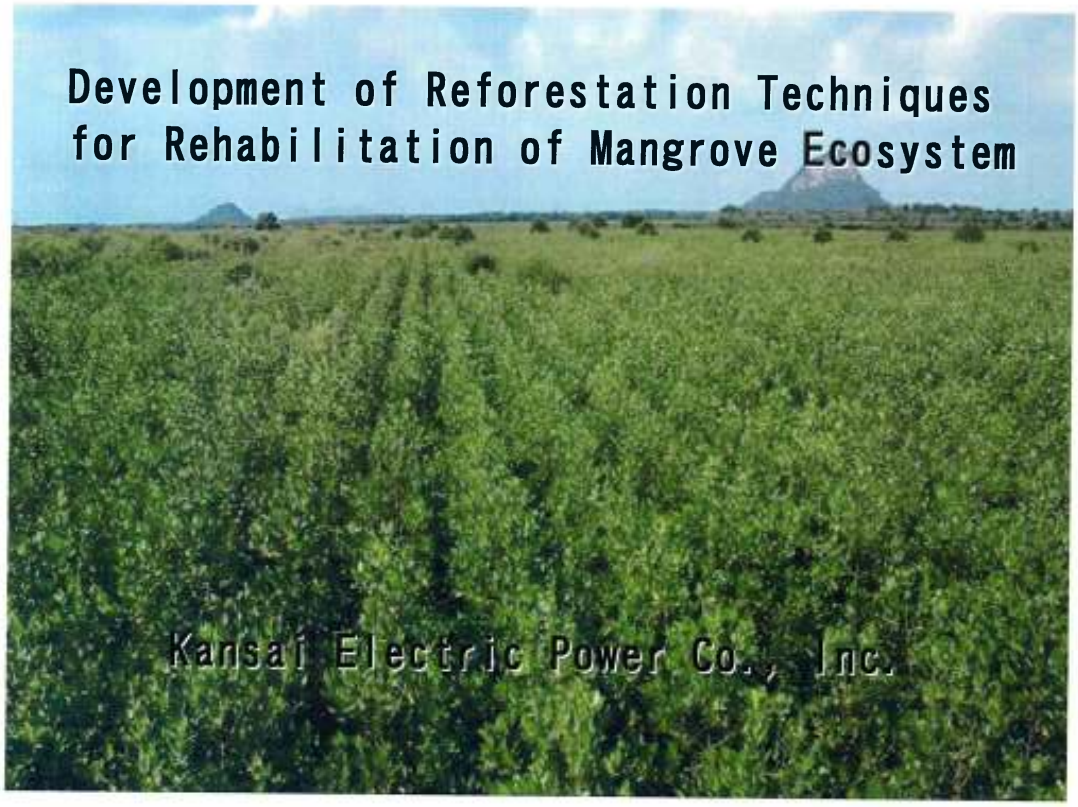


○Global warming prevention efforts of Kansai Electric Power Co., Inc.

○What is mangrove?

○Development of reforestation techniques for rehabilitation of mangrove ecosystem
- Development of reforestation techniques
- Contribution to local communities through reforestation
- Application of remote sensing to reforestation techniques
- Tsunami impact reduction effect of mangroves

○Summary and future plans

Global warming prevention efforts of Kansai Electric Power Co., Inc.
～New ERA Strategy～

What is the New ERA strategy?

We are actively promoting our New ERA Strategy of comprehensive measures to reduce greenhouse gas emissions.
We are conducting our business by pursuing balanced policies to promote the three ERA themes of efficiency(E), reduction(R) and activities abroad (A) in order to contribute further to confronting the global warming problem.

Efficiency:efficiency increase in total energy consumption in the society
Reduction:reducing greenhouse gas emissions from power supply industry
Activities Abroad:activities abroad for global warming issues

Global warming prevention efforts of Kansai Electric Power Co., Inc.

Activities Abroad
—Efforts to prevent global warming overseas—

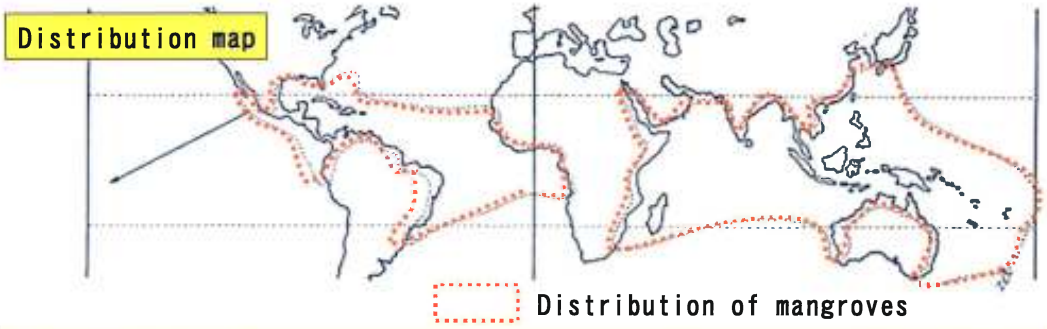
What is mangrove?

