ANALYSIS

Port-induced erosion prediction and valuation of a local recreational beach

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ABSTRACT

This study attempts to integrate environmental economics and coastal engineering in managing port-induced coastal erosion occurring at a common beach by using Map Ta Phut port in Thailand as a case study. The existence of the port creates coastal erosion which can be considered an externality that affects local inhabitants, and a port owner and shipping companies can be seen as "polluters". Overlaying of aerial photographs provided strong evidence that the coastline was severely eroded after the construction of the port. Coastal engineering softwares, LITPACK and MIKE 21 PMS, were utilized to predict future shoreline positions and investigate wave patterns around the port. The port alters wave climate and the port-induced erosion is jeopardizing a local recreational beach called Nam Rin, which is projected to disappear in 5 years. A valuation of Nam Rin beach using single-bounded dichotomous choice contingent valuation method revealed individual willingness to pay (WTP) for the beach, being 867.5 baht (approximately US$ 24.8) per year. Multiplying the individual WTP with the appropriate number of population to acquire the beach protection benefit and dividing such benefit by construction and maintenance costs of a particular beach protection measure, the polluters can select a proper beach protection approach that fulfills their benefit–cost requirement.

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1. Introduction

1.1. Coastal engineering and environmental economics

This study shows that erosion on the west coast of Map Ta Phut (MTP) port, Thailand, threatens a public recreational beach called Nam Rin. According to the nature of the coastal area, coastal erosion takes place whenever there is a land-connected structure protruding into the ocean (Kamphuis, 2000). The MTP port constructed on the open coast is regarded as the giant structure, therefore inducing severe erosion. The port-induced coastal erosion is considered one type of "pollution" because it affects innocent coastal inhabitants. The port’s decision makers who constructed the port, and shipping companies who utilize the port area can be seen as "polluters".

Coastal engineering, particularly wave pattern analysis and future shoreline prediction, provides science-based...
information to stakeholders. Their awareness about possible impacts of the port development is raised, and precautionary actions can be integrated into management.

Management of coastal erosion occurring at a public beach requires a different approach. If the erosion affects private properties, the resolutions may be best addressed by private negotiations. In the case where the negative side-effect involves the public beach, the negotiation cannot be organized since the claimant cannot be clearly identified, making the compensation amount undeterminable. If the port’s decision makers and shipping companies choose to conserve Nam Rin beach, they will be faced with the question of what type of beach protection should be utilized. This is because different protection methods incur different costs of construction and maintenance. Applying a realistic hypothetical erosion situation derived from the coastal engineering study, the contingent valuation (CV) can provide the polluters with a monetary value for the beach. They may perceive such beach value as the benefit of beach conservation or divide it by the costs to arrive at the appropriate beach conservation measure with a reasonable benefit-cost ratio.

Although a lot of CV studies have been done on coastal environments, most studies focus on replacement of coastal habitats by other anthropogenic activities or the unsustainable use pattern of coastal resources (see details in Ledoux and Turner (2002)). Very few studies and virtually none in Thailand have integrated coastal engineering and environmental economics to manage the coastal zone more sustainably. Thus, the objectives of this study in relevance to MTP industrial port are to:

a) examine historical shoreline positions before and after port construction,
b) predict shoreline positions on the west coast of the port in the future and provide possible explanations for coastal physical process of the erosion,
c) identify problems or conflicts that may happen due to the erosion,
d) investigate the monetary benefit of protecting Nam Rin beach that is being jeopardized by the erosion by using CVM.

Methodology is stated in Section 2. Results of aerial photo overlaying, wave pattern study, and shoreline predictions which were then used as inputs to valuate the beach are presented in Section 3. Management implications of beach value are discussed in Section 4. Finally, conclusion is presented in Section 5.

