Resource Institute Asia (CORIN Asia), Prince of Songkhla University, office in Pak Phanang. The information gained from the fieldwork provided background information for a stakeholder workshop held in Nakhon Sri Thammarat, 12-13th of June 2009. For more information about the project and workshop see appendix 1.

The thesis was supervised by Neil Powell, Swedish University of Agricultural Sciences (SLU) & SEI, and Maria Osbeck at SEI Asia Office.

I would like to thank Neil Powell and Maria Osbeck for providing me with this opportunity. Maria Osbeck deserves an extra thank for always being available and dependable for in-depth feedback. I would also like to send a big thank to Piya Wanpen as well as the staff at the CORIN Asia, Pak Phanang office. You really made me feel welcome as well as providing an insight to the Pak Phanang area I could not have obtained otherwise. All interviews and transcript writing was performed with "Charm", Payungsak Aiedkaew, interpreting and also guiding me all over the region, far beyond your job description. The literary search on organisations involved in plantations was largely conducted with Lauren Miller, Michigan State University. Many of the maps and handy tips on the selection of remote sensing methods were given to me by Wichai Pantanahiran Assistant Professor at Srinakharinwirot University. You are truly a catcher in the rye! I would also like to thank Dr. Somsak Boromthanarat head of CORIN Asia for providing insightful information helping me to understand the complex interaction between coastal and inland systems in Pak Phanang. CORIN Asia also provided accommodation and office space and facilities during my field work.

Digitalized flight images of the study area were obtained from Department of Lands in Nakhon Si Thammarat and Sinakharinwirot University in Bangkok.

Last I would like to thank all those that participated in the interviews and often went out of their way to provide me with information.

UPTEC W 10 008, ISSN 1401-5765 Printed at the Department of Earth Sciences, Geotryckeriet, Uppsala University, Uppsala, 2010.

POPULÄRVETENSKAPLIG SAMMANFATTNING

Transdisciplinär utvärdering av mangroveplanteringar i Pak Phanang, Södra Thailand

Peter Larsson

Mangroveskogar fyller många syften för både natur och människa. Kustnära mangrove skyddar till exempel stränder mot erosion, fungerar som barnkammare åt yngel och är habitat för flera ekonomiskt viktiga land- och vattenlevande djur. I Sydostasien har dock arean av mangroveskog halverats under den senare delen av förra århundradet. Detta beror på en ökad befolkning, framväxt av räkodlingsindustrin, eroderande kustområden och dåligt upprätthållande av lagar. Nu har den ökade vetskapen om konsekvenserna av avskogningen lett till ett åter- och nyplanterande av mangroveskog.

I mitten av förra århundradet var Pak Phanangbukten i sydöstra Thailand till stor del täckt av mangroveskog. Pak Phanang var vid den tiden en viktig handelsplats för den då betydelsefulla fiskeindustrin. I mitten av 1980-talet skedde ett uppsving i den internationella efterfrågan av odlade räkor vilket ledde till att en stor del av lokalbefolkningen och stora nationella företag började etablera räkodlingar i Pak Phanangbukten. Den snabba etableringen av räkodlingar visade sig dock ha förödande konsekvenser för både människor och ekosystem. Under 1990-talet växte en medvetenhet fram hos lokalbefolkningen, icke statliga organisationer och statliga myndigheter om fördelarna med att bevara mangroveskog. Den ökade uppmärksamheten kring mangrove och dess positiva effekter ledde till ett flertal återplanteringsprojekt i deltat runt Pak Phanang.

Denna studie gjordes för att identifiera de effekter, både fysiska och sociala, som mangroveplanteringar i Pak Phanangbukten ger upphov till. I undersökningen har lokalbefolkning, organisationer och grupper aktiva inom eller påverkade av planteringar identifierats och intervjuats. De lokala intervjuerna genomfördes i de tre byarna Ban Kong Kong (BKK), Ban Pak Nam Pak Phaya (BPNPP) och Ban Talad Has (BTH). Byborna i dessa tre byar är beroende av produkter från mangroveskog. Utöver detta har fjärranalys med satellit- och flygbilder använts för att komplettera intervjumaterialet.

Studien visar att arean av mangrove på gyttjebankerna och i övergivna räkodlingar har ökat sedan mitten av 1990-talet på grund av mangroveplanteringar. Under samma period har även sträckan av mangroveklädd strand på buktens västra sida ökat.

Samtliga intervjuade bybor i de tre byarna är i grunden positiva till plantering av mangroveskogar men däremot har det uppstått ett antal konflikter angående hur och för vem som mangroven planteras. Eftersom thailändsk lag förbjuder all avverkning av mangroveskog innebär det att de fördelar från mangroveområden och som utnyttjas av bybor endast är sekundära. Fördelarna med mangroveskog som tillkommer lokalbefolkningen är en ökad area där det är möjligt att fånga fisk, räkor och krabbor. Enligt bybor och lokala myndigheter är mangroveskog en viktig anledning till att lokalbefolkningen kan bo kvar i området.

Planteringar genomförs av flera aktörer. Den myndighet som har det övergripande ansvaret för mangroveplanteringar är Department of Marine and Costal Resources (DMCR). DMCR har för tillfället pågående planteringsprojekt i BKK och BTH. Många bybor deltar frivilligt i planteringar. Dessa anordnas ofta på buddistiska eller nationella högtider av den thailändska motsvarigheten till kommuner, Tambon Administrative Office (TAO). I BTH har den lokala TAO:n tagit en aktiv roll och administrerar mangroveplanteringar utan hjälp från DMCR. Det planteras för närvarande ingen mangroveskog i området kring BPNPP. Detta kan bero på avsaknaden av planterbara gyttjebanker i kusten utanför byn.

CONTENT

ABREVIATIONS

A.	Avicennia
BKK	Ban Kong Kong
BPNPP	Ban Pak Nam Pak Phaya
BTH	Ban Talad Has
CORIN Asia	Costal Research Institute Asia
Dep.	Department
DMCR	Department of Marine and Coastal Resources
DNP	Department of National Parks and Wildlife Conservation
DoF	Department of Fisheries
FAO	Food and Agriculture Organisation
GAP	Government Administrative Plan
IUCN	International Union for Nature Conservation
R.	Rhizophora
RDF	Royal Department of Forestry
S.	Sonneratia
SEI	Stockholm Environmental Institute
SLU	Swedish University of Agricultural Sciences
SSM	Soft System Methodology
TAO	Tambon Administrative Office
UN	United Nations
UNDP	United Nations Development Programme
UNESCO	United Nations Educational Scientific and Cultural Organization

1. INTRODUCTION

Mangrove areas provide a number of vital functions for coastal communities and ecosystems. Recent development in coastal areas in the tropical zone has led to a large degradation of this precious resource. In the beginning of the 20th century a large portion of the Thai coastline was covered by mangrove forests. However, the area of mangrove declined all through the latter half of the last century especially during the "gold rush" years, in the late 1980's to late 90's, when large areas of coastland, with the help of government investments, were turned into shrimp ponds (Lebel, 2004). Estimates of mangrove loss to shrimp farms vary, but 50%-60% of the mangrove area in Thailand is believed to have been lost since 1975 (Barbier & Cox, 2004). A lot of these areas are now being reclaimed for mangrove plantations, likely creating a great deal of conflicts with the people that have been using that land as their own for decades.

This trend has also been evident in Pak Phanang bay. Satellite images of the area show ample evidence of establishment of shrimp ponds in what was previously mangrove area. The degradation of mangrove areas was possible because of poor legislation, support of the expansion of the shrimp industry and short term economical planning. During recent decades, government and public awareness of the importance of mangroves has risen. This has translated into several restoration and afforestation projects in Pak Phanang bay (Thampanya, 2006).

1.1. OBJECTIVE

The objective of this thesis was to uncover the physical and social effects of mangrove plantations in Pak Phanang Bay as well as identify the roles, goals and impact of organisations, people and external driving forces involved in the process. The aim was to investigate these effects on the entire bay with extra focus on three coastal communities affected by mangrove plantation projects by incorporating the multiple perceptions of different stakeholders on mangrove plantations.

1.2. HYPOTESIS

In order to investigate the present situation in Pak Phanang Bay in the scope of the objective the following main hypothesis and four sub-hypotheses was set up.

Plantation of mangrove has social, economical and physical effects on Pak Phanang Bay and the people living there.

- The outputs from plantations in Pak Phanang Bay are a result of interacting organisations, institutions and physical constraints.
- The perceived values of plantations differ between stakeholders.
- The way mangrove plantations are performed reflects what the organisations implementing them value.

- The aim of plantations performed by local government organisations is not historical restoration, rather generating mangrove area.

2. BACKGROUND

2.1. STUDY SITE

Pak Phanang Bay is situated on the eastern side of the Malay Peninsula in Southern Thailand. Thailand has a vast coast line stretching for 2,815 km. The east coast facing the Gulf of Thailand is approximately twice as long as the coast along the Andaman Sea (1,878 km and 937 km) (Barbier & Cox, 2004).

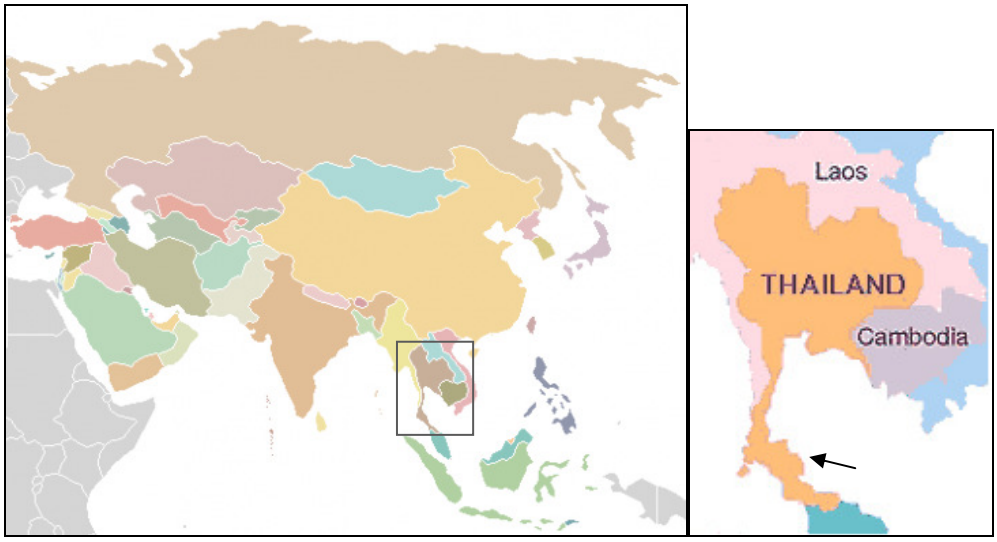

Figure 2.1. Thailand's location in Southeast Asia. The arrow indicates the location of Pak Phanang Bay. Picture (map work, 2009)

The study site is located in Nakhon Si Thammarat province. The province is divided into 21 districts which are divided into 165 communes. Three communities (villages) were identified by the EU MANROVE project for the field work. These communities were selected by the EU Mangroves project based on variations in biophysical conditions of mangroves systems and differences in how local communities depend on goods and services originating from mangrove ecosystems (Dulyapurk et al, 2007). The three communities are:

Ban Kong Khong (BKK), Pak Phanang Fang Tawan Ok Subdistrict, Pak Phanang District. The village is situated in the Pak Phanang Peninsular and is surrounded by old and healthy mangrove on all sides (Dulyapurk et al, 2007). There are currently 187 households in the village (village headman BKK).

Ban Pak Nam Pak Phaya (BPNPP), Ta Sak Subdistrict, Mueang District. BPNPP is located at the mouth of Phaya River. The area surrounding the village is dominated by shrimp farms and newly planted mangrove (Dulyapurk et al, 2007). There are approximately 130 households in BPNPP (Village Headman BPNPP).

Ban Talad Has (BTH), Pak Phun Subdistrict, Mueang District. BTH is located inland in the north-western part of the bay. Mangrove is largely limited to the newly formed

island outside the village (Dulyapurk et al, 2007). There are around 400 households in the village (Village Headman BTH).

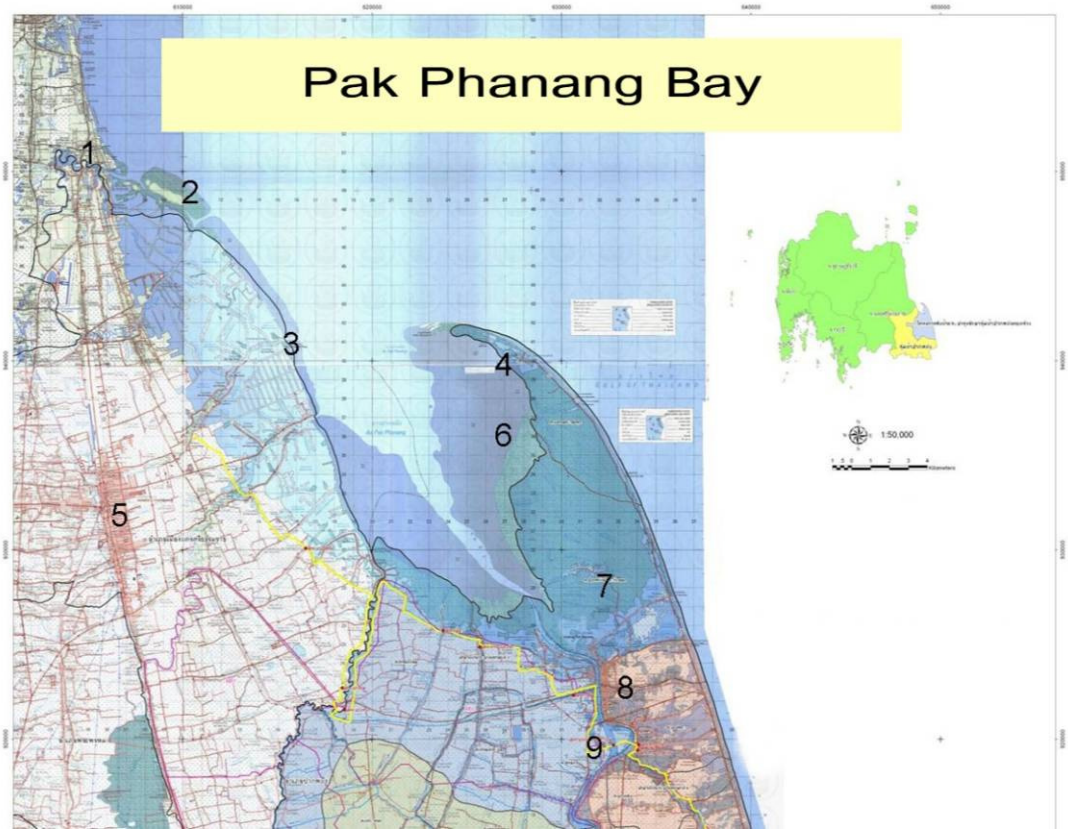

Figure 2.2. Map of Pak Phanang Bay. 1. BTH, 2. The island outside Pak Phun, 3. BPNPP, 4. Leam Thalumpuk, 5. Nakhon Si Thammarat city, 6. Mudflat area, 7. BKK, 8. Pak Phanang, 9. The Uthokvibhajaprasid water gate. Map from Royal Irrigation Department (RID) office in Pak Phanang.