Mangroves refer to all plants that grow in coastal and estuarine habitats where saline and freshwater mix. Many of them belong to the family Rhizophoraceae.
(They include Bruguiera gymnorrhiza (L.) Lam., Kandelia candel (L.) Druce, and Avicennia marina (Forsk.) Vierh.)

Stilt-roots

Functions of mangroves

- ○**High carbon storage capacity:** high ability in underground carbon fixation (according to joint AIMS studies).
- ○**Benefits to ecosystems:** producing organic substances to benefit surrounding ecosystems.
- ○**Environmental conservation:** Reducing the runoff of sediment and mud from land.
- ○**Disaster prevention:** Blockng sea breezes and high waves.



○Mangroves are distributed in the range up to 32-38 degrees north and south latitude. In Japan, they are found mainly in Okinawa Prefecture (ranging from Tanegashima Island to Iriomote Island) with a northern limit in Kagoshima Prefecture (Kandelia candel (L.) Druce).

○In 2000, the total area of mangrove habitats was 14,650,300 hectares, down 26% from 1980 (annual decrease of approximately 1%).

○Mangrove habitats account for approximately 1.5% of the area of Tropical forests. (Mangroves grow in coastal areas.)

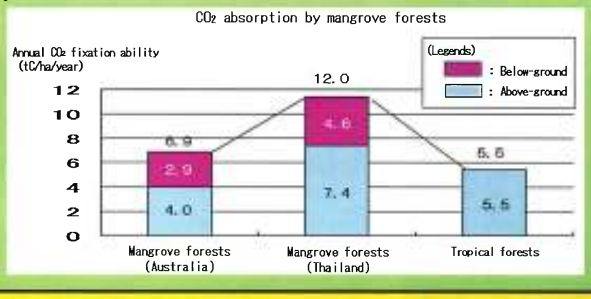
Joint international research with the Australian Institute of Marine Science (AIMS)

○FY1996 - FY1997
Hinchinbrook Island, Australia

○FY1998 - FY1999
Chumphon, Thailand

Research outline

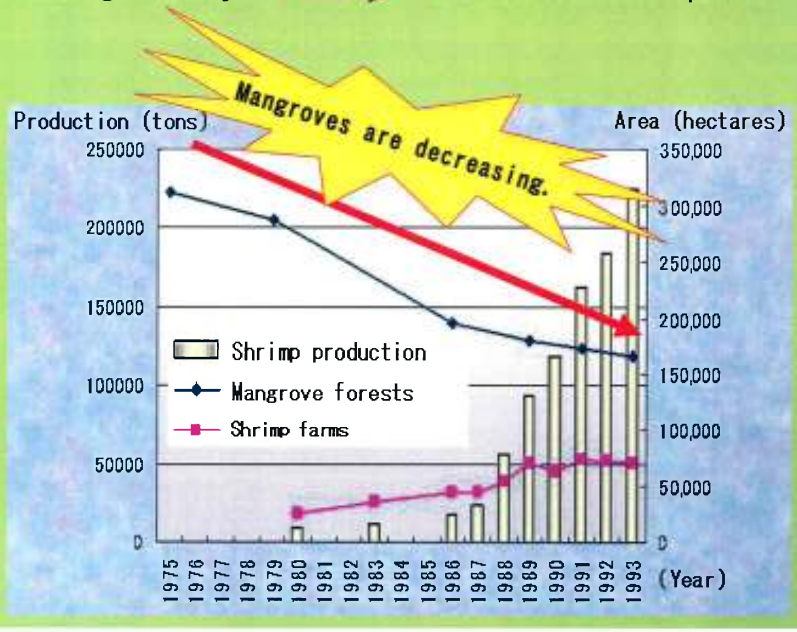
Research on annual organic carbon accumulation rate and carbon accumulation in mangroves
(daytime photosynthesis rate survey, soil survey, root digging survey and remote sensing method)

