# Adaptation Strategies for Coastal Erosion/Flooding: A Case Study of Two Communities in Bang Khun Thian District, Bangkok*

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## 1. INTRODUCTION

A rise in sea level has occurred globally, and a continuous rise in the level of the sea is one of the most certain impacts of global warming. One of the expected impacts of sea-level rise is inundation of coastal areas, which will have a negative impact on the livelihoods of the people living in those areas and on GDP. In Thailand, the impacts of coastal erosion, together with a relative rise in sea level owing to land subsidence as a result of excess groundwater extraction in the flat and low-lying areas of the Gulf of Thailand, which includes Bangkok, are expected to be significant. According to a Chulalongkorn University study, 11 and 2 percent of the coastline areas along the Gulf of Thailand and the Andaman Sea respectively are eroding at a rate of more than 5 meters a year. This is equivalent to 2 square kilometers of coastal real estate, valued at about US$ 156 million, being lost each year (World Bank 2006).

Coastal erosion involves not only a loss of land, but also of roads, electricity systems, land devoted to aquaculture, and farmland. Thanawat (2006) finds that 30 coastline areas in Thailand have been prioritized as being the most severely eroded coastal areas in the country, namely "hot-spot" areas. The coastline in Samut Sakhon and Samut Prakan provinces, and Bang Khun Thian district of Bangkok, share the same coastline (Figure 1), and are included in the hot-spot areas. However, owing to budgetary and time limitations, this study focuses only on Bang Khun Thian district of Bangkok, which we think offers useful insights into the adaptation behavior of local communities to this situation. In addition, the Bangkok Metropolitan Administration (BMA) is planning to deal with the coastal erosion problem in the Bang Khun Thian area; the planned action is still under study in deciding appropriate alternatives. However, the BMA study emphasizes engineering or infrastructure alternatives, which lack adaptive behavior at the household level. This study will help to fill the gap in the BMA study as it relates to the adaptation of households.

Bang Khun Thian is the only district in Bangkok province that is located on the coast; it has a coastline 4.7 kilometers long. The area located next to the shore is Ta Kam subdistrict where the total population and the number of houses are 38,699 persons and 16,956 houses respectively. A BMA study (2006) found that two village communities in Ta Kam subdistrict have been directly affected by coastal erosion, that is, villages number 9 and 10. In 2005, the total number of houses in those villages were 382 and 327 respectively (BMA 2006).

Coastal erosion is most critical in the village number 9, where the stakes marking the Bangkok boundary are already submerged (see Figure 2); the erosion is taking place at the rate of 20-25 meters of coastal land per year. During the past 28 years, coastal erosion has decreased the village's shoreline, from 4 to 800 meters (Thanawat 2006).

The objective of the study is to determine the adaptation strategies of households and communities with regard to coastal erosion/flooding. The structure of this paper is as follows: Section 2 describes the geographical characteristics and economic activities in the study area. Section 3 describes the method of data collection. Section 4 presents important findings of the survey. Those findings emphasize the adaptation strategies to coastal erosion in the study area. The last section is conclusion and lessons learned from the study.

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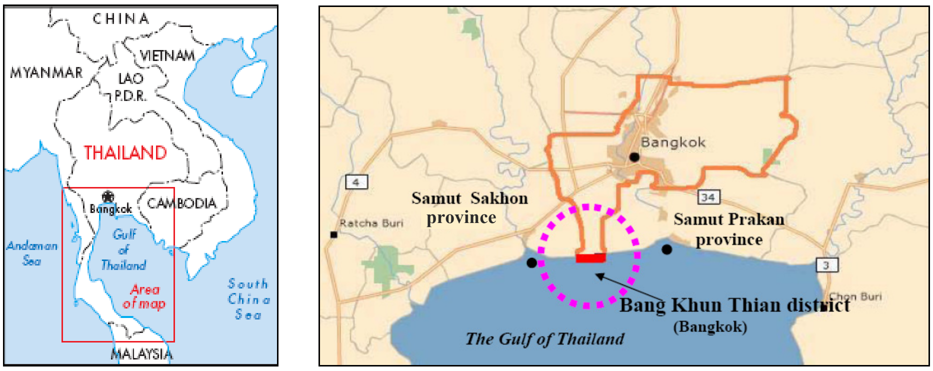
**Figure 1 The Gulf of Thailand (left) and the Study Area in Bang Khun Thian District, Bangkok (right)**




*Source:* World Bank, 2006.