1.2. Study site overview

MTP port, Thailand (Fig. 1), owned by the Industrial Estate Authority of Thailand (IEAT), occupies approximately 2.8 km of shoreline with breakwaters that are about 4.75 km in length. The construction of the port began in 1989 and operations began in 1992. The port was constructed on an open coastline...
and behaves like a big wall, obstructing natural coastal sediment transport.

IEAT conducted an EIA study on impacts of the port construction. The result indicated severe shoreline erosion. The erosion effect caused by the port was known before its construction began but the port was so vital for national economy that its benefits outweighed its environmental impacts. If Thailand’s government at the time of construction preferred the beach conservation to the port, it would have never decided to commence the construction.

The EIA did not extend the erosion study far enough to include Nam Rin beach. The EIA study covered approximately 4000 m from the port while Nam Rin beach is about 4200 m away. As the result, IEAT did not accept the responsibility to take care of the eroded beach. One may argue that IEAT used the EIA as an excellent excuse to deny responsibility. Should IEAT and shipping companies as the “polluters” do something to protect the beach?

2. Methodology

This study started with an attempt to prove that erosion at Nam Rin beach was caused by MTP port. Overlaying of aerial photographs was implemented to investigate erosion history. MIKE21 PMS and LITPACK simulations were carried out to inspect wave pattern and predict future Nam Rin erosion. The result that Nam Rin beach would be eroded away was used as a scenario in the CV survey. Single-bounded dichotomous choice method was selected as an elicitation technique.

2.1 Historical shoreline investigation and future shoreline prediction

Historical shoreline positions were extracted from a) sets of aerial photographs taken in 1975, 1981, 1996, and 2001, b) satellite images captured in 2003, and c) Google Earth images that represented the port in 2006. They were joined together by ERDAS software. The shoreline position of each set was measured from an arbitrary baseline, using MapInfo software. Overlaying of such data revealed an erosion impact that the port had, as well as the effects of other coastal objects in the past. It is important to note that the aerial or satellite pictures taken after 1996, only contain information within the first 4000 m from the port. Beyond this point, there is a strategic military airport and any picture containing the location of the airport is, by law, prohibited for distribution.

Wave pattern around the port was studied by utilizing MIKE 21 PMS, which is a software developed by Danish Hydraulic Institute (DHI), and is capable of analyzing wave patterns associated with the existence of coastal structures. A bathymetry map used in this study was from a field survey conducted in 2003 by Mouchel Co.Ltd., Thailand. The MIKE 21 PMS case study was characterized by southwest (SW) waves, having the wave height of 1.7 m and wave period of 5 s. The expected result was to have an insight into how wave propagation was altered by the port.

Predictions of future shorelines in 2011 were done by using LITPACK, a software package also developed by DHI. The study site was visited to identify other coastal objects present around the port. Their effects were investigated both systematically and separately. In addition, a discussion with local government (Ban Chang Local Administration, personal communication, 2006) was carried out to gain information about what was done to deal with the erosion problem at Nam Rin beach. All information was included in a model calibration. A site re-visit along Nam Rin beach verified the model.

2.2 Contingent valuation method (CVM)

The CVM involves the use of a survey questionnaire to elicit hypothetical willingness to pay (WTP). It is commonly used as one of the standard approaches to measure total economic values of non-market goods such as recreational resources (Hanemann et al., 1991). The total economic value consists of direct and indirect use, as well as non-use values (Ledoux and Turner, 2002). One can only resort to asking individuals (in a survey) how much they are willing to pay to obtain the change (or to avoid it). A benefit-cost analysis addresses this issue by converting the change of well-being into money, and compares it to the actual money that has been spent on providing the goods (Polome et al., 2005).