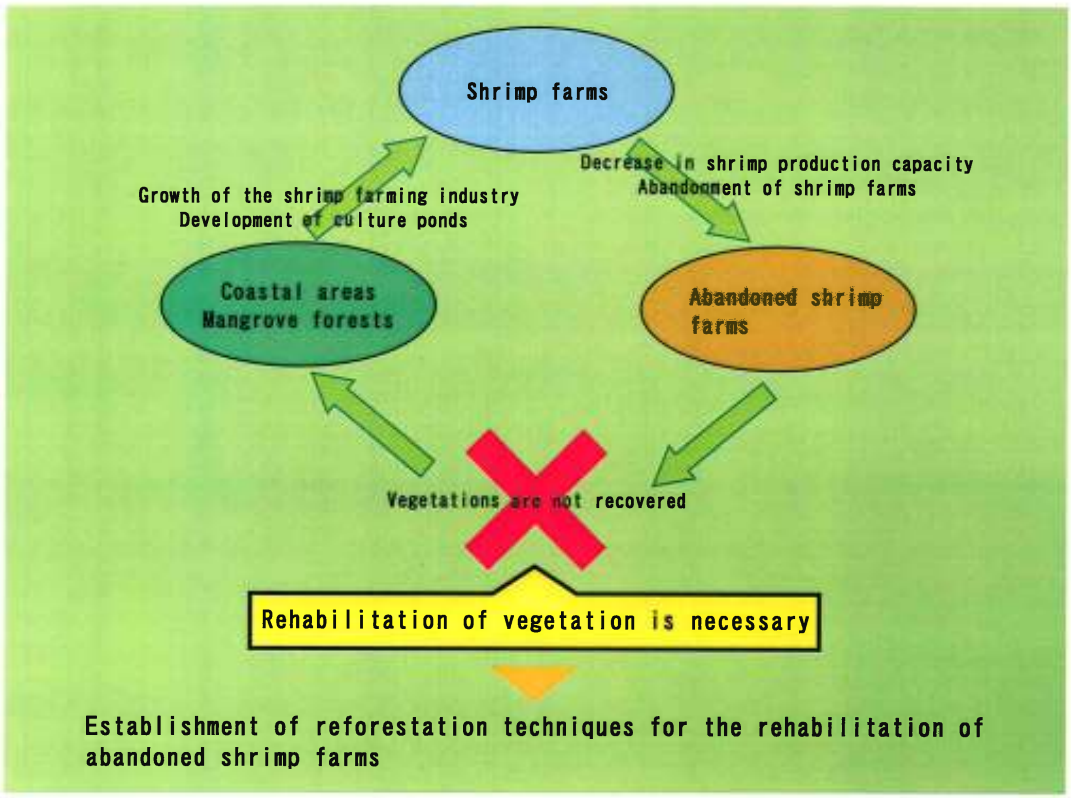


Mangrove forests: a promising candidate as a carbon sink with a CO_2 fixation ability equivalent to tropical forests

Background 1: Changes in the area of mangrove forests in Thailand

Growth of the shrimp farming industry → Loss of mangroves resulted from coastal development





Site of a former shrimp farm (Don Sak)

Background 2: Erosion of coastlines

Changes in the depositional environment of tideland due to haphazard coastal development

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Mangroves die and coastline erosion accelerates.

new mudflat

Eroded coastline

Establishment of reforestation techniques for Reforestation in areas where environmental conditions are changing quickly to ensure prevention of coastline erosion

Development of reforestation techniques for rehabilitation of mangrove ecosystems

Research organization
(a joint research of three parties)
Japan : Kansai Electric Power Co., Inc.
The General Environmental Technos Co., Ltd.
Thailand : Department of Marine and Coastal Resources,
Ministry of Natural Resources and Environment

Research period
October 2000 - March 2007
(approx. 6 and a half years)

Study sites
Thailand:Abandoned shrimp farms
(Khanom, Songkhla and Don Sak)
new mudflats
(Khanom, Samut Songkhram and Songkhla)
Eroded coastline (Samut Songkhram)

Total Reforestation area: Approx. 100 hectares

Development of reforestation techniques for rehabilitation of mangrove ecosystem

〈Research topics〉

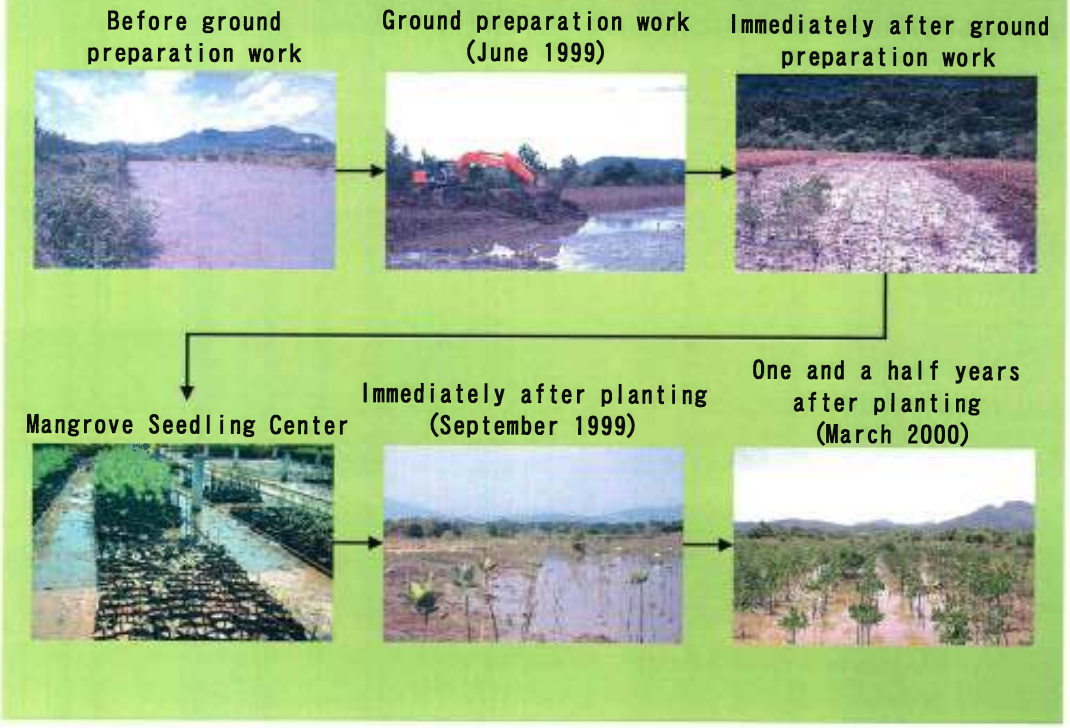
○Development research on reforestation techniques
- Development of reforestation techniques for abandoned shrimp farms
- Development of reforestation techniques for eroded coastlines
- Development of reforestation techniques for Lake Songkhla