Figure 2.3. "Samae" (A. officinalis or A. marina) tree with planted *R.* Mucronata along a riverside in the background.

2.2. MANGROVE

Mangroves are a type of evergreen, salt tolerant, forests that are found along the coastlines of tropical and subtropical regions. They are particularly found along deltas and where rivers discharge freshwater and sediments to the sea (Thampanya, 2006).

Mangroves supports nursery functions for many juvenile fish and shrimp species. Many of these are important commercial species. The complex root system of mangrove forests serves as refuge for juvenile fish and shrimps (Bosire, et al. 2008).

Mangrove forests play a significant role as sediment traps and reduce tidal flows. Mangrove-dominated coastlines exhibit less

erosion than non-vegetated segments of coast (Thampanya et al, 2006).

There are 87 mangrove species belonging to 41 families found in Thailand. The five most common families in are Rhizophora (*R.*), Avicennia (*A.*), Combreta, Palmae and Sonneratia (*S.*) (Dulyapurk et al. 2007).

On the Pak Phanang Peninsular, *A. alba* is the dominant species at progressing mangrove edges followed by *S. caseolaris* and, in lower abundance, *S. alba* along with the occasional *R. Apiculata* (Thampanya, 2006). According to Thampanya et al. (2006), the export of mangrove propagules through the natural channels, draining the mangrove forest on the peninsula to the mudflats, (Figure 2.2. nr. 6) is substantial enough to support an expansion of the forest. *A. alba* is the most important species for colonizing new mudflats in the Pak Phanang Bay (Panapitukkula et al. 1998). On a different study done on the Pak Phanang Peninsular the mangrove families of *A.* and *S.* were found to be the most important as pioneer species for establishment on previously unvegetated mudflats. Seedlings from the *R.* family exhibited less survival in more exposed plots, but better survival rate than the two previous mangrove families in areas with higher neighbouring plant density. This makes the *R.* family a successor on the mudflats outside Pak Phanang Peninsular after the colonisations phase is completed (Thampanya, 2006).

2.3. MANGROVE PLANTATIONS

Plantations of mangrove alter the natural cycle of Pak Phanang Bay. Understanding the way mangrove plantations are performed and what the general characteristics of planted areas are is important in providing the rich picture of this study.

Mangrove plantations are a way of colonising areas with mangrove that has been deforested or due to other reasons lack mangrove cover. Planting mangrove is a suitable alternative when the ecosystem has been altered to the degree where it cannot self-correct or self renew (Bosire et al. 2008). Destructed mangrove forests have a way of "self rehabilitating" through natural creeping and propagule migration (Thampanya, 2006). The regeneration through secondary succession after an area has been planted is dependant on propagule availability. Lewis (2005) proposed a new term "propagule limitation" to describe situations where mangrove succession is limited due to lack of natural stands of mangrove and/or the expansion is hindered by structures such as roads, dikes etc.

Knowledge of the natural conditions at plantatation sites as well as an understanding of mangrove bahaviour is vital in order for mangrove plantations to be successful. According to Bosire et al. (2008) mangrove plantation sites are often not assesed thouroghly before they are planted and can in some cases lead to failure in colonising the planted area.

Planted mangrove has different characteristics than non planted mangrove. On a study of 12 year old planted *R. Mucronata* in Kenya the forest density was found to be substantially higher (4864 stems ha^{-1}) than nearby natural stands of the same species

(1796 stems ha^{-1}). These results are in the same ranges as biomass studies done in Thailand. Planted areas have different species composition than natural stands of mangrove. This also leads to different species composition of animals living in the mangrove area (Bosire et al. 2008).

In Thailand, most of the mangrove planted, more than 110 km^2, in 1991 to 1995, was on previously unvegetated tidal mudflats. More recent restoration projects in Southern Thailand have focused on restoring mangrove areas destroyed by both illegal and legal shrimp farms. However, the restored areas are small in comparison to the area that has been deforested during the last century (Barbier & Cox, 2004).

Plantations require capital investments and the cost of planting mangrove in Thailand was, in 1998, estimated to 500 US$ per ha (Thampanya, 2006).

The associated land use conflicts linked with mangrove plantations and how and for who plantations are conducted in Pak Phanang Bay is discussed in the results and analysis section.

2.4. SHRIMP FARMING

Reasons for mangrove destruction are important in understanding why and when the mangrove areas in Pak Phanang Bay were deforested. Shrimp farming is a large industry on the east coast of Thailand and is accountable for a large portion of the deforestation of pristine mangrove (Lebel, 2002). This section provides information on how shrimp farming is performed as well as the structure and national importance of the shrimp farming industry.

Shrimp is the most internationally traded seafood of which 25 % is from aquacultures. Japan, the US and EU are the world leading importers of shrimp. Thailand is the world's largest exporter of frozen shrimp. In the decade leading up to 1998 Thailand had 18 % of the global market share of frozen shrimp. This makes the product one of Thailand's three largest exports and generated in 2002 more than 2 billion US$ per year (Lebel, 2002).

Although shrimp farming began in Thailand as early as in the 1950s (CORIN, 1991), the actual boom in intensive farming did not occur until the mid 80's when the demand for shrimp in Japan increased the export prices (Barbier & Cox, 2004). The export rose rapidly due to the emergence of intensive farming practises for aquacultures from the mid 80's to the mid 90's (figure 2.4.). Shrimp farming became a very lucrative field and many Thai farmers transformed rice paddies and mangrove forests into aquacultures (CORIN, 1991).

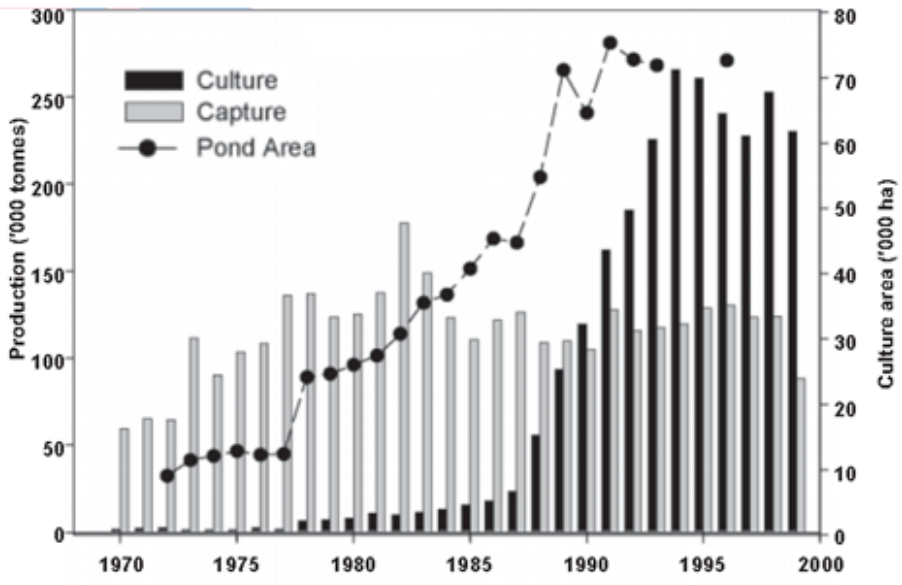

Figure 2.4. Growth of the shrimp aquaculture industry in Thailand. The solid bars are production of shrimp in tonnes from capture fisheries and cultivated from aquacultures. The dashed line is the area of shrimp farm pond area (Lebel, 2002).

In 1994, the shrimp farming industry employed approximately 97,000 people and 53,000 people indirectly according to the Thai Department of Fisheries (DoF) (Lebel, 2002).

In Thailand, there are a number of large industrial companies, active in the shrimp farming business. These companies have been successful in creating a vertical production chain where the companies are involved in all stages in the production, from the making of fish meal, all the way to selling the product on the global market. The fast emergence of the shrimp farming industry was made possible by the Thai government's export-oriented policies. According to Lebel et al. (2002. p 318) *"The bias in aquaculture research and development and extension services has been toward shrimp as a high-value export crop requiring high levels of inputs, and not on aquaculture of fish suitable for domestic consumption or to improve livelihoods of the poorest"*. The short term aim of the Thai government and the Thai Dep. of Fisheries has been the rapid expansion of aquaculture to earn foreign exchange. After the economic crisis in South-East Asia in 1997, when the Thai currency lost a lot in value, the Dep. of Fisheries vowed that the shrimp industry would help in the recovery (Lebel, 2002).

Shrimp farming yields and profits has been characterized by a dramatic "boom and bust" pattern. Export prices depend greatly on market destinations as well as the quality of shrimp. This is due to global trends in export for instance the 1997-1998 financial crisis was devastating for many Thai shrimp framers. Each individual pond owner is vulnerable to loss of shrimp harvest due to disease and also to loss of income due to decline in global export prices. In an extensive survey done by Lebel et al. (2002) 74 % of the farmers had experienced major crop failure. Shrimp disease was found to be the most important reason for crop failure.

In Thailand most shrimp farms are managed unsustainably. Water quality issues and diseases make the yield decline rapidly and ponds are normally abandoned after 5 to 6 years (Barbier & Cox, 2004). Shrimp farms could be managed in a more sustainable way, but these systems are generally too expensive for the small-scale pond operations (Mangrove Action Project, 2006. a).

Shrimp farming remains an important sector in Thailand. The government has set ambitious national targets for shrimp export. The government support to the shrimp farming and at the same time call for sustainable management of coastal areas indicate that there is overlap in the policy framework.

3. THEORY

A number of theories are used in the thesis to make a holistic view of mangrove plantations in Pak Phanang Bay. This section provides information of the theories used as a base for the discussion in the results and conclusion parts of the thesis. The theory section also includes background information about the remote sensing techniques used. The information about remote sensing techniques will is important for justifying the choices of techniques given the maps images available for the analysis.

3.1. EPISTEMOLOGY

The use of interdisciplinary research is currently intensifying as universities and other research organizations are trying to fill gaps in knowledge in disciplines like behaviour and management of social-ecological systems. This requires a fully integrated approach between the different research fields. The different fields carry with them different epistemologies (theories of knowledge) with different concepts of what constitutes knowledge, how it is produced and how it is best applied. In these times of rapidly changing social-ecological relationships, traditional research is caught in strictly disciplinary approaches and is ill equipped to address the multitude of issues that cut across the different sectors of academia. A lot of research done, despite the progress of interdisciplinary research, has the tendency to only include or privilege one epistemological discipline (Miller et al, 2008). The difference in epistemology is not only an issue within academia and research. It is also an important factor dividing people and organisations with different stance on a particular issue. In the context of the thesis differences in epistemologies can be between government official, local residents, private companies etc. Understanding the epistemology of the different actors in a conflict is an important step towards reconciliation and finding a suitable and lasting solution.

In many cases, important stakeholders have been ignored when assuming that the products associated with them are the primary good that the management of the resource needs to promote. In this case, it is important to make a distinction between current land use and ideal utilization of mangrove forest and its assorted products. In many conceptual models of that forms the basis for policies and programmes fail to count for the spatial, temporal and cultural heterogeneity between different sites (Brown

& MacLeod, 1996). This is interesting in this case since there are a number of ecosystem services related to mangrove forests. Are these services the optimal goods for the people that benefit from them or could the mangrove areas be used in a better way?

3.2. ECOSYSTEM MANAGEMENT

How natural resources, such as mangrove areas, are used and managed reflects a view of what people and those in charge value with the area. Different ecosystems are valued differently depending on the intended benefits of the user. An ecosystem could have an intrinsic value as an undisturbed natural area or for economical values for production purposes. This section goes through theories about ecosystem and the management of these.

In classical ecology there is a belief that competition is the predominant process that leads to patterns in community structures. One of the important features in this theory is that coexistence requires a stable equilibrium point. In order to achieve equilibrium, the ecosystem is predicted to go through succession patterns when closing in on the equilibrium. However, many ecosystems have failed to follow these patterns suggested by the equilibrium theory (Brown & MacLeod, 1996). A key aim of environmental managers has been to keep the ecosystem in a “climax state”. The climax state is according to this view regarded a stable state, but may in fact not be an equilibrium in the system. The increase in demand for products from the ecosystem enlarges the importance of ecologically and economically sustainable natural resource management. One problem with both these views is finding an agreement amongst scientists, public and private resource managers on what climax state or pristine pieces of land are. These evaluations have often been performed by only asking leading figures in communities what goods and services they gain from the ecosystem (Brown & MacLeod, 1996). This is an important factor for the mangrove management in the Pak Phanang Bay and is closely related to epistemology. In other words, is the benefits people gain from mangroves, according to the current management, the most desirable?

Traditionally, natural resource management agendas were developed around the implied notion of pristine ecosystems as the most desirable goal. Humans where, however, not included in this and were regarded as a disturbance that disrupts the system (Brown & MacLeod, 1996).

Studies have shown that ecosystems such as coral reefs, lakes, oceans, forests and arid lands do not always respond to stress by changing gradually. Instead, ecosystems can suddenly shift to a contrasting state. Loss of ecosystem resilience due to human induced stress often paves the way for such dramatic shifts. This emphasises the need for maintaining the resilience in ecosystem management (Scheffer et al, 2001).