**Figure 2 Stakes Marking the Bangkok Boundary in Bang Khun Thian District, Bangkok**


*Source:* Rawadee and Areeya, 2008.

## 2. DESCRIPTION OF THE STUDY AREA

### 2.1 Profile of Bang Khun Thian

The coastal area of Bang Khun Thian district is situated along the upper Gulf of Thailand and is bounded by Samut Prakan province to the east and by Samut Sakhon province to the west. The study area comprises 4.7 km of muddy coast; currently, no mangrove forest has survived, except for fringes along the shoreline. A number of shrimp ponds extend northward from the shore, as shown in Figure 3. Farmers' houses are located on a canal which skirts the shrimp ponds; the canal is also the main route that coastal communities use for transport and travel.

### 2.2 Economic Activities in the Study Area

The major economic activity in this area is coastal aquaculture, with the raising of shrimp and blood cockles being the main occupation. All the shrimp farmers in the study area use extensive farming techniques, requiring little management and investment. Based on this approach, the farmers, or more accurately aquaculturists, impound wild larvae from the sea and then grow them to market size. The shrimp feed on naturally occurring organisms; thus, the farmers do not need to use feed or fertilizer to make the shrimp grow. Almost all the costs of this form of aquaculture are related to the construction and maintenance of dikes. Harvesting is done by draining the pond and collecting the shrimp in nets. However, the farmers harvest the shrimp in such a casual way that there is no exact harvesting period and the yields are uncertain. The most important factor in determining production levels in shrimp farming is the quality of water.

Owing to the decreasing yields from shrimp farming caused by water pollution and a decrease in the number of larval shrimp in nature, the farmers have been turning to raising blood cockles along with farming shrimp in order to maintain their earnings. Like shrimp farming, cockle farming requires little management, since cockles feed naturally on the nutrients in the clay at the bottom of the ponds. Farmers have only to impound larval cockles and wait for them to grow to market size, a process which takes about a year. Therefore, the production costs of cockle farming are related mostly to the cost of cockle larvae.

**Figure 3 Aerial Photograph of the Coast in Bang Khun Thian District, Bangkok, Depicting Shrimp Ponds**


*Source:* www.thaigoogleearth.com, visited in October 2007.

## 2.3 Current Impacts of Coastal Erosion/Flooding

Over the past three decades, it has been claimed that more than 500 meters of the Bang Khun Thian coast have already been eroded; that level of erosion is equal to about 400 hectares of land when considering the total loss (Figure 4). The degree of erosion is more severe around the mouth of the canal. From an analysis of aerial photographs taken between 1952 and 1991, the rate of erosion was approximately 7-12 meters per year at the beginning, increasing to 33.1 meters per year in the period 1987-1991 (Isaraporn 2001). Further analysis of those photographs and of earlier ones reveals that the retreat of the coast was accompanied by a remarkable change in the shape of the coastline, i.e., from a regular, smooth coastline formerly to a very irregular coastline now (Winterwerp, Borst, and de Vries 2005).

Studies show that coastal erosion in Bang Khun Thian district is caused by a decrease in sediment yield, natural land subsidence, sea-level rise and the impacts of waves and storms (Winterwerp, Borst, and de Vries 2005; Thanawat 2006; Isaraporn 2001). Subsidence of 1 cm annually would result in an apparent coastal retreat of 5 meters per year (Winterwerp, Borst, and de Vries 2005). Thanawat (2006) estimates that the sea level in the upper Gulf of Thailand will rise by 10-100 cm in the next 50 years. When the effects of land subsidence are integrated into the calculation, the coastal area is projected to be inundated for about 6-8 km inland from the current shoreline during the next 100 years.