○Contribution to local communities through reforestation
- Sustainable aquaculture system in mangrove habitats
- Development of hatching techniques and catch research for mud crabs
- Lifecycle analysis on the effective use of mangroves

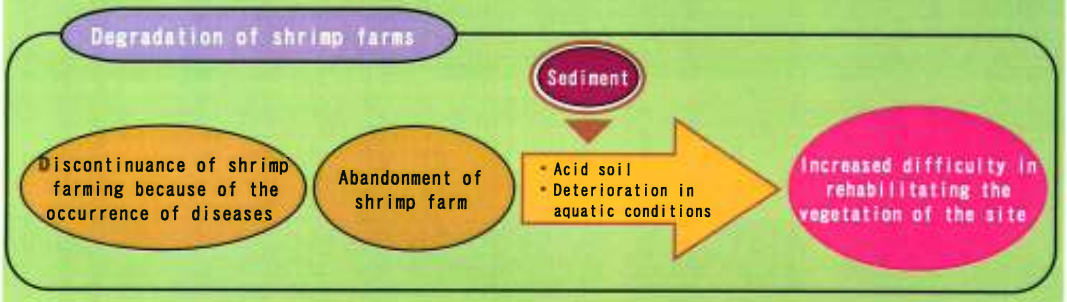
○Application of remote sensing to reforestation techniques
- Measurement of above-ground biomass
- Determination of suitability of mangrove reforestation sites

○Tsunami impact reduction effect of mangroves

Differences in damage are compared between mangroves and other tree species in areas struck by the Indian Ocean Tsunami.



Research 1: Development of restoration techniques for abandoned shrimp farms



A shrimp farm in operation

A degraded shrimp farm

Research 1: Development of restoration techniques for abandoned shrimp farms

Plantation: Sediment deposition caused by wastewater inflow from adjacent shrimp farms raises the ground elevation, which worsens the site environment and makes it difficult to rehabilitate the vegetation.

Test method

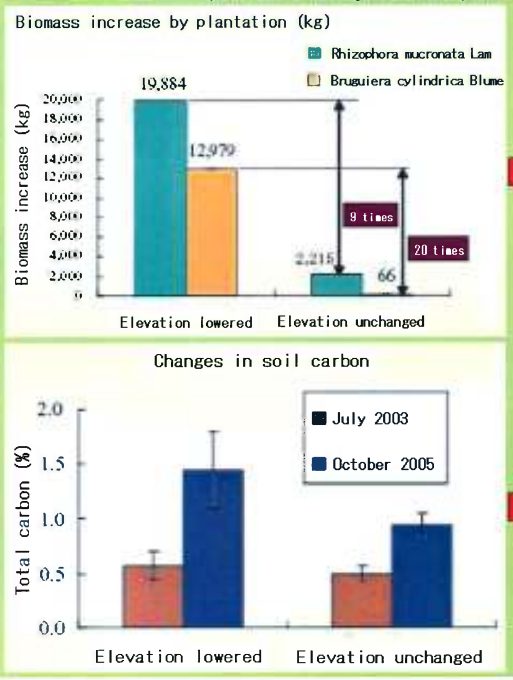
Digging up to lower the ground by 30 cm → restoring aquatic conditions.
Creating a weir → blocking the inflow of sediment

<Bruguiera cylindrica Blume>

<Rhizophora mucronata Lam>

Research 1: Development of restoration techniques for abandoned shrimp farms

Test results (Four and a half years after plantation)



For mangroves to grow:
- ○suitable aquatic conditions are necessary, and
- ○selection of species suitable for the aquatic conditions of the site is important.

Ground improvement is effective in increasing soil carbon.

Research 2: Establishment of restoration techniques for eroded coastlines

The coastline along the northwestern part of the Gulf of Thailand has suffered serious erosion problems with the shoreline receding 20m every year.

↓

The ground is strengthened by accelerating the early growth of mangrove seedlings through the enhancement of rootage.