Well managed and governed mangrove areas could potentially help in increasing the services gained from mangrove ecosystems for a number of stakeholders in Pak Phanang Bay. The potential for this is evaluated in the results section.

3.3. SYSTEM THEORY

The earliest use of the term systems theory was first developed from the realisation that scientific analytical methodologies sometimes failed because they did not take into account the interactions that take place. General systems theory is a way of studying the components of a system as well as the interaction of these components with each other and the surrounding environment. The concept of holism grew out of the concept that the overall result of a combined system has emergent properties that are different from the properties of its individual components (Kirk, 1995).

Mangrove links terrestrial and marine systems, and the complex land use system and set of actors requires a holistic approach in which system theory is a useful tool in finding a identifying the combined results of all the interactions that takes place in Pak Phanang Bay.

3.3.1. Hard system

Hard systems are predominantly used in the classical natural sciences. It is a reductionist way of isolating problems that are deterministic and quantifiable. The systems have to have a number of known inputs and outputs and a predictable causality between these. Hard systems are good for making models, forecasts, simulations and mathematical programming (Brown & MacLeod, 1996). The hard systems approach is used in this case for detecting changes in mangrove cover and other physical land changes over time with the use of remote sensing techniques.

3.3.2. Soft System Methodology

The methodology was first developed by Checkland in the late 60s at the University of Lancaster in the UK. It is used for complex systems where there are no clearly defined boundaries. This approach is suitable for human systems where the people involved are enabled to participate in the making of the system model. This is more likely to encourage acceptability of the model. SSM can be used to find system boundaries and system activities which can be useful in combination with 'hard' techniques (Lehaney & Paul, 1996).

The soft system tools contain a number of components (BOLA, 2009). The components useful in this context as part of the results and analysis are: clients, actors, transformation, worldview, owners and environment. These are used to structure the results and analysis section in order to uncover the aims and impacts of the different organisations and groups involved in mangrove plantations.

Transformation is the change that is occurring. The transformation can be separated into input and output**.** Inputs are the elements of the system contributing to the change. These are generated from a combination of social and environmental factors influencing the transformation. The outputs are the resulting characteristics and functions generated from the transformation (Bergvall-Kåreborn et al, 2004). The transformation is the process both influencing and being influenced by the social and environmental context.

The worldview is the epistemological and ontological assumptions determining how different actors view the transformation. Individuals and societies perceptions of reality are their worldview which acts like the foundations from which all decisions are made of. Inputs are generated from the agendas of people and organizations making worldview a strong influence on the transformation.

Environment can be separated into physical and policy environment. The environment helps to set boundaries in terms of what limitations there are to the system. These are the constraints that affect what "path" the transformation can take given the ecosystem, organizational, economical and political characteristics Bergvall-Kåreborn, et al. 2004.

Stakeholders are separated into three different categories, actors, clients and owners. The actors are the people or organisations that carry out the transformation. Clients are those that are affected by the transformations. They are separated into beneficiaries and victims. The definition of owners is the people or organisations that can prevent the transformation from happening. The owners can have both formal and informal power (Bergvall-Kåreborn et al, 2004).

3.4. REMOTE SENSING AND SATTELITE IMAGERY

This section introduces the theory behind the remote sensing. Providing information about the different techniques used. The remote sensing was used to measure and visualize the changes in Pak Phanang Bay. The data gained from remote sensing was useful in the results and analysis when it came to detecting changes due to plantations and also to critically analyze the information gained from the interviews.

3.4.1. Landsat TM satellite images

Parts of the remote sensing were performed on satellite imagery from the Landsat TM satellite. The Landsat TM satellite orbits at 705 kilometres above the earth surface, passing the same area of the earth's crust every 16 days. TM is short for Thematic Mapper which records the surface reflectance of electromagnetic radiation from the sun in seven discrete bands. The satellite records visible light and three bands in the infrared spectrum (Satellite impressions, 2004). Band 5, 1.55 – 1.75 μm, is preferably used to distinctly separate forest area, crop land and water surfaces. This makes Band 5 a suitable choice for detecting and measure the area of mangrove forests. The Landsat images are built out of a raster of pixels. In band 5 each pixel is accredited a value between one and 256. These values represents a certain shade, lower values represents darker shades by default. Water surfaces are represented by dark shades (low values), distinctly darker than vegetated areas. Cropland appears in a lighter tone than forest areas. Band 5 has limitations when it comes to separating cropland and urban areas (PSU, 2009).

3.4.2. Global Information System (GIS)

GIS is a collection of software and data used to manage and visualise information of geographical areas and to analyse spatial relationships. GIS programmes offer a framework for organising spatial data along with related information.

3.4.3. Projected and geographical coordinate systems

A projected coordinate system is defined on a two-dimensional surface with constant length, angles and areas across the two dimensions. The projected coordinate system is based on a geographic coordinate system that in turn is based on a spheroid (ESRI, 2009, a).

The earth fitting spheroid is based on the earth's centre of mass as the origin. Datum defines the position of the spheroid relative to the centre of earth. The most recently developed and widely used datum is WGS (World Geodetic System) 1984. It serves as the framework for position measurement worldwide (ESRI, 2009, b). WGS 1984 succeeded India 1975 as the standard Projected Coordinate system in Thailand. Transformation of a map or image into WGS 1984 from India 1975 is done by shifting each axis according to the values in table 3.1.

Table 3.1. Transformation parameters (d) and possible errors (e) in meters from India-1975 to WGS-84.

Datum	Ellipsoid	dX	dY	dZ	eX	eY	eZ
India 1975	Everest (India 1830)	210	814	289	3	2	3

On a gridded network, uniformly spaced horizontal and vertical lines forms X-and Y-axises. The Z-axis is perpendicular to both the X- and Y- axis, indicating the elevation of a point in the three-dimensional coordinate system.

4. METHOD AND MATERIAL

A combination of quantitative and qualitative methods was used in order to achieve a picture that is as close to the reality as possible. The interview material was important in order to see how people on different levels perceive the situation. The interview results were in turn backed up or questioned with a literary search and remote sensing.

4.1. INTERVIEWS

During the field work, March to June 2009, interviews where performed with 31 people in Bangkok, Krabi, Nakhon Si Thammarat, Pak Phanang and its surroundings. People interviewed represented an organisation or a group that affected, or was affected by mangrove plantations. Those interviewed were people representing international and governmental organisations as well as local villagers and local representatives. The approach allowed a learning process not only for the researcher but also the people participating in the interviews and workshop. This made the working progress a part of formulating the aim and goals of the thesis. All interviews, except those on international level, were conducted in Thai with an interpreter.

Below is the core questions that all interviewees was asked:

- What do you think the role of mangroves in Thailand has been over time?
- What do you think is the purpose of mangrove rehabilitation?
- Who in your opinion manages and controls the management of mangroves in this area?
- Whose guidelines do you follow?
- Who should be involved in mangrove management? If not involved, why?
- Who are the main beneficiaries from mangrove plantation and conservation?
- What are the preconditions for mangrove plantations and how should it be done?

The questions were adjusted to suit each interviewee. When representatives for an organisation was interviewed the questions was addressed towards the organisation view rather than the persons. At the national and international level the questions were aimed towards different "ideologies" regarding mangrove rehabilitation. At the local level, the questions were more connected to the practical use and policies in mangrove areas and conflicts between different stakeholders in the study site. It was important that the interviewee was well aware of his or her organisation's standpoints. Examples are important in validating the statements as well as for finding more stakeholders.

The information gained from interviews was referenced in the report with the organisation or village the interviewee represents followed by the geographical scale he or she is active within (international, national, regional, local). All names were left out of the thesis due to the sensitive matter in some of the material.

4.2. REMOTE SENSING

The remote sensing was used to detect the physical transformation of the bay over time due to plantations and external forces. The result from the remote sensing was used to complement the qualitative information gained from the interviews.

4.2.1. Maps, images and software

The arcGIS 9.3 software was used to measure changes in length of the coastline in the bay, green cover in the shrimp pond area, visualise erosion outside BPNPP and identify spots where land was accumulating.

arcGIS is an integrated collection of GIS software. The software provides a platform for spatial analysis and mapping. In this case the following built in coordinate system was used (table 4.1.). Built in features and tools used for the analysis are explained in table 4.2.

Table 4.1. Reference system used when making GIS calculations and maps

Geographic Coordinate System:	Projected Coordinate System
GCS_WGS_1984,	WGS_1984_UTM_Zone_47N

Table 4.2. arcGis features used in the remote sensing

Feature	Description
Raster	Flight and satellite images are digitalised photos. These consist of a number of pixels put in a grid called a raster. Each pixel can only have one value. The value often represents a colour.
Point	A fixed position on the map (projected coordinate system).
Polyline	A line consisting of two or more points linked together with straight lines.
Polygon	Three or more points forming the corners of an area linked by straight lines.
Mask	A polygon feature used for indicating an area of interest in order to extract it.
Extraction	Certain features can be extracted from a map or raster image. If the extraction is based on area it can be performed with a mask.
Georeferencing	Using a known reference point to spatially align a raster image to its correct coordinates
Metadata	Image specific information

All flight images which were projected in the right coordinate system were transformed according to table 3.1.

A table over available aerial photos of Pak Phanang Bay are listed in Table 4.3.

Table 4.3. Information of the aerial photos, of Pak Phanang Bay, used in the remote sensing.

Type	Year	Scale	Comment
Aerial Photo	1974	1:15,000	Black and white
Aerial Photo	1995	1:50,000	Black and white
Aerial Photo	2004	Unknown 1:<15,000	Colour, Some areas missing

Flight images might be referenced in the correct projected coordinate system but lacking accuracy. Georeferencing was used as a tool for enhancing the precision of the photo. For georeferencing, the river line shape file (table 4.5.) was used because of its exact alignment with the aerial photo from 2004. All others flight images were in need of georeferencing. Extra effort was put on the accuracy of the near coast areas.

Table 4.4. Information about the tree Landsat TM images gained from images metadata.

Year	**Image**	**Number of bands**	**Pixel size (m^2)**
1994	Landsat 5 TM	7	28.5 x 28.5
2007	Landsat 7 TM	7	25.0 x 25.0

In addition to the satellite images in table 4.4., there is a Landsat TM image from 2006. The image was not used in calculations of green cover in the shrimp pond area due to clouds veiling over the western side of the bay.

Table 4.5. Other GIS features used in the calculations.

File	Type	Cover	Year
Amphoe	Shape	Nakhon Sri Thammarat province	Unknown
Riverline	Shape	Nakhon Sri Thammarat province	Unknown

4.2.2. Length of mangrove coastline

In order to determine the length of coast line with mangrove a polyline shape file was created. The line was drawn in the areas with mangrove next to the coast line. The length of the line was calculated in the arcGIS attribute table. The same was also done for coast without mangrove cover. Segments of the coastline forested with thick vegetation for more than 50 meters (measured length) inland was classed as mangrove coast. For the results from this calculation see table 5.3.

4.2.3. Erosion around BPNPP

In order to determine the erosion around BPNPP, another more accurate georeferencing was made. In this case, common features from the flight images from 1974, 1995 and 2004 was used for instance roads, shrimp ponds and individual houses. A polyline made out of segments covering 100 meters each was created. The ends of each segment were put in the forest-water edge. A 200 meter line was drawn from the midsection of the 2004 polyline in order to visualise the extent of the erosion. For results see environment in the results and analysis section.

4.2.4. Green cover in shrimp pond area

This section explains the general method for calibrating what pixel values represents mangrove green. The case specific procedure of calibrating with the data provided available for this analysis follows this section.

In order to determine the mangrove cover and development in shrimp pond area an approximate mask of the shrimp pond area was drawn. The mask was shaped to cover all shrimp ponds on the area of interest. Band 5 was extracted from the Landsat images from the maps that are compared and saved as grid files.

Reference areas with mangrove outside the shrimp farm area with mangrove cover was identified through “on site visits” as well as cross checked with flight pictures from nearby years. Polygon features were drawn on homogenous mangrove areas. These were used as masks to identify what pixel values represented “mangrove green” in the reference area from each year. Several reference areas on different locations were used in order to remove biases due to angle towards the satellite and the sun. The use of large reference areas helped to minimise the risk of local abnormalities influencing the pixel value distribution in the reference area. Mangrove reference areas, with pixel values, were extracted from the Band 5 grid files. The pixel values from the mangrove area were drawn as diagrams, using Microsoft Office Excel, showing Y = number of counts

and X = value. The counts were approximated into normal distribution showing the probability as Y and pixel value as X parameters.

To approximate the count for each pixel value, for the reference area, into a normal distribution the standard deviation (σ) was calculated using eq. 3 & 4 from the frequency distribution (d_i) of the pixel values in the reference areas. The interval of pixel values representing mangrove green was set to be the 90 % quantile of the approximated normal distribution from each reference area. The extent of the interval representing mangrove green was calculated with eq. 5. The interval of pixel values representing mangrove green for each year was extracted from the mask area. The area of mangrove green was calculated with eq. 6.

$$d_i = \frac{Y_i}{Y_{tot}} \quad (1)$$

$$\mu = \frac{\sum_i^n X_i * Y_i}{Y_{tot}} = \sum_i^n X_i * d_i \quad (2)$$

$$\sigma^2 = \frac{\sum_{i=0}^{n} (Y_i - \mu)^2}{Y_{tot} - 1} \quad (3)$$

$$\sigma = \sqrt{\sigma^2} \quad (4)$$

$$P|\mu - \lambda_{\frac{\alpha}{2}} * \sigma < X < \mu + \lambda_{\frac{\alpha}{2}} * \sigma| = 1 - \alpha \quad (5)$$

$$A = p_a * \sum_i^n Y_i \quad (6)$$

d_i = frequency of Y_i

Y_i = counts for value Xi

Y_{tot} = total number of counts

μ = mean value

X_i = Value number i

n = number of values

σ^2 = variance

σ = standard deviation

P|interval| = probability of the interval

α = confidence interval

$\lambda_{\alpha/2}$ = quantile

p_a = pixel area

A =area

4.2.5. Calibration of mangrove green

In order to determine the area of mangrove green in the shrimp pond area on the western side of the Pak Phanang Bay pixel values representing mangrove green needed to be determined. This was done by calibrating what pixel values from each satellite image represents mangrove green according to the previous section.