Important evidence that indicates the seriousness of the situation with regard to the inundation of the study area is the deserted old water-gates, which were once part of farmers' shrimp ponds (Figure 5, left). Thus far, aquaculture ponds have retreated further inland, that is, farmers have had to abandon their water-gates when they become covered by water; they then build new ones and reconstruct some parts of the pond walls. As mentioned previously, the shoreline of the study area has also been affected by strong waves and storms, as shown in Figure 5 (right); strong waves cause mangroves at the shoreline to fall over when their root system fails to provide sufficient anchoring.

**Figure 4 Map Shows the Inundated Area of Bang Khun Thian District, Bangkok**


*Source:* BMA, 2002.

**Figure 5 An Old Pond's Gate That Is No Longer in Use (left), Mangroves Fall Over Due to the Impact of Strong Waves (right)**

*Source:* Rawadee and Areeya, 2008.

## 3. METHODOLOGY

This study was based on site visits, discussions with local people, a concise literature review, and a survey. Data collection began with a focus-group discussion with a former village headman and local people in the study area. The purpose of the meeting was to gather relevant information and determine the scope of some forms of adaptation options which have been undertaken in the study area. Also, a pretest of the draft questionnaire was carried out in order to check whether it was workable; 10 people were interviewed as a sample population in the pretest. The sample was chosen from households affected by coastal erosion/flooding and the ones who knew the details of adaptation strategies. A sample of 40 households was selected randomly. The survey was conducted in September 2007 using face-to-face interviews.

## 4. RESULTS OF THE SURVEY

### 4.1 Socio-economic Profile of Households

As mentioned previously, the total number of samples in this study was 40. There were a slightly larger number of female respondents; all of them were aquaculturists. The education levels of the respondents were as follows: primary school (57.5%) and secondary school (32.5%). In the past, wild shrimp larvae were plentiful, and the farmers earned a considerable income from shrimp farming. There was no incentive for people in this area to seek a higher education. The majority of respondents were heads of households (65%), and most of them (80%) were local people born in the study area. (Table 1)

The high average age of the respondents (about 47 years old) reflects the initial screening of the household members who knew the details of adaptation strategies. The average annual income of the households was about 468,278 baht per year or US$ 13,625,[1] which was triple the mean income of farm operators for the country as a whole in 2006[2] (National Statistical Office 2006). The average area of the aquaculture farms was 68 rai (11 hectares)[3] per household (in terms of extended families). Most farmers (67.5%) owned their own farm, the average area of which was 49.5 rai (7.9 hectares) devoted to aquaculture. For the farmers who rented their farm (12.5%), the average area devoted to aquaculture was 79.8 rai (12.8 hectares). The average inundated area was 5.7 rai (0.9 hectare), which accounted for 8 percent of household farm area (Table 2).

**Table 1 Socio-economic Profile of the Respondents, Bang Khun Thian District, Bangkok, 2007**

| Characteristics | Frequency (persons) | Percentage |
|---|---|---|
| **Occupation** | | |
| - Aquaculturists | 40 | 100.0 |
| Total | 40 | 100.0 |
| **Education** | | |
| - No formal education | 1 | 2.5 |
| - Primary | 23 | 57.5 |
| - Secondary | 13 | 32.5 |
| - Diploma/vocational certificate | 1 | 2.5 |
| - Bachelor's degree | 2 | 5.0 |
| Total | 40 | 100.0 |
| **Status** | | |
| - Household head | 26 | 65.0 |
| - Spouse | 10 | 25.0 |
| - Daughter/Son | 2 | 5.0 |
| - Siblings | 2 | 5.0 |
| Total | 40 | 100.0 |
| **Origin of people** | | |
| - Local people | 32 | 80.0 |
| - Non-local people | 8 | 20.0 |
| Total | 40 | 100.0 |

*Source:* Rawadee and Areeya, 2008.