Research 2: Establishment of restoration techniques for eroded coastlines

Test method

Use of soil amendments

1. NPK
   (A common agricultural fertilizer)
2. Coconut fiber
   (Rich in organic matters, also used in nurseries)
3. Humic acid
   (A polymeric organic acid, high fertilizer effect)

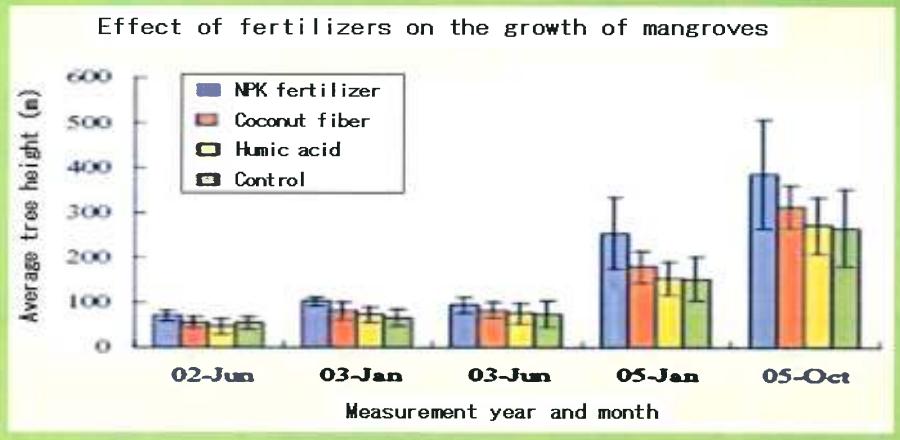
NPK

Coconut fiber

Humic acid

Research 2: Establishment of restoration techniques for eroded coastlines

Test results



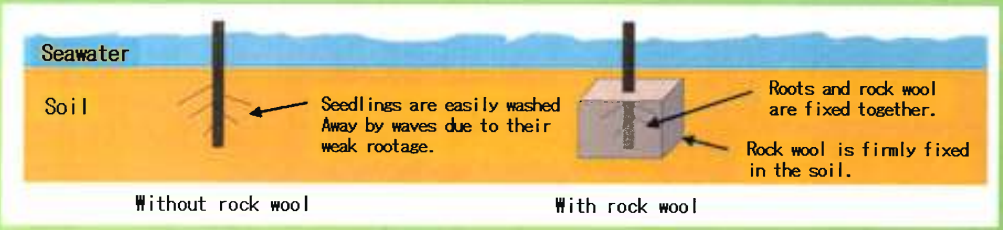
- ○Soil amendments are effective in increasing growth rate.
- ○NPK fertilizer is particularly effective.
- ○The more inland the site is, the more effective the amendments are.

Research 3: Development of restoration techniques for Lake Songkhla

- Lake Songkhla:
  The largest lake in Asia. Development and coastal erosion have diminished the mangroves in the lake and have been changing the lake ecosystem.

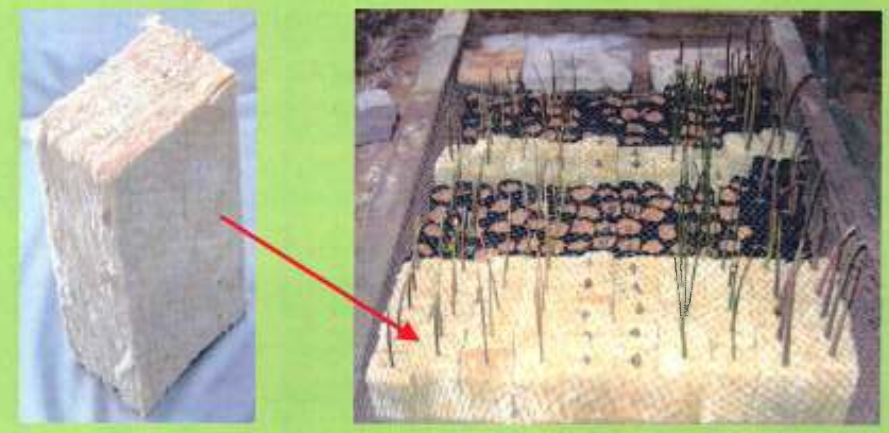
Test method

1. Selecting the seedlings of native Sonneratia caseolaris (L.) Engli., a relatively taller species.
2. Planting in a season when the salinity is low (October - January, salinity of 1% or less).
3. Using rock wool.
   (Roots are wrapped with rock wool to promote rootage.)



Research 3: Development of restoration techniques for Lake Songkhla

Improvement in rootage by using rock wool



Research 3: Development of restoration techniques for Lake Songkhla

Test results

Rootage of seedlings with their roots wrapped with rock wool was Relatively good at inland sites.