The area with shrimp ponds hereafter referred to as the shrimp pond area was drawn using the polygon feature. The mask feature representing the shrimp pond area covered approximately 102 km^2. The counts of each value from the reference mangrove areas (figure 4.1), from 1994 and 2007 were plotted as a function of pixel value (figure 4.2).

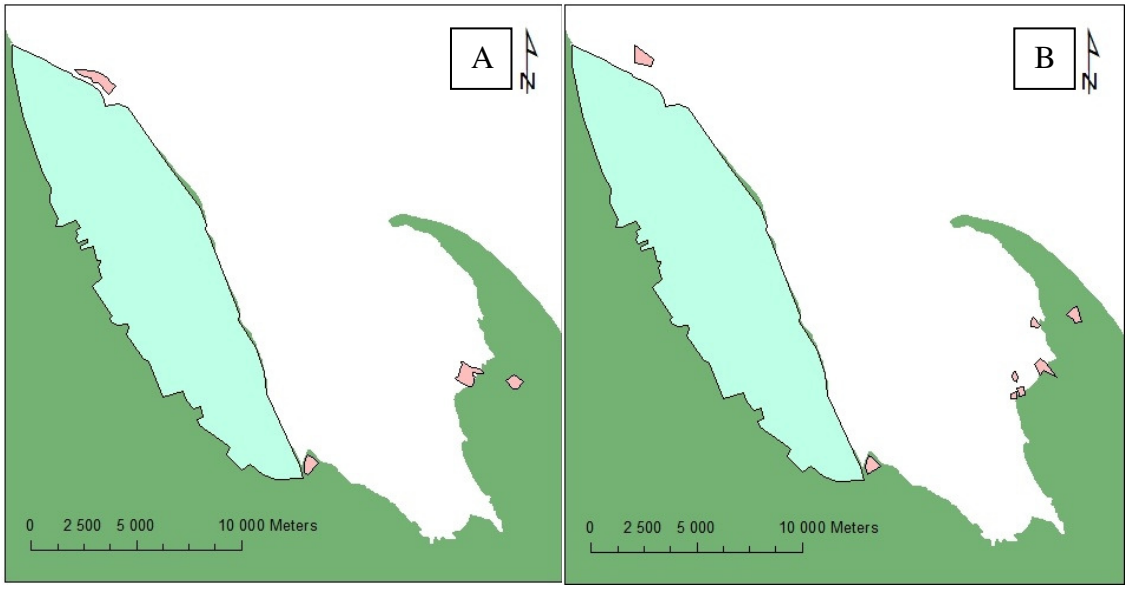

Figure 4.1. Areas selected as mangrove reference, pink fields, and the mask, blue field, selected as shrimp pond area. A, 1994. B, 2007. Background is the Amphoe shapefile (table 4.5.). All reference areas were situated in mangrove areas, due to land expansion since the Amphoe shapefile was created.

Three main areas were used as mangrove reference areas. The island outside Pak Phun, the mid section of the Pak Phanang Peninsular and the most eastern part of the conservation area in the south of the bay. Due to land expansion, all mask features were situated on vegetated land. The reference mangrove area for year 2007 was divided into several small areas because of the presence of clouds over the Pak Phanang peninsular at the time the photography was taken.

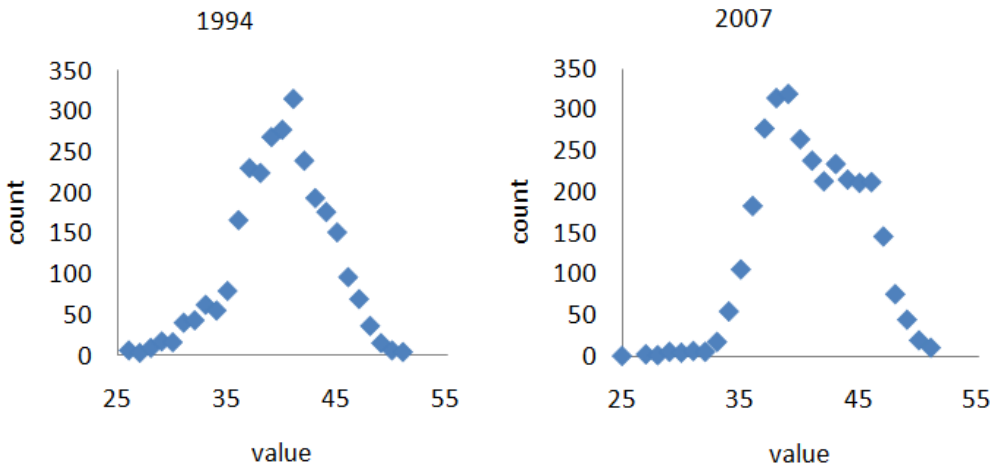

Figure 4.2. Range and distribution of values in mangrove reference area for each year.

The frequency distribution from each year was showing characteristics of normal distribution (figure 4.2). The discrete distribution of pixel values was approximated as a continuous normal distribution and compared to the frequency distribution calculated with equation 1 (figure 4.3).

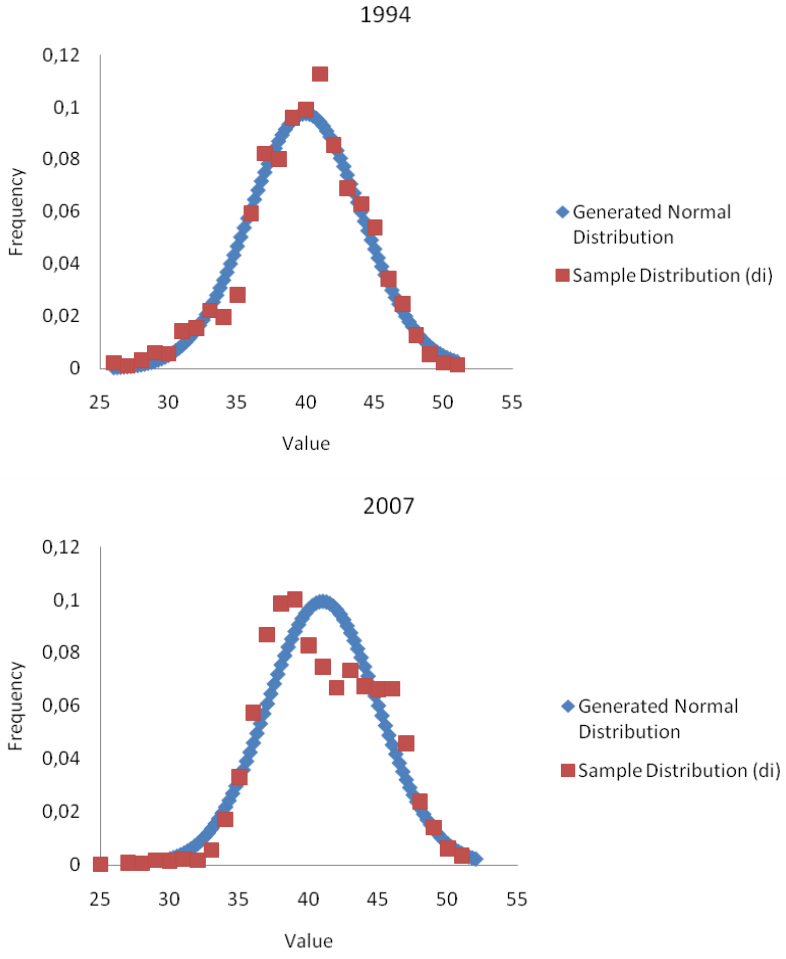

Figure 4.3. Frequency distribution and normal approximation for pixel values in the reference areas from 1994 and 2007.

In order to make a normal distribution as an approximation of the counts for each value the mean value was calculated according to equation 2. Equation 3 and 4 was used to calculate the standard deviation.

Table 4.6. Calculated approximations from the reference mangrove area. The interval is in integers since the pixel values are discrete.

Year	Reference pixel count	Area mask (km^2)	Mean, μ	Standard Deviation, σ	Interval, P(0.9)
1994	2796	2.27	39.96	4.09	33 - 47
2007	3187	1.99	40.98	4.01	34 - 48

To determine the interval for 90% ($\alpha = 0.10$) confidence interval Equation 5 was used. $\lambda_{0.05} = 1.645$ was obtained from a normal distribution table (Blom et al. 2009) and multiplied with the standard deviation to obtain the interval for pixel values representing mangrove green (table 4.6.). The interval with pixel values representing mangrove forest is the same number of pixel values for both years. However, the interval representing mangrove in 1994 was one value lower than for those representing mangrove in 2007. The area of mangrove green (figure 5.9.) in the shrimp pond area was calculated using equation 6. For the resulting area of mangrove green in the shrimp pond area see transformation in the results and analysis section.

4.5. CATWOE

A soft system methodology has been applied to understand the role and interaction and the interdependency between actors clients and owners who are directly or indirectly linked to the transformation i.e. mangrove plantations in Pak Phanang Bay. A type of the soft system tool "CATWOE" was used in order to make well recognised structure for the results and analysis from the interviews and the remote sensing. The CATWOE uses the soft systems components explained in the soft system section in the theory section. In this case the results were presented as an ETWOCA. The ETWOCA contains the same elements as the CATWOE although in a different order to create a more narrative storyline based on the scope of the thesis. The result was presented by explaining the soft system components in the following order environment, transformation, worldview, owners, clients and actors. A part of the aim of doing the ETWOCA was to find as many interconnections between the different components and finding out how they influence the transformation.

The environment was put into two categories physical environment and policy environment. The physical constraints limiting where mangrove can be planted was put in the physical environment. The effectiveness of Laws and policies in limiting or providing support for plantations were analysed as part of the policy environment.

The transformation section was separated into input and output. Inputs were the elements of the system contributing to plantations in the Pak Phanang Bay. All inputs were considered both social and environmental as long as they made a contribution to

the transformation. The effects of the transformation given the environmental constraints and input were considered output.

Peoples and organisations attitudes towards plantations of mangrove were considered Worldview. The section includes what the people perceived the benefits with plantations and also what conflicts it induces.

The stakeholders were separated into actors, clients and owners. Those organisations and people capable of stopping plantations in the Pak Phanang bay were considered owners. Group of people who are influenced by the plantations but can't stop or alter the transformation was considered clients. Clients were separated into beneficiaries, those that benefit from the transformation and victims, those that are negatively affected.

5. RESULTS AND ANALYSIS

The method used in this thesis provided information on both the institutional setting in Thailand as well as the situation in Pak Phanang Bay regarding mangrove plantations. Information about the laws and institutions in Thailand offered a foundation for the analysis. The analysis was formatted as a CATWOE in order to make a well recognised structure that combined the results from the interviews and the remote sensing. The combined result from the thesis uncovered the social, economical and physical effects from mangrove plantations by assessing the goals and impact of the different organisations and local groups active in mangrove plantations in Pak Phanang Bay.

5.2. INSTITUTIONAL SETTING

The there are a number of national policies involved in the regulation of land use in mangrove areas and the protection of mangrove forests. These laws are aimed toward and carried out by governmental institutions. The different governmental organisations involved directly or indirectly in mangrove plantations play a large role in how mangrove management and plantations are performed on a local scale. This section provides a vertical introduction to the laws and main governmental bodies active in mangrove plantations.

5.2.1. National Policies

Thailand's national policies are set against the background of the Thai constitution of 2007. Prior to 2007 the laws were set against the 1997 constitution. The 1997 constitution called for the sustainable use of natural recourses through good governance, people participation and the right of individuals and local communities to participate in decisions (World Bank, 2006) as well as communities having a meaningful role in environmental protection. Section 290 of the constitution empowered local authorities to conserve and manage natural recourses and the environment (IUCN, 2007).

In Thailand, mangrove rehabilitation efforts started in 1991 after a cabinet resolution prohibiting the government to grant concessions in mangrove forests. Mangrove rehabilitation projects were granted in coastal provinces (IUCN, 2007).

There are a number of laws related to mangrove protection and legal use (table 5.1.). The following laws are those mentioned by local villagers and representatives from local governmental organisations.

Table 5.1. Table of laws regulating the use and rights in mangrove areas.

Name	Year	Type	Description
The Forest Act	1941	Act	The Act controls concessions of logging as well as collection of non-timber forest products. In 1968 the concession right was changed so each concessionary had the right to harvest an area of 400 to 800 ha. New concessions of mangrove were stopped in 1990 and all concession activities were ceased in 2003 (World Bank, 2006).
The National Reserved Forest Act	1960	Act	Controls the use and protection of forest areas and resources. All mangrove forests are designated as reserve forest area according to this Act. It controls all activities carried out in mangrove areas as well as providing guidelines for the Department of Forestry (World Bank, 2006).
The National Park Act	1961	Act	The Act prohibits trade, transport of species and other human disturbances, within park boundaries, to protect flora and fauna. The scope of the act applies to both terrestrial and aquatic national parks. Ownership of land is not possible and all natural resources in the area are to be strictly conserved (World Bank, 2006).
N/A	1987	Cabinet Resolution	With this resolution mangrove areas were classified into two classes: conservation zones and economic zones. Economic zones are divided into 2 sub-zones: economic zone A and economic zone B (figure 5.1.) (Ongsomwang et al, 2005).

5.2.2. Land titles and classification

The legal framework and land ownership, past and present, is important to understand in order to get a view of what made the change in Pak Phanang possible. The classification of mangrove area from 1987 used in the past by the Department of Forestry is shown in figure 5.1.