**Table 2 General Characteristics of the Respondents, Bang Khun Thian District, Bangkok, 2007**

| Characteristics | Minimum | Maximum | Mean | Number of respondents |
|---|---|---|---|---|
| Age (years) | 30 | 78 | 47.3 | 40 |
| Household member (persons) | 2 | 12 | 4.2 | 40 |
| Household income (baht/year) | 45,000 (US$ 131) | 1,528,000 (US$ 44,457) | 468,278 (US$ 13,625) | 40 |
| Total area devoted to aquaculture (rai) | 30 (4.8 hectares) | 200 (32 hectares) | 67.5 (10.8 hectares) | 40 |
| Area devoted to aquaculture (for farmers who own their own farm: rai) | 30 (4.8 hectares) | 90 (14.4 hectares) | 49.5 (7.9 hectares) | 27 |
| Area devoted to aquaculture (for farmers who rent their farm: rai) | 40 (6.4 hectares) | 140 (22.4 hectares) | 79.8 (12.8 hectares) | 5 |
| Area devoted to aquaculture (for farmers who own their own farm and also rent a farm: rai) | 80 (12.8 hectares) | 200 (32 hectares) | 124.5 (19.9 hectares) | 8 |
| Inundated area devoted to aquaculture (rai) | 0 | 18 (2.9 hectares) | 5.7 (0.9 hectares) | 40 |

Notes: 1. US$ 1 = 34.37 baht as of October 2007. 2. 1 hectare = 6.25 rai.

*Source:* Rawadee and Areeya, 2008.

## 4.2 Adaptation Options and Cost of Adaptation

The aquaculturists in Bang Khun Thian district have been trying to protect their shrimp ponds for more than 30 years. The survey results revealed that all the adaptation strategies of the households were autonomous. It also found that households have individually adapted to the problems at hand. However, the households also acted as a group, led by the former headman, in requesting government assistance so that they could cope with the coastal erosion. Their action may be considered as one type of collective adaptation.

The households must take care of their protective structures by themselves. If one household does not apply/maintain such structures, a negative externality will be generated for the neighbors. Sometimes conflicts occur in the communities when neighbors cannot afford to pay the cost of maintenance and they let the breakwater gradually deteriorate.

In respect of the awareness of the local people concerning climate change issues, what the households know is that natural phenomena exist that are caused by global warming, which has become a hot issue in Thailand. However, they may not know many details about the impacts of global warming or climate change; most of the local people do not know that global warming has caused the sea level to rise. Households have responded to the impacts of flooding without considering the possible residual impacts from the potential rise in the sea level in the near future.

### *4.2.1 Adaptation Options*

Efforts have been made to stop the processes of erosion; all the households have applied more than one option in this regard. In terms of the protective strategies, we observed that the households had tried to apply all types of adaptation if they could afford them, since each adaptation option has its own function. Unfortunately, our survey data could not explain the adaptive capacity of the households. Nonetheless, what we observed during the survey was that most households frequently complained that they might not survive very long if government agencies would not do anything for them, as some households had borrowed money from their relatives and others had taken bank loans to pay for the adaptation costs. According to our survey data, the choices of adaptation did not depend on tenure characteristics. Some farmers who rented the land also tried to apply all the protective options that they could afford as long as they were profiting from the aquaculture farms. In other cases, landlords were the ones who paid for the adaptation costs. For this reason, many protective strategies have even been applied to rental land. The choices of household adaptation may be classified into three types of autonomous adaptation as follows:

***(1) Protection:*** some households have applied hard structures in parallel with the coast in order to protect their aquaculture ponds. Examples of such structures are a stone breakwater (Figure 6, left), a bamboo revetment (Figure 6, right), heightening of dikes (Figure 7, left), and a concrete-pole breakwater (Figure 7, right). The function of such construction is to lessen the impact of waves and storms. In addition, some aquaculturists heightened the walls of their ponds and reinforced them by constructing bamboo revetments. Such protective methods function like a package, i.e., the individual options cannot substitute others but rather support other options. Among these, stone breakwaters are the most popular (Table 3). However, the construction of a stone breakwater involves some physical constraints. If the sea level in some areas is too low for navigating a large boat, it is impossible to transport the stone needed to build the breakwater. For this reason, some households did not use stone breakwaters to protect their land.