5 years later

Plantation on a new mudflat

5 years after restoration

The survival rate of the mangroves planted after six months of plantation was 70%

Contribution to local communities through reforestation

Silvofishery is a compound of silvo (forest) and fishery and refers to a system in which forestry and fishery coexist.

An experimental silvofishery site

Research 1: Sustainable aquaculture system in mangrove habitats

Concept of silvofishery

Abandoned shrimp farms

Aquaculture harmonized with mangrove reforestation

Rehabilitation of mangrove ecosystems

Silvofishery

Improvement of natural fishery resources

Increase of the income of local residents

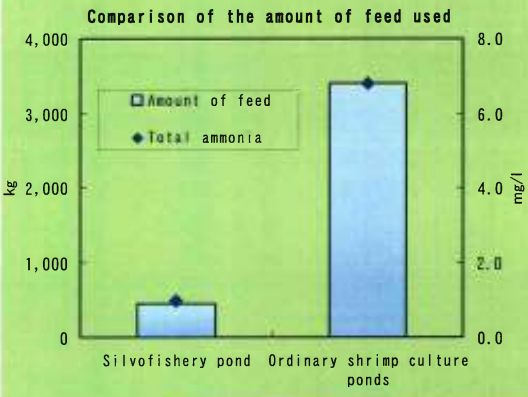
Prevention of water pollution

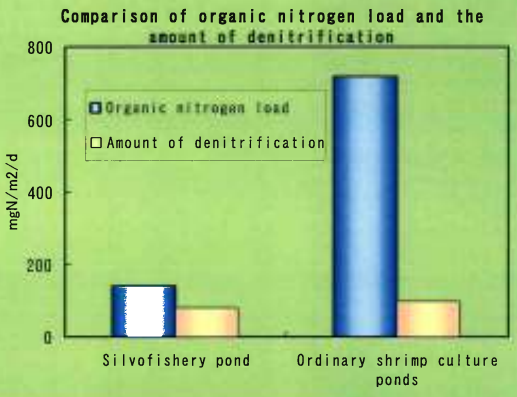
Local residents engaged in silvofishery in Nakhon Si Thammarat in Thailand

Research 1: Sustainable aquaculture system in mangrove habitats

Research outline

A pond where silvofishery had been conducted for 27 years was studied.

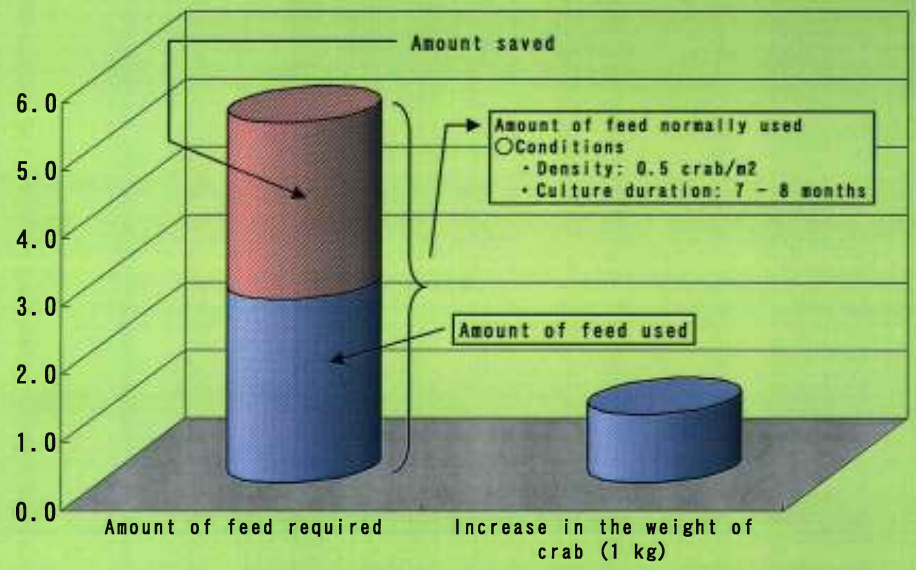




Results of the study on a silvofishery pond

- ○The amount of feed used is significantly low.
- ○The total ammonia nitrogen is significantly low.
- ○Self-purification ability is high.

Amount of feed (kg) required to increase the weight of mud crab by 1 kg



Research 2: Development of hatching techniques and catch research for mud crabs

Study subject: Mud crabs (large, grow rapidly, high unit price)

○Development and technical exchange activity for hatching techniques
- Research on the conditions necessary for hatching (amount of sand on the bottom of water tanks at hatcheries, suitable temperature)
- Catch research for mud crabs

→Collection of basic data for establishment of a system that ensures sustainable mud-crab fishing

Mud crab

Research 3: Lifecycle analysis on the effective use of mangroves

Research outline

Lifecycle analysis (LCA) of mangrove charcoal (plantation - charcoal making - selling)
- Case 1: Plantation is implemented.
- Case 2: High-density plantation is implemented on a 10-year cycle for charcoal production.