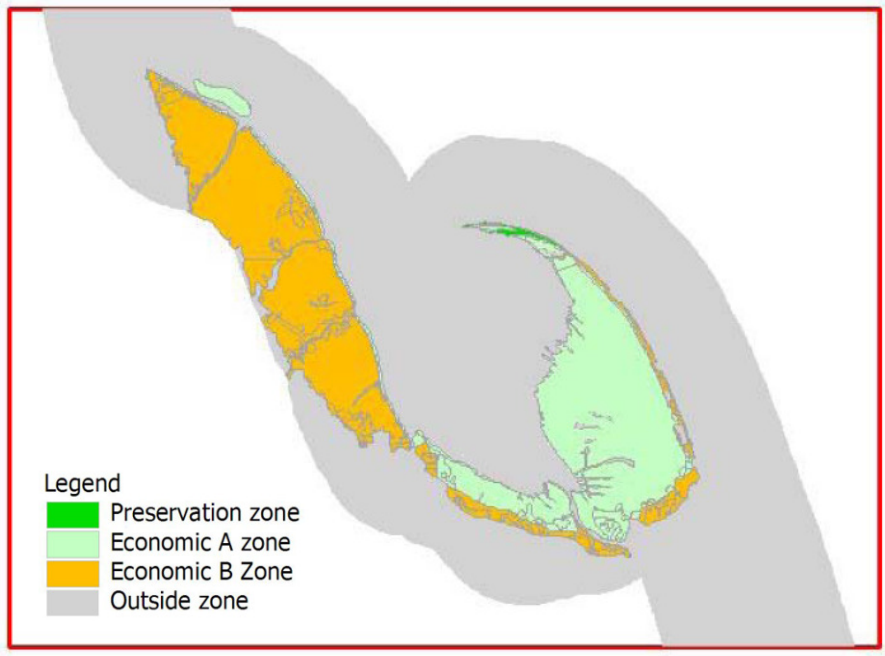

Figure 5.1. The 1987 zoning by RDF (Ongsomwang et al, 2005).

These zones were a result from the 15 December, 1987, resolution on the Mangrove Land Use Zones. The zones are:

- **Preservation zone:** Natural resource preservation area.
- **Economic A zone:** Areas in which mangrove can be utilized as a sustainable resource.
- **Economic B zone:** Areas where mangrove can be utilized for development purposes.

The Pak Phanang Peninsular is a wildlife conservation area under the Wildlife conservation and Protection Act 1964 (DMCR local & regional). The northern part of Laem Thalumpuc cape is classed a National Park, under the 1961 National Park Act (DNP regional).

Villagers and companies in the coastal areas can get legal land titles. There are three land titles that the villagers can get (table 5.2.). These provide different levels of land ownership and land use options.

Table 5.2. Table of legal documents and its assorted rights and responsibilities.

Document	Description
Sor Kor 1	The document is a notification form of possession of land. People who apply for this are required to prove their presence in the area. This paper shows that the person has notified possession of land. Inhabitants of the area are allowed to install fences or some kind of boundary around the land as well as small wooden structures on their untitled land (IUCN 2007).
Nor Sor 3	This is a legal title certifying that the person holding the land has the right to possess it. This land title can be used as a legal document or to use the benefit of the land as an owner (IUCN 2007). People holding the title are limited to selling their land to other people with a proven local connection (villager, local).
Chanot	This document is a certificate for ownership of land. A person holding this document has the legal right to own the land and use it as evidence to confirm their right (IUCN 2007).Persons who holds this certificate is entitled to sell the land to whomever they wish (villager, local).

Shrimp farm investors, large private companies, run shrimp farming on a large portion of the land that was formally classed economical B zone. The investors acquired the land in the late 1990's during the economical crisis (see shrimp farming) from local farmers who could not pay their loans back. Many farmers or workers now lease shrimp ponds from the investors. Investors are large companies, often involved in many steps of the production and retailing of shrimp products (Villager BPNPP & BTH).

5.2.3. Governmental institutions

There are a number of governmental organisations, at different hierarchical levels, involved in mangrove plantations. These are the organisations implementing the laws stated in the previous section.

Funding for each ministry is according to the Thai Government Administrative Plan (GAP). The GAP for the period 2005 to 2008 included specific targets for natural resource and the environment, including coastal resources (World Bank, 2006).

Ministry of Natural Resources and Environment (MoNRE) was established in 2002 as part of al large reform of the public sector. The ministry is responsible for the protection and conservation of protected areas, water resources, mineral resources, marine and coastal resources and environmental quality (IUCN, 2007).

Department of Marine and Coastal Resources (DMCR) is under the jurisdiction of MoNRE and was also formed in the 2002 reform of the public sector. The department took over the responsibility of mangrove conservation, rehabilitation and management from the Royal Forestry Department (IUCN, 2007).

The DMCR provides community training for villagers informing benefits of mangrove and how to manage it. The community training is performed by staff from the central office in Bangkok (DMCR, local).

One of the key roles of the DMCR is providing seedlings (figure 5.2.) to schools, TAO, villagers or NGO's active in plantations (DMCR regional & local).

Figure 5.2. A nursery with *R. Mucronata* seedlings at the DMCR station in Ta Rai.

The DMCR budget, both on local and regional level, is based on previous year's planted area. DMCR main office gets their money from Department of Finance after submitting a report about mangrove planted area. The budget allocation is regardless of planted species or suitability of the plantations (DMCR local & regional).

There are two DMCR stations responsible for plantations in Pak Phanang Bay

1. DMCR research station, Ta Sak
2. DMCR research station, Ta Rai

In addition to this, there is a DMCR station in Pak Phanang. The stations main objective is to survey mangrove areas and protect it from encroachers (DMCR local)

Royal Department of Forestry (RDF) (also known as The Royal Forestry Department) does not have direct responsibility over mangrove in terms of plantations and protection, in Pak Phanang Bay (RDF regional). However, laws regarding mangrove plantations, protection and conservation are issued by the RDF. Since the creation of DMCR, in 2002, these tasks have been carried out by the DMCR (DMCR local).

Department of National Parks and Wildlife Conservation (DNP) are responsible of National Parks and animal conservation programmes. The area of Bang Kong Kong and Laem Thalumpuk are classed a non-hunting area and the Northern tip of the cape is a National Park. In addition to DMCR, DNP are active in the area (DMCR, Local). DNP do not have any responsibility in the area around site 2 and 3. DNP regional office in Nakhon Si Thammarat is not taking part of mangrove replantations (DNP regional).

Department of Fisheries (DoF) Department of Fishery is the main ruling body when it comes to "wild fishing", aquacultures and shrimp farming. The DoF has a role in patrolling the coast in order to prevent fishing with illegal gear and methods. Then aim of the DoF is to promote "wild fishing", aqua- and shrimp cultures by planting fish, shrimp and crab as well as providing guidelines and research on methods etc (DoF aquaculture).

Tambon Administrative Office (TAO) is under the Ministry of Interior (IUCN, 2007) and was formed as part of the decentralization of the Thai government resulting from the 1997 constitution and the 1999 decentralisation act. The TAO serves as a small local government unit, close to the local people (AIT, 2010). The local office also serves as an important link between the DMCR and the communities. The TAO has representatives in each village to help the DMCR in finding areas suitable for plantation or restoration (TAO East Pak Phanang & Ta Sak, villager BPNPP). TAO has a budget for infrastructure projects like roads etc. (IUCN, 2007) but also for mangrove protection and plantations (TAO BKK & Pak Phun).

Village headmen are the official representatives for the villages. They are elected by the villagers. The headman provides a vital role, connecting the villagers with the authorities such as TAO and the DMCR. Village headman has a responsibility or at least a role to play in mangrove plantation and protection (DMCR, local).

5.2. CATWOE

This section provides a structured outline of the soft system components that together illustrates the present situation in Pak Phanang Bay. The structure is a variation of the CATWOE methodology explained in the method section. The different components of the CATWOE are not considered to be isolated entities but are rather seen as modules in a larger system. The combination and interconnections of these elements leads up to the present transformation in the bay. The CATWOE revolves around a transformation which in this case is the plantations of mangrove in Pak Phanang Bay.

5.2.1. Environment

The environment is the constraint limiting the transformation. The physical constraints determine where mangrove can grow. The transformation is limited both by the physical environment but also the policies influencing the transformation.

Physical Environment

Mangrove forests are prominent on the entire Pak Phanang Peninsular, the island outside Pak Phun and the southern part of the bay. The estuary of Pak Phanang Bay is a good spot for mangrove growth where sediment delivery makes a soft bottom coastline. The hook shaped Pak Phanang Peninsular protects the mangrove against strong weather events and erosion (CORIN, 1991). The bay is shallow with large areas of mud flats (figure 5.3.). According to a local DMCR officer, new mudflats occur every year outside the planted mangrove at Laem Thalumpuk Cape.

Figure 5.3. Picture of Pak Phanang Bay taken towards BPNPP from Laem Thalumpuk Cape.

On these shallow areas, there are mainly two locations where natural mangrove expansion is possible (see transformation). One is the south of Laem Thalumpuk Cape (figure 5.4., A) and the other is the island outside Pak Phun (figure 5.4., B).

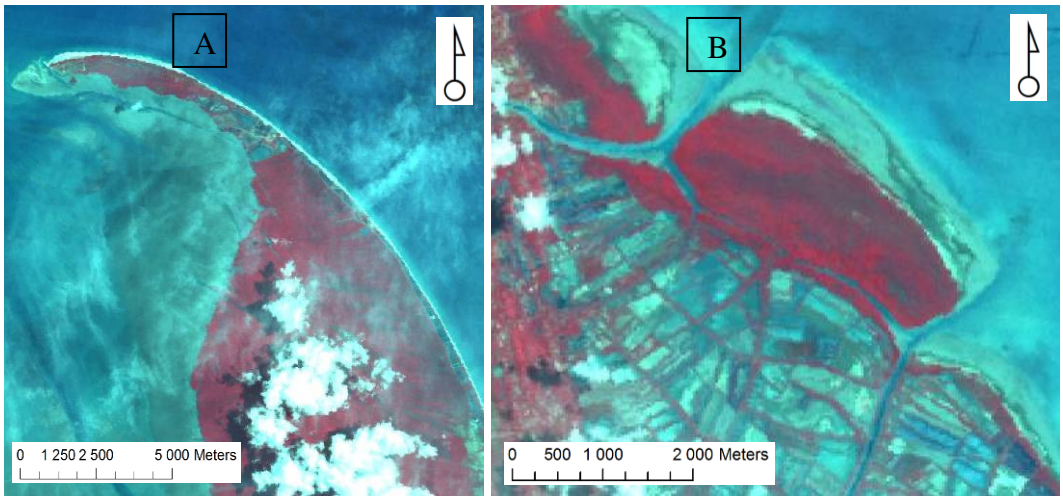

Figure 5.4. Areas with mangrove progression A. Pak Phanang Peninsular. B. The island outside Pak Phun. Mangrove is indicated by red areas.

Mangrove progression on the inside of Pak Phanang Peninsular is possible, if there are no disturbances in the area. Presently, fishing boats and traffic across the mudflats represents a major source of disturbance, dislodging numerous seedlings (Thampanya, 2006).

In 1995, the “Uthockpharasid” water gate (figure 2.2. nr. 9) near Pak Phanang City was constructed in order to store freshwater during the dry periods for the upstream rice farmers. Sedimentation in the bay has increased after the construction of the water gate and the development of mudflats has also increased (villager, BKK, BPNPP, BTH, DNP). This has also affected the salinity of the bay (Villager BKK BPNPP & BTH). According to villagers, in BKK the annual flood has increased since construction of the water gate.

The shoreline outside BPNPP suffers from erosion (figure 2.2.) (villager & village headman BPNPP)(figure 5.5.). On some spots more than 200 meters of land has been lost since 1974.

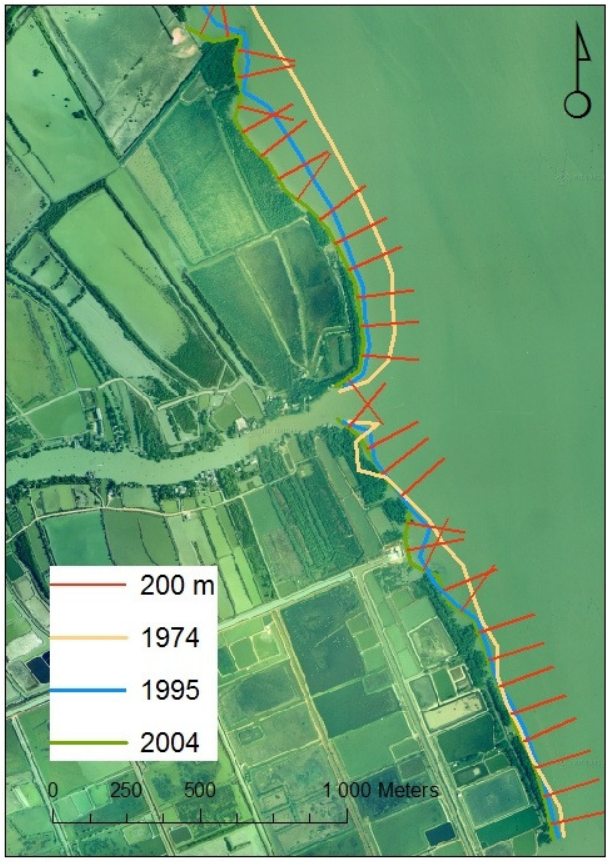

Figure 5.5. Visualisation of the movement and former location of the coastline in 1974 and 1995. Aerial photo from 2004.

Mangrove cannot withstand the erosion outside BPNPP. On many places along the shore shown in figure 5.5., concrete walls has been built to protect against the erosion (observation BPNPP).

The western side of the bay is largely converted into shrimp ponds (figure 5.6.). This area used to be mangrove forest (villager BPNPP & BTH)(visual estimation flight image from 1974). This area is also referred to as the shrimp pond area in this paper.