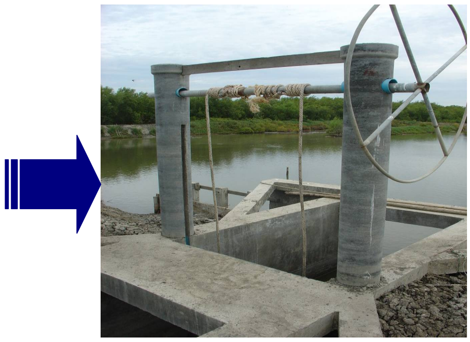
***(2) Retreat:*** some farmers needed to retreat or move their ponds inland; thus, they had to build new water-gates (Figure 8) and reconstruct the dikes.

***(3) Accommodation:*** some households had to rebuild/renovate their houses due to flooding (Figure 9).

**Figure 6 A Stone Breakwater (left) and a Bamboo Revetment (right)**

**Figure 7 Heightening of Dikes (left) and a Concrete-pole Breakwater (right)**

**Figure 8 A New Water-Gate, Which Needs to be Rebuilt Every Time the Sea Encroaches Further Inland**



New water-gate

**Figure 9 Example of Rebuilding and Renovating a House**

*Source:* Rawadee and Areeya, 2008.

**Table 3 Number of Households Applying Each Adaptation Option**

| Adaptation options | Number of households applying adaptation options (households) | % |
|---|---|---|
| ***1. Protection*** | | |
| - Stone breakwater | 32 | 80 |
| - Heightening of dike | 26 | 65 |
| - Bamboo revetment | 19 | 48 |
| - Concrete-pole breakwater | 2 | 5 |
| ***2. Retreat*** | | |
| - New water-gate | 29 | 73 |
| ***3. Accommodation*** | | |
| - Rebuilding/renovating house | 19 | 48 |
| Total | 40 | 100 |

Note: all households applied more than one option.

*Source:* Rawadee and Areeya, 2008.

### *4.2.2 Costs of Adaptation*

When asked how long they had been affected by coastal erosion, most aquaculturists could not indicate exactly when the adverse impacts first started. They would always say that they had been affected for a long time. To calculate the adaptation costs, it would be necessary first to calculate the costs for each household in the same period of time. Otherwise, we could not compare the costs among the households. It was easier for the aquaculturists to remember certain events than specific dates in calendar years. One event that they could remember very well was dedicating land to BMA in 1993. Therefore, we set this event as the baseline time for calculating the adaptation costs of all the households.

With regard to those costs, it should be noted that all the households chose more than one adaptation option, usually combining various options. For example, some aquaculturists built a stone breakwater to protect against large waves, but they also needed to heighten/reinforce their ponds' walls. The accumulated costs of all the adaptation strategies which the aquaculturists had to bear on their own for 14 years totaled 1,506,219 baht (US$ 43,824) per household.[4] The average costs that the aquaculturists had to expend each year for adaptations was 107,587 baht (US$ 3,130) per household (Table 4), which accounted for approximately 23 percent of the average household income.

## 5. CONCLUSION AND LESSONS LEARNED FROM STUDY

Coastal erosion has become one of the most serious problems in Thailand in recent years. The impacts of relative rises in sea level due to land subsidence, climate change, or both are expected to be an inundation of coastal areas, which will have a negative impact on the livelihoods of local communities. The sediment yield in the upper Gulf of Thailand has been decreasing as a result of the construction of dams on upland rivers, while the land subsidence is caused mainly by an excess withdrawal of groundwater (Winterwerp, Borst, and de Vries 2005). In Thailand, 30 coastal areas have been identified as having the most severe degree of coastal erosion in the country, namely "hot spot" areas. Bang Khun Thian district in Bangkok province is located in a coastal erosion hot spot: the Bangkok boundary mark is already submerged. The rate of coastal erosion in Bang Khun Thian is approximately 20-25 meters per year, which means that the shoreline has decreased by 4 to 800 meters within the past 28 years (Thanawat 2006).