Results

An interview survey conducted in a charcoal producing area (Samut Songkhram) for LCA analysis of CO_2 emissions, employment and socioeconomic effects showed that sustainable charcoal production were beneficial in both cases.

Charcoal kiln for mangrove

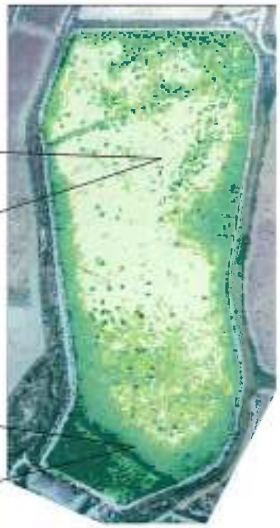
Production of charcoal

Application of remote sensing (using a wireless helicopter) to reforestation techniques

Research 1: Estimation of above-ground biomass

Tree height: approx. 1m
A site where growth is poor

Tree height: 2 – 3 m
A site where growth is good



Results of a survey of the amount of CO_2 fixed using a wireless helicopter
Measured site: A large-scale plantation (25 hectares) in Don Sak
Approximately 100,000 trees were planted in September

A technique that measures the amount of CO_2 fixed by mangroves using remote sensing technology was developed.

Research 2: Determination of suitability of mangrove reforestation sites

A system to determine the suitability of a site for reforestation

Data related to factors that influence the growth of mangroves were collected at sites where plantation was executed

A formula to predict the growth of mangroves

↓

A growth increment over two years is predicted

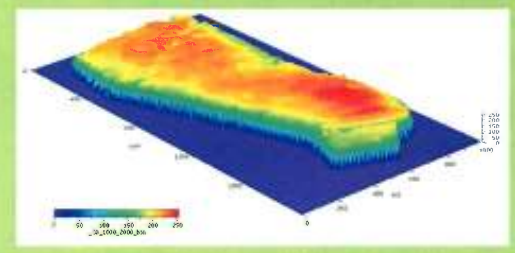
Suitability of a site where reforestation is planned is determined

The system served to identify measures necessary for rehabilitation of vegetation to facilitate rehabilitation of mangroves

Degraded site

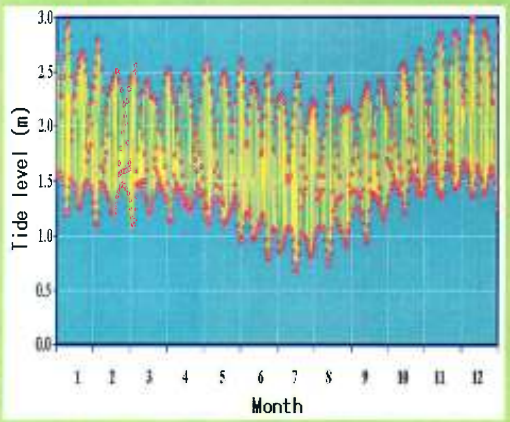
Research 2: Determination of suitability of mangrove reforestation sites

GPS survey

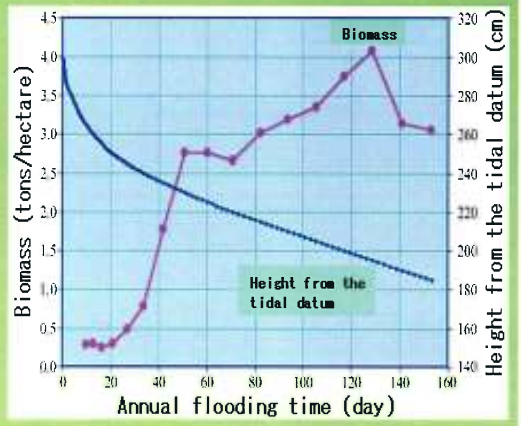


3D image of the relative elevation of a plantation

Research 2: Determination of suitability of mangrove reforestation sites



Annual changes in tide level in Samui Island



Relationship between annual flooding days and biomass

The volume of biomass sharply decreased as the annual flooding time was shorter than 50 days.

Research 2: Determination of suitability of mangrove reforestation sites

Development of a system to determine the suitability of plantation sites

Factors that influence the growth of mangroves are extracted.

(Factors: 13 items including land elevation, hardness, volume water content, pH, salinity, carbon rate, oxidation-reduction potential, total carbon, total nitrogen, concentration of Ca, Mg, K and Na)

	Factor 1	Factor 2	Factor 3	Factor 3
Relative elevation	-0.83	0.09	-0.11	0.12
Soil hardness	-0.66	-0.43	-0.29	0.29
Volume water content	0.61	0.60	0.32	-0.07
Oxidation-reduction potential	0.20	-0.06	-0.02	-0.94
pH	-0.70	0.39	-0.24	-0.30
Salinity	0.70	0.47	0.27	0.08
Total carbon	0.80	-0.55	0.03	0.09
Total nitrogen	0.58	-0.70	-0.16	-0.11
Carbon rate	0.83	-0.41	0.11	0.16
Exchangeable Ca	0.14	-0.42	-0.80	-0.17
Exchangeable Mg	0.64	0.48	-0.47	0.21
Exchangeable K	0.24	0.56	-0.72	0.11
Exchangeable Na	0.70	0.25	-0.38	-0.04
Eigenvalue	5.15	2.67	1.88	1.21
Cumulative contribution rate	39.60	60.10	74.60	83.90