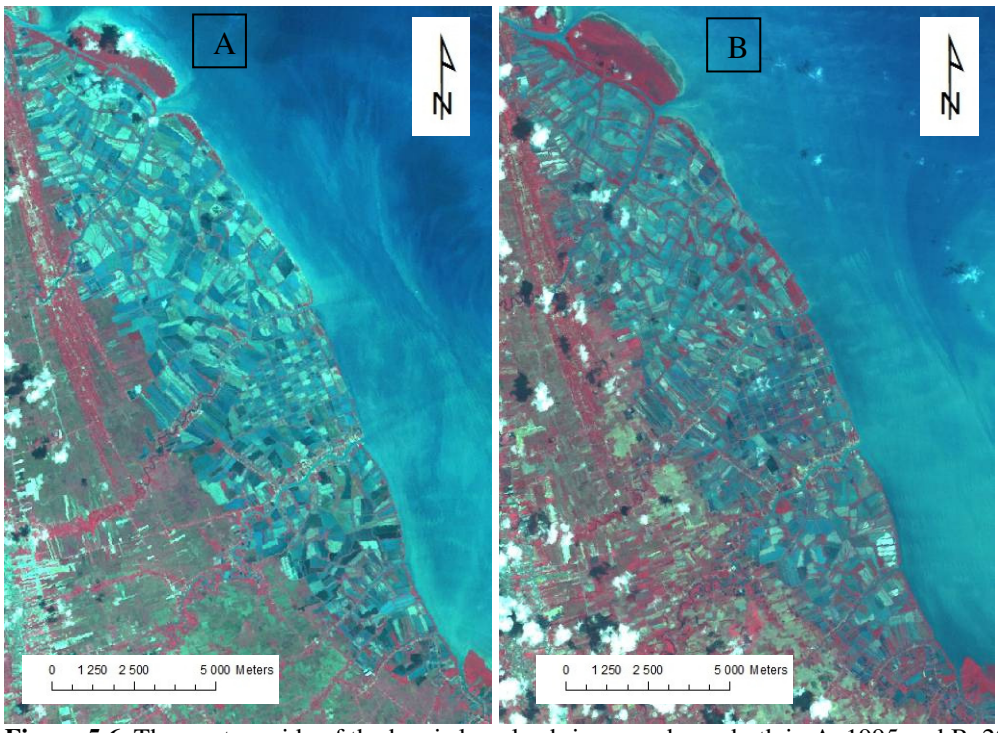

Figure 5.6. The western side of the bay is largely shrimp pond area both in A. 1995 and B. 2007.

Policy Environment

According to the present legislation villagers are not allowed to cut down mangrove in the mangrove areas (villager BKK BPNPP BTH, village headman BPNPP, DMCR local). Mangrove area is declared with each planted area (DMCR local). It unclear if that is only for plantations funded and performed by the DMCR. The mudflats outside Laem Thalumpuk and Pak Phun as well as the entire peninsular are classed as mangrove area. This area was previously classed economical A zone according to the 1987 zoning (figure 5.1.). These zones were only used by the RDF prior to the formation of the DMCR (DMCR regional & local, RDF regional). However, presently all mangrove areas are classed as conservation area which legally prohibits all cutting of mangrove (DMCR regional & local, RDF regional).

The laws used by the DMCR are Forestry Act 1941 and National Reserved Forest Act 1964 (table 5.1.). The Pak Phanang Peninsular is a wildlife conservation area under the Wildlife conservation and Protection Act 1964 (DMCR local & regional). The northern part of Laem Thalumpuc cape is classed a National Park, under the 1961 National Park Act (Dep. of National Parks).

According to villagers and local DMCR officers, villagers do cut down mangrove for personal use. DMCR and villagers agree on an area where cutting is allowed and after that the area is replanted (DMCR local, villager BKK).

5.2.2. Transformation

The CATWOE revolves around a transformation. The transformation is in this case the plantation of mangrove forest in Pak Phanang Bay. How, where and by whom mangrove is planted is generated by the mix of stakeholders and worldviews active in Pak Phanang Bay. The measures performed by stakeholders influencing the transformation were considered input to the transformation. The outputs were the new system characteristics generated by the input and environmental limitations.

Input

Plantations are mainly performed on three separate areas (Village headman BPNPP, DMCR local).

- mudflats
- abandoned shrimp ponds
- riversides/canals

Mangrove plantations on mudflats are limited to the island outside Pak Phun (figure 2.2. nr. 2) and on the inside of the Pak Phanang Peninsular (figure 2.2. nr. 6). The latter area's coast has been entirely planted (map at the DMCR Ta Rai station, field visit). The island outside Pak Phun and its connected mudflats has also been subjected to large plantations (DNP Regional, DMCR local, villager BTH) (figure 5.8.). Plantations on mudflats are protected by a fence making the area inaccessible (villager BKK, DMCR Local). Plantations are also done to repair damaged inland mangrove areas (DMCR local, villager BKK).

The shrimp pond area (figure 4.1.) has been subjected to plantations. Plantations on inland areas have been in abandoned shrimp ponds and on riversides (villager BPNPP, Village headman BPNPP, DMCR local, DNP Regional).

In previous government, DMCR, RDF and TAO, mangrove projects *R. Mucronata* and to a far lesser degree *R. Apiculata* was planted (DMCR local & regional, DNP regional, TAO Pak Phun). This year (2009) there is a DMCR plantation with "Samae" (*A. officinalis* and *A. marina*) on the mudflats outside Laem Thalumpuk. However, most of the planted area in that very same project is still planned to be *R. Mucronata* (villager BKK, DMCR local). There are cases when non-planted diverse mangrove has been cut down by the DMCR and replanted with *R. Mucronata* (Village Headman BTH, villager BPNPP).

Figure 5.7. DMCR Plantation with *R. Mucronata* near Pak Nakhon, Ta Sak. Note the barrier put in front of the plantation.

One of the large plantations programmes around BPNPP and BTH was the Green Carpet project. The project started in the late 1990's when approximately 8 km^2 of mangrove forest were planted over the course of a few years in abandoned shrimp ponds and on the island outside Pak Phun (DNP, Regional). All replantations performed by TAO Pak Phun have been on the newly formed island (figure 5.8. nr. 1).

Around BPNPP and BTH government land has been reclaimed, by the DMCR, according to the 50-50 principle. Farmers occupying government land convert 50% of their land to mangrove forest (villager BPNPP & BTH, village headman BPNPP & BTH, DMCR local).

Output

The plantations in Pak Phanang Bay, during recent decades, have lead to a number of changes, one of those being increased forested area. The increase in mangrove cover is evident on the progressive mudflats (figure 5.8. nr. 1 & 2). This is also an area that has been subjected to a number of plantations (input). Although no estimation of the increased mangrove area on the mudflats has been done in this thesis the expansion of land is clear. Mangrove area has also progressed in the southern end of the bay although the expansion was mainly before 1995 (figure 5.8., nr. 3).

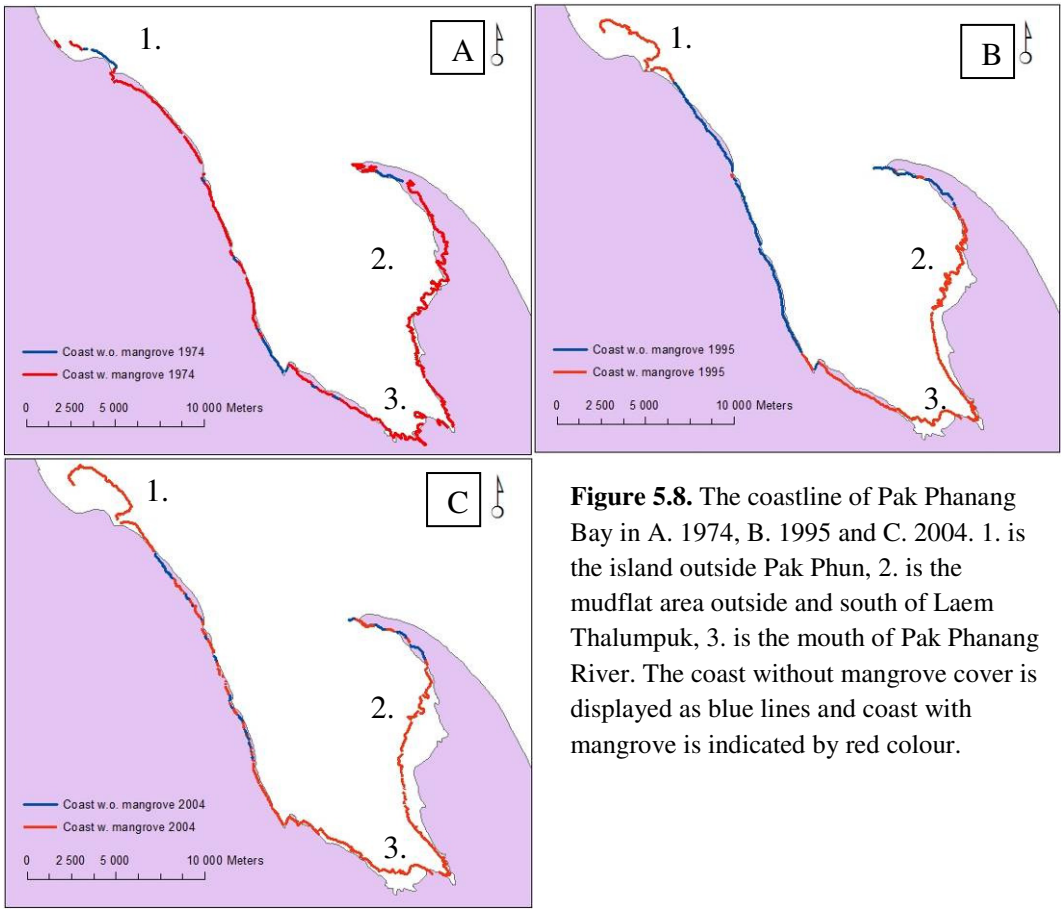

Figure 5.8. The coastline of Pak Phanang Bay in A. 1974, B. 1995 and C. 2004. 1. is the island outside Pak Phun, 2. is the mudflat area outside and south of Laem Thalumpuk, 3. is the mouth of Pak Phanang River. The coast without mangrove cover is displayed as blue lines and coast with mangrove is indicated by red colour.

The coast line, measured from the Pak Phun River to the tip of Leam Thalumpuk Cape, was longer in 1974 and 1995 than in 2004 (table 5.3.), despite the formation of the mangrove island outside Pak Phun. Two reasons for this are:

1. Mangrove plantations around area 2.
2. Decreasing area of water in the bay due to land and mangrove progression

The plantations around nr. 2 (figure 5.8.) has lead to a smoothening of the mangrove water edge. This is likely due to that the plantations were made in straight rows making the coast line smoother than the rugged mangrove coast characterised by natural creeping (see input). Land and mangrove progression on the inside of the bay makes the open water area inside the bay smaller. This can be related to mangrove plantations, natural creeping and formation of mudflats (see environment).

Table 5.3. Length of coastline and length of mangrove covered coastline from Pak Phun River to the Laem Thalumpuk cape.

Year	1974	1995	2004
Coastline (km)	66	64	61
Mangrove coastline (km)	57	45	54
Coast covered by mangrove (%)	86	70	89

As shown in figure 5.8. and calculated in table 5.3, the forested area next to the coast was almost depleted along the western side of the bay in 1995 but restored in 2004 to the same percentage as in 1974.

There has been an increase of mangrove green in the shrimp pond area since the mid 1990's. As explained in the input section, plantation projects have been performed in this area. In addition to plantations, there are also naturally grown mangrove areas within this area (field visit). Mangroves grow naturally in abandoned shrimp ponds and other vacant areas as long as they are not cut down by locals (villager BPNPP & BTH). The green area in the shrimp pond zone increased from 18.9 km^2 in 1994 to 25.2 km^2 in 2007(figure 5.9.). The cover of mangrove green went from 18.5 % to 24.7 % of the total area of the shrimp pond area.

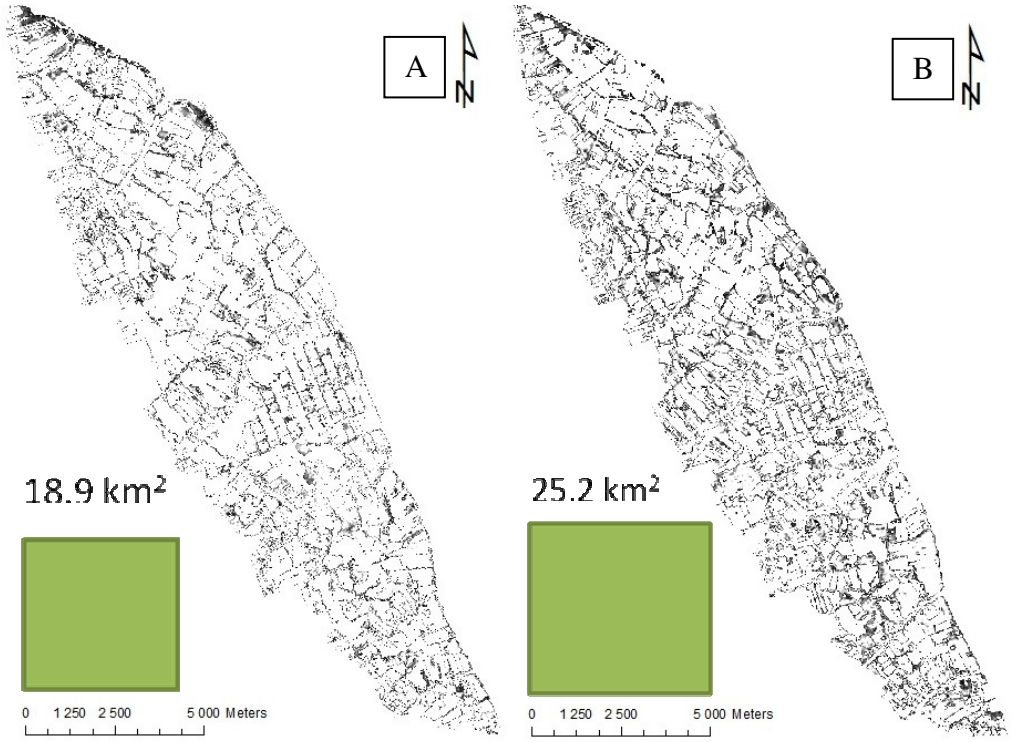

Figure 5.9. Pixels with values that represent mangrove green in the shrimp pond area. A. 1994, B. 2007. The green squares illustrate the area of all pixels representing mangrove green in the shrimp pond area for each year.

As stated in the input section the favoured species when it comes to plantations is R. *Mucronata.* The species grows taller, has straighter trunks and thicker foliage than other mangrove species (Dep. of National Parks, DMCR local & regional) (Bosire et al. 2008). The transformation does not only increase the mangrove area, it also changes the mangrove characteristics and taxa. The planted mangrove areas consist of larger, denser forests than naturally grown diverse mangrove (Village headman BTH, Dep. of National Parks, DMCR local & regional, field visit to BPNPP) (Thampanya, 2006), see mangrove plantations in the background section.