Two villages in Bang Khun Thian district, the main economic activities of which are shrimp and blood cockle farming, have been directly affected by coastal erosion. It was found that the households had applied autonomous adaptation for preventing coastal erosion/flooding. The household adaptation methods can be categorized into three types: (1) protection strategies, which consist of stone breakwaters, bamboo revetments, and the heightening of dikes, (2) retreat, for which farmers need to rebuild a new water-gate, and (3) accommodation, by rebuilding/renovating their houses in order to avoid the impacts of coastal erosion or flooding. It should be noted that all the households have applied more than one adaptation strategy.

In terms of the economic impacts of coastal erosion, the villagers have a non-negligible burden in terms of adaptation. Our survey shows that the annual adaptation cost is approximately 107,587 baht, or US$3,130 per household,[5] an amount which accounts for 23 percent of the annual household income. Furthermore, a number of aquaculture farms are inundated, indicating that they have lost their asset. The average inundated area is approximately 5.7 rai or 0.9 hectare per household, which accounts for 8 percent of the household aquaculture area.

**Table 4 Adaptation Costs of Households**

| Adaptation costs | Minimum | Maximum | Mean | Number of respondents |
|---|---|---|---|---|
| Accumulated adaptation costs from 1993 to 2007 | 78,556 (2,286) | 4,035,725 (117,420) | 1,506,219 (43,824) | 40 |
| Annual adaptation costs | 5,611 (163) | 288,266 (8,387) | 107,587 (3,130) | 40 |

Note: The figures in parentheses are values in US dollars: US$ 1 = 34.37 baht in October 2007. All values are in 2006 prices.

*Source:* Rawadee and Areeya, 2008.

Even though a protective structure has been provided by a local government agency, i.e., the BMA stone breakwater, it affords merely a temporary solution, which is not functioning very well now. Also, the villagers receive compensation for flooding from a national government agency.

What we have learned from this study is as follows:

1) The existing household adaptation, in which a household individually applies its adaptation, may not be the "right" solution. According to engineering knowledge regarding coastal protection, the protective structure needs to be built along the entire shoreline. If the protective structure is built along only some parts of the coast, the impact of waves and rising sea levels in other parts without any protective structure will probably be even worse. Since some households cannot afford the adaptation costs, this negative externality may affect their neighbors.

2) In the past, wild shrimp larvae were plentiful and the aquaculturists could make a considerable amount of money from shrimp farming. Also, there was no incentive for the farmers to attain a high level of education. However, wild shrimp larvae have become increasingly scarce in recent years. This situation has adversely influenced the production of shrimp farms tremendously and thus the earnings of the aquaculturists. Also, owing to their low educational attainment and lack of other professional skills, the aquaculturists cannot easily shift to other occupations. This is one of the reasons why those aquaculturists are willing to pay high adaptation costs for protecting their shrimp and shellfish farms. Fortunately, children in those areas are attaining a higher level of education than their parents did; hence, the next generation will have more opportunities for finding other jobs.

Currently, because the local government in each coastal area has the authority to take care of coastal erosion in the area, the strategies for coastal erosion protection in each area is planned independently. As previously mentioned, for the protective structures to be effective, they should be designed for the whole upper Gulf of Thailand. Therefore, solution of this problem demands collective decisions by the national government in dealing with these issues.

## ENDNOTES

[1] US$ 1 = 34.37 baht as of 2 October 5, 2007.

[2] The mean income of farm operators (mainly those owning land) is approximately 154,044 baht per year per household, or US$ 4,482.

[3] 1 hectare = 6.25 rai.

[4] At 2006 constant prices.

[5] At 2006 constant prices.

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