A formula that predicts the tree height of mangroves over two years was developed

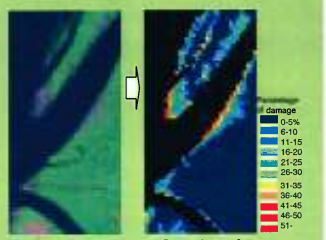
Mangrove growth prediction formula (over two years) (H)

$H = 58.30 + 13.96 \times PC1 + 5.24 \times PC3$ ($r2 = 0.65$)

Evaluation of the tsunami impact reduction effect of mangroves (comparison with other tree species)

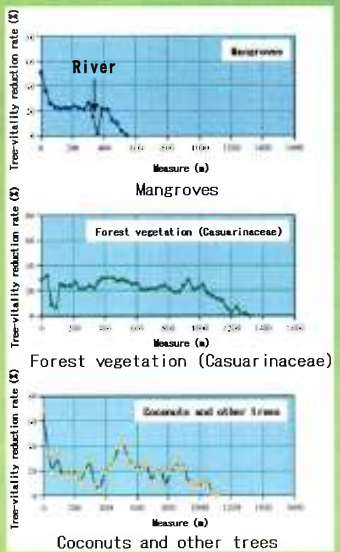
A newspaper article Reporting the tsunami damages

Damages to forests caused by the tsunami were analyzed for several tree species (the vitality of trees was measures) using satellite images (see graphs below)



A satellite image (Thailand)

Result of analysis on tree damages caused by the tsunami



The plantation size necessary to prevent the damages of tsunami similar in class to the December 2004 Indian Ocean Tsunami

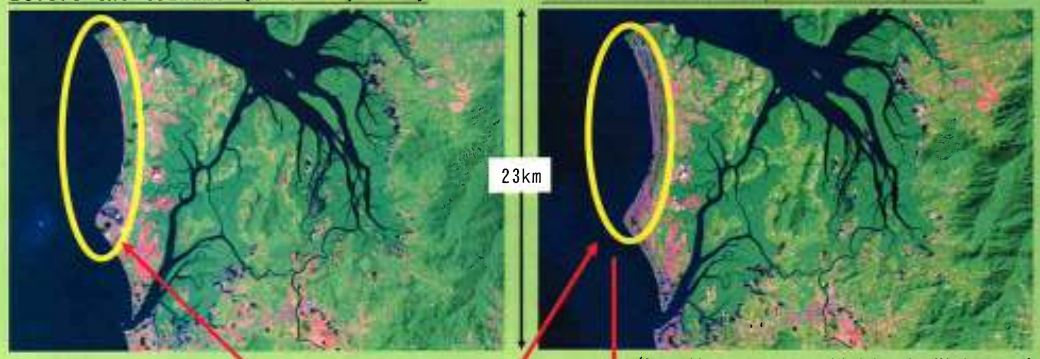
-- Mangroves: 520 m, Coconuts: 1,110 m and Casuarinaceae: 1,320 m

The tsunami impact reduction effect of mangroves was two times or more that of other tree species

Damages caused by the Indian Ocean Tsunami (Landsat satellite images) [150km north of Phuket, Thailand]

Before the tsunami (March 17, 2004)

After the tsunami (December 30, 2004)



(Satellite images provided by the Ministry of Natural Resources and Environment, Thailand)

(Red: degraded areas, green: forests)

Many forests and houses were severely damaged

The Indian Ocean Tsunami, which occurred on December 26, 2004 off the coast of Sumatra, caused severe damages across Southeast Asia

Development of reforestation techniques for rehabilitation of mangrove ecosystem

〈Summary〉

○Development research on reforestation techniques

Thirteen factors that significantly influence the growth of mangroves were identified by experimentally planting mangroves under various conditions. A system was developed, which determines the suitability of plantation sites by predicting the growth of mangroves based on identified factors.

○Contribution to local communities

A "silvofishery" system that allows environmental conservation and sustainable aquaculture was developed. Information on the system was offered to the Thai Government to serve for policy making.

○Evaluation of the amount of CO_2 fixed by mangrove reforestation using remote sensing technology

A technique was developed to measure, with high accuracy (90% or over), the amount of CO_2 fixed by mangroves using images taken by a wireless helicopter.

○Tsunami impact reduction effect of mangroves

It was confirmed that the tsunami impact reduction effect of mangroves was larger than that of other tree species.
The plantation size necessary to significantly reduce the damages of tsunami similar in class to the Indian Ocean Tsunami is as follows:
Mangroves: approx. 500m
Other tree species: approx. 1,000m or over

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