Increased planted area also leads to an increase of protected mangrove area. It is uncertain, however, if the area is classed as protected before mangrove is planted or as a direct effect of the plantation. The increase in mangrove area does leave less room for other land uses such as shrimp farms, villages, fish ponds etc.

Possible outcomes of the transformation

As explained in the introduction, neither R. *Mucronata* nor R. *Apiculata* is a common colonising species under natural conditions on Pak Phanang Peninsular (Thampanya, 2006). By performing plantations, species are bypassed in the succession chain of natural mangrove colonisation and progression. According to Thampanya (2006) R. *Mucronata* is a successor species on the mudflats of the Pak Phanang peninsular. By bypassing these species and creating monoculture forest, a shift in mangrove species-succession and composition may be induced. If mangrove is planted on areas where natural creeping species is impossible, could be due to erosion and waves, the there would be no room for other species to grow. This would maintain the monoculture forests that are induced by the plantations (figure 5.10.). If other species are diminished, they would have less seeds that can grow thus, making the species scarcer according to the "propagule limitation" factor explained in the introduction.

Since the *R. Mucronata* forests grow larger, denser and stronger it is plausible that is serves better for storm mitigation than diverse mangrove.

The decrease in length of the coast and open water area due to plantations, creeping and development of mudflats, in the bay actually makes less room for sea animals in the bay. Plantations around nr. 2, figure 5.8., might in this case actually reduce the habitat of fish and crustaceans that thrive in mangrove-mudflat area.

Figure 5.10. Monoculture forest outside BPNPP (MANGROVE, 2009).

5.2.3. Worldview

This section provides information of what makes the transformation worthwhile for different groups involved in the transformation. The information is compiled on different geographical levels starting with the international context. National level analyses the views of those in charge of national mangrove programmes in Thailand as well as the view of laws concerning mangrove. The local level section handles the interpretation of mangroves from villagers and local government officers.

International

International organisations, like the IUCN, UNDP, FAO and UNESCO, have been and are active in mangrove related questions. The focus from international organisations is not primarily on mangrove, but rather on the services and effects provided by forested coastal zones (IUCN & UNDP international). According to representatives interviewed from both IUCN and UNDP the 2004 tsunami brought up the issue of mangrove as storm protection, something that was already known of but hadn't been showcased before on a regional scale in the same way. This made mangrove a symbol of coastal ecosystem management (IUCN international). This is despite the uncertainties and debate regarding what effect mangrove had on actually mitigating the tsunami (UNDP international)

One example of how the word mangrove has been used, after the tsunami, to create extra attention is the Mangroves For the Future (MFF) programme launched by the former US president Bill Clinton, and implemented by the IUCN and UNDP. The programme is despite its name a coastal aid programme focusing on "reef to ridge" costal management, not primarily on mangrove related issues (IUCN international). The aim is to strengthen coastal communities and livelihoods in 10 countries, including

Thailand, around the Indian Ocean (Wildsingapore, 2006). One way of doing this is to support community led mangrove plantations projects (UNDP international).

The different international organisation has focused on mangrove in slightly different ways. FAO's focus has been on the productive purposes of mangrove like charcoal and fishing. UNESCO has been involved in mangrove research cataloguing and documentation, for more than 20 years. Much of the research on mangrove, at least in Thailand, was funded by UNESCO. IUCN has been active in mangrove plantations focusing on the conservation agenda. But has during the last 5 years made a transition into conservation coupled with livelihood thinking. The UNDP has sustainable land management projects that include mangrove specific issues (UNDP international).

Mangrove plantations where carried out through international organisations before the 2004 tsunami (see transformation). According to a UNDP representative "*There has been a general concern for mangroves, at least in this region [Southeast Asia], for at least 20 some years among the scientific community. Probably there has been a transition of knowledge from scientists towards policymakers. There has also been work by communities. Community engagement has raised the profile of mangroves*."

National

Mangrove forests in Thailand are claimed for state management. According to Sudtongkong & Webb (2008) this is due to that "*Scepticism persists within Thai government circles about whether coastal villages can sustainably manage and protect mangroves*". The National Targets for conserved mangrove area are set by the National Economical and Social Development Plans (NESDP). The target of Thailand's mangrove forest management, as designated in the Ninth Social- and Economic Development Plan: 2002–2006, is to safe-guard not less than 2,000 km^2 of mangrove forest. According to IUCN (international) "*They [Thailand] have come close to the maximum practical value [of mangrove area]*." The Tenth Social- and Economic Development Plan: 2007–2011 focuses on the rehabilitation of mangrove forests to ensure the continuation of their natural abundance through coastal and marine resource management. Another aim of the plan is to enhance local communities' participation in these matters (Chotthong & Aksornkoae, 2009). This shows an increasing concern and increased value for mangrove on a national level. However, this does not include community utilisation of mangrove as a wood resource. The Thai laws do not leave any room for communities to sustainably manage the mangrove wood (DMCR local, DMCR regional, villager BKK, Village headman BTH), at least not in Pak Phanang. This reflects a view of the lawmaker that mangrove has an intrinsic value, not as a sustainable resource for wood.

On a national level mangrove plantations are justified with emotional, economical and environmental reasons. There are for instance Royal Projects linked to mangrove management and plantations (TAO BTH, Village headman BTH, IUCN international). The projects that are linked to royal initiatives has a strong emotional element tied them

(IUCN international). In Krabi (on the Andaman side) eco-tourism has been a strong reason for promoting mangrove plantations (DMCR national, UNDP international). An important environmental reason on for mangrove plantations is to decrease national emissions of green house gases. DMCR has recently, 2008, started a plantation programme in abandoned shrimp ponds. The aim of this project was to reduce global warming as well as to increase the mangrove area (DMCR local & regional). The hazard reducing effects of mangrove forests has been recognised at an early stage on a national level in Thailand. The mangrove area on the Pak Phanang Peninsular has been protected as a storm buffer by a cabinet resolution in following Hurricane Harriet in 1962 (Dep. of National Parks regional)(CORIN, 1991) that had devastating effects on the Pak Phanang area.

As far as this study has shown, there is no recognition of the importance of species diversity from decision makers on a national level. The *R. Mucronata* has proven to be a suitable species for plantations. The species is easy to plant and has a good survival and growth rate compare to other species (Dep. of National Parks, DMCR local & regional). This is lightly the reason why *R.* Mucronata is the most commonly planted mangrove species.

Local level

There are a number of stakeholders active in mangrove plantations on local level. These are villagers, local government offices, private companies and NGO's (see owners, clients and actors). The view on mangrove and plantations of these reflect on how and why plantations are performed.

There is a general consensus amongst all local stakeholder interviewed that the plantations has led to better environmental conditions in the bay. These include better water quality, increased area to find fish shrimp and crab and the case of BPNPP less land loss to coastal erosion. In all of the three sites a substantial part of the villagers are relying on the mangrove for their livelihood (see clients). This is likely making the villagers in the three sites more in favour of the past transformation. There are no conflicts concerning mangrove plantations as a concept but rather on how, to what degree, where and by whom they are performed. The positive view on mangrove is reflected on the number of voluntary plantations performed in the bay, mainly conducted by the TAO's (TAO Ta Sak & Pak Phun, Dep. of National Parks regional). Almost all of the villagers interviewed in the tree sites had participated in voluntary plantations (see actors).

In BPNPP and BTH there is a general consensus amongst villager's that the quality of water along the coast is better, than 20 to 10 years ago when there were hardly any mangrove in the shrimp pond area. Another benefit according to villagers at these two sites is that mangrove reduces erosion along the coast and riversides. Villagers and village headman in BPNPP claims that the goods they get from mangrove (fish, shrimp

and crab) are a strong reason for that they can live in the area. This reason for mangrove plantations was also stated by a DMCR officer at the Krabi Regional office.

According to the village headman in BPNPP, villagers with land titles close to water, plant mangrove on their land to protect from erosion.

Villagers of BKK did not mention the global warming perspective and possible reducing effects of mangrove forests. In BPNPP a villager expressed a concern about plantations in the name of global warming. According to him, "*Global warming is because of the industrialised countries, but they try to solve it here [in Thailand] by using the villagers land. Why not fix it in their own countries?*" Villagers, village headman and the head of the TAO in BTH, however, used global warming as a reason for planting mangrove. The village of BTH has other CO_2 reduction projects as part of a royal programme (village headman BTH).

The local authorities, DMCR and TAO, involved in plantations stated the same reasons as the villagers in favour of plantations. Representatives of both of these organisations is in favour of plantations with *R. Mucronata* due to that it is easily planted, grows well, and provides good timber (DMCR local, TAO Pak Phun).

Conflicts

Despite the positive consensus regarding the benefits with mangrove plantations a few conflicts occur due to the transformation. The conflicts are mainly generated by limitations in the daily life of the villagers or by unwanted effects from the transformation.

Many villagers of BPNPP and BTH suggest that the *R.* is not native to the area. According to them the soil, around their villages, is not suitable for *R. Mucronata* and the leafs pollute water and shrimp ponds. The planted mangrove forests are also too dense; making the mangrove areas inaccessible (villager BPNPP).A better choice according to many villagers would be to use "Samae" because it does not grow as thick and pollutes less. According to the same villagers, *R. Mucronata* is suitable to plant on riversides and mudflats where the water exchange rate is faster and dense root system helps to prevent erosion (villager & village headman BPNPP, villager & village headman BTH). Planting many species would be a way of restoring the previous mangrove ecosystem that provides a better habitat for animals than the present monocultures (villager BTH, Village headman BTH).

The area where mangrove plantations are performed can also generate conflicts. There is a mixed view amongst fishermen in BKK regarding plantations on mudflats outside Laem Thalumpuk. Some fishermen in BKK want to use the mudflats for finding fish and crab (villager BKK, DMCR local). Other fishermen in the village claim that plantations on mudflats are good since it increases the area where sea animals can hide and regenerate. In the BPNPP and BTH there is no conflict regarding disappearing

mudflat area (villager BPNPP & BTH). No one interviewed opposes plantations in damaged mangrove areas on the Pak Phanang Peninsula.

In BPNPP most of the villagers interviewed expressed a wish to be able to cut mangrove commercially. According to the village headman in BPNPP the villager's are eager to take care of the plantations themselves and also to use the mangrove they planted. This is also something requested by a local DMCR officer who wished there was a way for governmental enterprises to harvest and sell wood from the mangrove areas. The DMCR local officers do, however, allow villagers to cut mangrove for personal use, fishing gear, house reparations etc. Sometimes an area with already damaged mangrove is selected by the DMCR and villagers allowing the area to be cut and then replanted (DMCR local, villagers BKK & BTH).

According to the village headman in BPNPP the training and recommendations from the DMCR are not sufficient. Techniques for planting are not suitable to the villager's habitat and needs. There is no continuation in the training. According to the villge headman the DMCR needs to understand their particular habitat before recommending techniques and what species to plant.

5.2.4. Owners

Owners are those that could stop the transformation from happening. The section highlights what groups and organisations have the role of owners in each study site.

Plantations in the mangrove area around BKK are performed by the DMCR (DMCR local, RDF regional, villager BKK). The DMCR needs a concession from the villagers in BKK before planting. The TAO East Pak Phanang is not involved in mangrove plantations other than as a participant (villager BKK, TAO East Pak Phanang).

In BPNPP Village headman, TAO and villagers decide where and when plantations are performed (village headman BPNPP). DMCR currently does not have any ongoing plantation projects in the area although they protect and monitor the mangrove in the area (DMCR Local).

BTH is situated in situated in Pak Phun Sub-district. The TAO Pak Phun has taken a strong role in mangrove plantations and management. Plantations are performed by TAO Pak Phun without involving the DMCR (TAO Pak Phun). According to the Head of TAO Pak Phun, they have been managing mangrove plantations since 1996. "*We have taken the lead in mangrove rehabilitation planning and after that we involve the village head*" (Head of TAO Pak Phun). The DMCR also conducts plantations on the island outside Pak Phun (DMCR local).

Villagers of BPNPP and BKK are owners of mangrove plantations because the DMCR is obliged to ask them for permission before planting (villager BKK & BPNPP, DMCR local). All the villagers interviewed in BTH including the village headman claims that they cannot influence the location of plantation sites. This is despite being under the

authority of the same local DMCR office as BPNPP. This might be due to the high level of influence by the Pak Phun TAO.

5.2.5. Clients

Clients are those that either benefit (beneficiaries) or are negatively influenced (victims) by the transformation.

Beneficiaries

As reflected in the worldview there local communities largely benefit from the transformation. People participating in mangrove plantations and collection of seeds facilitated by the DMCR directly benefit as paid labourers. Plantations are performed by both men and women (Villagers BKK BTH & BPNPP).

Mangrove plantations have increased the area where villagers can find fish, shrimp and crab (villager BKK BPNPP & BTH). There are people in all three communities that are relying on these goods (Dulyapurk et al. 2007). There is a strong consensus (see worldview) that the quality of water is better due to the increased area of mangrove. This means off shore fishermen are also benefiting from mangrove plantations. Mangrove related products are sold at local markets. Working at the local markets is a common female job (villager BPNPP & BTH).

The village of BKK is highly dependent on mangrove areas and the benefits they gain from the planted and natural mangrove. This is mainly because the villagers are not allowed to have shrimp farms in the village (villager BKK, Village Headman BKK) and possibilities to have aquacultures and fisheries are limited (villager BKK).

The DMCR local offices all the way to the central office and indirectly MoNRE have more influence and control of coastal land due to the transformation. The budget of the DMCR is based on previous year's planted area (see governmental institutions).

The TAO's also has a budget for mangrove management (TAO East Pak Phanang & Pak Phun) and plantations (see owners) and are likely benefiting from the transformation. This is likely true for TAO Pak Phun that has taken a strong role in mangrove plantations in the district.

Victims

Mangrove plantations require large areas of land. The land that has been planted cannot be used for other uses than finding shrimp, crab and fish. Those that have lost land to plantations are victims of the transformation. Areas around BPNPP and BTH used for shrimp farming by villagers has been reclaimed for plantations by the government (village headman BPNPP & BTH)(see transformation). Investors (see land titles and classification) have also lost land according that has been reclaimed for plantations (villager BTH).

In BKK there are a number of fishermen who gather mussels, crab, shrimp and fish on the mudflats outside Leam Thalumpuk (villager BKK, DMCR local). The transformation could lead to a decline in mudflat area and limit accessibility to the villagers fishing waters

5.2.6. Actors

Plantations are performed by villagers either as paid labourers in DMCR projects or voluntary plantations run by TAO's or other organisations. Villagers interviewed in all three sites have participated in voluntary plantations. These are performed by villagers, the village headman and TAO's on important days and holidays such as the Kings or Queens's birthday, Mothers- and Fathers day etc. Students from universities also participate in the plantations (villager BKK BPNPP & BTH, TAO Ta Sak & Pak Phun). The TAO provides a link with schools by providing them with areas to plant mangrove in (TAO East Pak Phanang & Ta Sak).

The Green Carpet project was a joint venture between Thailand Environment Institute (a NGO) and a Japanese University, which provided the money (DNP regional).

Apart from TAO and the DMCR PPT, a Thai Oil company, performs plantations in the BKK area (TAO East Pak Phanang).

5.3. METHODOLOGY

The selection of methods provided a good insight in the number of issues that occur due to mangrove plantations. The effects of the transformation are both influencing the human and natural systems in the bay. The combination of hard and soft systems helped to capture those effects and also to see the transformation from different perspectives.

Large parts of the results are based on interviews. These have brought information to the thesis that could not have been obtained by other methods. However, there is a risk that the information gained from interviews is false or miss interpreted. In order for the information to become more accurate most results relied on information from more than one interviewee or in combination with other sources. Quotes were used to enhance the credibility of the analysis. However, in interviews conducted with an interpreter these were rather "quote on quote" than first hand information. Quotes from Thai speaking people were therefore used sparsely in the result section.

The remote sensing helped to provide a better understanding of the physical effects of the transformation in Pak Phanang Bay as well as backing up information gained from the interviews. The maps and images used in the thesis was acquired from a secondary source. The information from the metadata on pixel size etc. was regarded as true. The calculation of mangrove next to the coast includes an estimation of what is considered mangrove or not. The exact results from that calculation can be debated but the trend is evident.

The method, for calculating inland green area, provides an easy to use estimation of what was defined as green area. A problem might occur when the continuous normal

distribution is converted into a discrete interval of pixel values. The effect on estimated area is large if a pixel value is included or not. This is a problem if the intervals for both maps compared are rounded off differently. The pixel size differs between the satellite images from 1994 and 2007 differ between 28.5*28.5 and 25*25 meters. There is a possibility of smaller land areas counting mangrove green in the latter image. This has however been regarded to have little or none effect on the results.

6. CONCLUSIONS

The results show the multitude of stakeholders, environmental-, and social- factors that influence the transformation. The hard system analysis, remote sensing, has helped to answer the questions: what physical changes have occurred in the bay? The use of soft system analysis has in this case helped to answer the questions by who and why.

Plantation projects have been occurring on both mudflats and inland shrimp ponds. The mangrove cover on the mudflats has increased in Pak Phanang Bay since the mid 1990's. The area of mangrove green in the shrimp pond area has also increased measurably during the same period. Mangrove plantations have brought a change to the bay, not necessarily restoring the pre- shrimp farming ecosystems. The plantations with one or two species might have led to local changes in the mangrove species composition. This effect may be larger in the inland shrimp pond area where mangrove was, according villagers and the remote sensing, largely deforested during the peak of the shrimp farming boom. On the Pak Phanang peninsular mangrove has been abundant for a long time and there are still likely propagules from many species available. However, natural progression, as explained by Thampanya (2006), on the penisular might be disturbed by traffic on the mudflat area.

Mangrove plantations are, according to this study, performed similarly regardless of the desired outcomes of the project. There are several reasons for planting mangrove thus several climax states depending on the users' preferences. The DMCR and TAO seem to value a thick strong forest with good growth rate. Such forests likely increase the storm mitigation effects as well as possible CO_2 reducing effects. The view of the DMCR and the TAO's has likely influenced the way mangrove plantations are presently performed. Another key element of why the present monoculture plantations are promoted is likely the cost efficiency. To manage and plant a diverse forest would be more job intensive and therefore costly. On the other hand villagers benefiting from mangrove areas by finding crab fish and shrimp, value a less dense and more accessible forest. The different demands on land use and wanted effects from stakeholders make mangrove management and plantations that suits everybody a hard feat.

There is a risk that national goals on planted area lead to plantations on areas where mangrove is not suitable. If this is the case in Pak Phanang is not certain, but the DMCR and TAO might not have ecosystem services for local people as a primary objective. This is based the way plantations are performed. Examples of that is the construction of barriers (figure 5.7.) around plantations as well as making dense species-poor forests.

The national laws on community use of mangrove resources seem to reflect a view that the climax service of the mangrove system is primarily collection fish, shrimp and crab. Villagers in all three communities expressed, in some way or another, the wish for being enabled to use and make money from mangrove wood. Something that is not possible with the present legislation. Economical benefit from sustainable use of mangrove wood is however something that could justify the monoculture plantations with *R. Mucronata.* The potential in using mangrove timber as a resource for wood and fuel could be substantial.

There seem to be little coordination between DMCR and the TAO's. This is extra evident in BTH where TAO Pak Phun has taken a strong role in mangrove plantations. Cooperative planning and funding could help to increase plantations efficiency and long term management.

Further studies are needed in order to make an even more holistic view of the present situation in Pak Phanang Bay. Important areas left to study are: A, The impact on sedimentation and ecological make up of the bay due to the Uthockpharasid water gate. B, introducing mangrove as a sustainable resource for community development. C, finding alternative economically viable livelihood scenarios for communities in order to move away from mangrove dependence.

REFERENCES

INTERVIEW REFERENCES

Department of Lands	Representative from Dep of Lands, Nakhon Si Thammarat, one session
DMCR local	Representatives from Ta Rai (one session), Ta Sak (2 sessions) office and Pak Phanang, 4 people
DMCR regional	Representative from Krabi Office
DoF, Aquaculture	Representative from DoF, local office, one session
DoF, Fishery Patrol	Representative from DoF, local office, one session
IUCN international	Representative from IUCN Bangkok office
Villager BKK	4 people
Villager BPNPP	5 people
Villager BTH	4 people
Village Headman BKK	one session
Village Headman BPNPP	2 sessions
Village Headman BTH	2 sessions
TAO East Pak Phanang	Representative from TAO East Pak Phanang, one session
TAO Ta Sak	Representatives from TAO Ta Sak, one session, 2 people
TAO Pak Phun	Representatives from TAO Ta Sak, one session
DNP	Representative from Nakhon Si Thammarat office, also involved in the Green Carpet Project, one session
RID	Representative from RID Pak Phanang, one session

WRITTEN SOURCES

AIT (2010). URL: http://www.library.ait.ac.th/ThesisSearch/summary/Narumol%20Thapthim.pdf

Barbier, B. E., & Cox, M. (2004). An Economic Analysis of Shrimp Farm Expansion and Mangrove Conversion in Thailand. *Land Economics, Vol. 80* , 389-407.

Blom, G., Enger, J., Englund, G., Grandell, J., & Holst, L. (2009). *Sannoliksteori och statistikteori med tillämplingar.* Lund: Studentlitteratur.

Brown, J. R., & MacLeod, N. D. (1996). Integrating ecology into natural Resource Management Policy. *Environmental Management Vol. 20* , 289-296.

BOLA (2009). URL:http://www.bola.biz/research/ssm.html

Chotthong, B., & Aksornkoae, S. (2009). *Sustainable Community-based Mangrove Rehabilitation in Thailand.* Bangkok: Thailand Environment Institute. URL: http://www.tei.or.th/Projects/Community_base_mangrove.pdf

CORIN (1991). *Coastal Management in Pak Phanang: A historica perspective of the Resources and Issues.* Costal Resource Institute Prince of Songkla University.

Dulyapurk, V., Taparhudee, W., Yoonpundh, R., & Jumnongsong, S. (2007). *Report of Work Package 1: Multidisciplinary Situation Appraisal of Mangrove Ecosystems in Thailand.* Faculty of Fisheries, Kasetsart University, Bangkok, Thailand.

ESRI. (2009), a. URL: http://webhelp.esri.com/arcgisdesktop/9.2/index.cfm?TopicName=

ESRI. (2009), b. URL: http://webhelp.esri.com/arcgisdesktop/9.2/index.cfm?TopicName=_Datums.

Havanond, S. (1997). Mangrove Forest Conservation in Thailand. *Biol. Bull. NTNU, Vol. 32(2)*, 97-102.

International Law Office (2008). URL:http://www.ilo-phuket.com/legal-documents/land-ownership-rights.html.

IUCN (2007). *Policies and emerging issues in coastal forest management in Thailand.* Bangkok: IUCN.

Kathiresan, K. (2003). How do mangrove forests induce sedimentation? *Biol. Trop, Vol. 51(2),* 355-360.

Kirk, D. (1995). Hard and soft systems:a common paradigm for operations management? *International Journal of Contemporary Hospitality Management, Vol. 7 No. 5,* 13-16 © MCB University Press, 0959-6119.

Lebel, L. N. (2002). Industrial Transformation and Shrimp Aquaculture in Thailand and Vietnam: Pathways to Ecological, Social, and Economic Sustainability . *Ambio, Vol. 31(4)*, 311-323.

Lehaney, B., & Paul, R. J. (1996). *SOFT SYSTEMS METHODOLOGY AND SIMULATION MODELING.*

Lewis, R. R. (2005). Ecological engineering for successful management and restoration of mangrove forests. *Ecological Engineering*, 403–418.

MANGROVE (2009). URL:www.flickr.com Search phrase: MANGROVE Pak Phun

Mangrove Action Project (2006). RL:http://www.mangroveactionproject.org/news/the-map-news/mapnews177-04-nov-06#feature

Map Work (2009) URL:http://thedomusacademy.com/2009/09/11/geography-map-work/

Miller, T. R., Baird, T. D., Littlefield, C. M., Kofinas, G., Chapin, F., C. L. Redman, C. L. (2008). Epistemological pluralism: reorganizing interdisciplinary research. *Ecology and Society, Vol. 46*.

Office of Environmental Policy and Planning (2002). An Inventory Of Wetlands of International and National Importance in Thailand. Bangkok: Ministry of Science Technology and Environment

Ongsomwang, S., Rangsipanich, A., Pungkul, S., & Suekuni, J. (2005). Evaluating Mangrove Plantation Sites using Remote Sensing and GIS in Nakhon Si Thammarat Province, Thailand.

Panapitukkula, N., Duarteb, C., Thampanyaa, U., Kheowvongsria, P., Srichai, N., Geertz-Hansen, O. (1998). Mangrove Colonization: Mangrove Progression Over the Growing Pak Phanang (SE Thailand) Mud Flat. *Estuarine, Coastal and Shelf Science Vol. 47*, 51-61.

PSU (2009). URL:http://web.pdx.edu/~emch/ip1/bandcombinations.html.

Satellite Impressions (2004). URL: http://www.satelliteimpressions.com/landsat.html

Scheffer, M., Carpenter, S., Foley, J. A., Folke, C., Walker, B. (2001). Catasthrophic shifts in ecosystems. *Nature Vol. 413*, 591-596.

Sudtongkong, C., Webb, E. L. (2008). Outcomes of State- vs. Community-Based Mangrove Management in Southern Thailand. *Ecology and Society Vol. 27*.

Thampanya, U. (2006). *MANGROVES AND SEDIMENT DYNAMICS ALONG THE COASTS OF SOUTHERN THAILAND.* Delft: Wageningen University.

Thampanya, U., Vermaat, J. E., Sinsakul, S., & Panapitukkul, N. (2006). Coastal erosion and mangrove progradation of Southern Thailand. *Estuarine, Coastal and Shelf Science Vol. 68*, 75-85.

Wildsingapore (2006). URL:http://www.wildsingapore.org/news/20061112/061204-4.htm).

World Bank (2006). Policies, Institutions and Management. *Thailand Environment Monitor 2006.*

APPENDIX 1.

The MANGROVE project

Mangrove project and project partners

The MANGROVE Project is a part of the EU Sixth Framework Programme. The project began in 2005 and will run until 2009. It is a collaboration between seven partner organizations from six countries. The project aims to improve understanding of mangrove ecosystems, communities and conflicts and to develop knowledge-based approaches to reconcile the multiple demands on mangroves and adjacent coastal zones in South East Asia *. SEI was involved in work package 8 of the project which also involved performing a final workshop. The information from this thesis was used in to find discussion topics as well as for identifying important stakeholders.

Full name of the project is MANGROVE *ecosystems, communities and conflicts*. It is an attempt to understand the "link between mangrove ecosystems and associated social systems". The project is conducted in Indonesia, Thailand and Vietnam.

Project partners:

- Kasetsart University, Bangkok, Thailand
- Mulawarman University, East Kalimantan, Indonesia
- Vietnam National University, Hanoi
- Network of Aquaculture Centres in Asia-Pacific, Bangkok, Thailand
- Stockholm Environment Institute, Stockholm, Sweden
- Wageningen University, The Netherlands
- Centre for Environment and Society, University of Essex, Colchester, UK

Stockholm Environmental Institute, SEI, is an independent, international research institute. The Institute is specializing in sustainable development, environment issues and developing policies using a collaborative participatory approach. It works at local, national, regional and global policy levels. The institute is working towards goals advocated in Agenda 21. SEI has research centres all over the world (sei.se). The thesis was conducted within the SEI Asia office situated in Siam square, Bangkok, Thailand.

The Coastal Resource Institute Asia, CORIN Asia, is connected to the Prince of Songkla University in southern Thailand. The institute is dedicated to the sustainable utilization of Thailand's coastal resources. CORIN Asia aims are to identify and solve problems related to costal resource management. One of their objectives is also to repository of information on southern Thailand's coastal zone. CORIN Asia provided accommodation, office, contacts and an interpreter during the field work.

*http://www.enaca.org/modules/mangrove/index.php?content_id=27