In general, steps to performing the dichotomous choice contingent valuation (DC CV) are to perform a pre-test in a small focus group to determine the likely range that people will be willing to pay for the amenity. This preliminary finding is used to make up a survey instrument, which must inform respondents about precise objectives of the interviews. A randomly selected group is asked whether it will be willing to pay X dollars, if the environment is protected as described. This procedure is repeated with other selected groups with different amounts of dollars. Follow-up questions and the reasons behind the “yes” or “no”, along side with personal information such as age, gender, education, degree of active use are collected for further analysis (Hackett, 1998). A critical assumption about the CV is that the respondents are able to translate a wide range of criteria into a single monetary amount representing the total value to them of a particular resource (Amirnejad et al., 2006).

In this study, the single-bounded DC approach was used because the respondents could be facilitated to complete the valuation process by choosing between “to pay” or “not to pay” (Venkatachalam, 2004). Strategic behavior may be minimized in the DC technique since it is incentive-compatible (Carson et al., 1996, 2001; Hanemann, 1994; Venkatachalam, 2004).

Unlike multi-bounded approach, the single-bounded approach does not suffer from yes-saying effect (Andreoni, 1989; Chien et al., 2005), indignation and guilt effect (Bateman et al., 2001), and weariness effect (Bateman et al., 2001). However there are a number of effects that may influence the result of the single-bounded DC study, such as anchoring effect (Michell and Carson, 1989), free-riding effect, and overpilgreging or hypothetical bias (Venkatachalam, 2004). The anchoring effect is a tendency that people make decision from an initially given value (Michell and Carson, 1989). The free-riding effect applies to those who do not want to contribute, holding an assumption that others will do good enough to protect the beach (Venkatachalam, 2004). Finally, the hypothetical bias is defined as the potential divergence between the real and hypothetical payments (Venkatachalam,
Since the respondents do not have to actually pay the amount they state, they may accept the request easily without due consideration. Therefore, the survey was designed such that it would not give any hint to the respondents that made them behave strategically (Michell and Carson, 1989; Venkatadachalam, 2004).

2.2.1. Interview questionnaire and data collection
Since a CV questionnaire must base on a realistic hypothetical market, a simulation result of LITPACK was used as a scenario to elicit individual WTP. The questionnaire was designed to provide respondents with adequate and accurate information. Data was collected by well-trained staff on 1st to 19th March 2006. Appropriate time for data collection was between 4:30 and 6:30 pm. Only people over 18 years old on Nam Rin beach were randomly selected and interviewed. In the case of a group visit, one person was interviewed. The questionnaire was divided into 4 sections. The first part included an explanation of an erosion situation. Since the respondents were on the beach at the time of the interviews and immediately able to notice the erosion (the survey was on-site and face-to-face), the hypothetical situation was easily understood. They were informed that the data from the survey would not be used for any specific policy but instead for academic research to measure the economic value of Nam Rin beach. This could reduce rejection rate from the respondents (Lee and Han, 2002). They were also informed that there was no right or wrong answer and their sincere responses would be appreciated.

In Section 2, interviewers informed the beachgoers that results from computer simulations suggested that Nam Rin beach would be eroded away unless an erosion mitigation was implemented. At this point, pictures of current Nam Rin beach and the nearby eroded beach (a picture taken at 4000 m from the port) were compared (Fig. 2). The scenario of severe beach erosion was mentioned but the cause of the erosion was not given. Knowing the cause of the erosion might induce feelings that would interfere with the valuation process.

Section 3 contained questions on WTP. The respondents were asked if they were to take part in helping to protect the beach by annually donating money to a club established by Nam Rin beach lovers. An open-ended (OE) approach was
carried out prior to the DC approach in order to acquire the likely range of WTP. Forty respondents were asked “how much are you willing to donate to protect the beach?” Modes of the OE WTP were analyzed and used as initial values for the DC method. Bid amounts were 100, 200, 300, 500, 800, 1000, and 1500 baht/year (US$1 was about 35 baht). Forty beachgoers were interviewed for each bid amount. The 1500 baht bid was selected as the highest bid because almost 100% rejection was achieved, while the 100 baht bid was chosen as the lowest bid since it achieved almost 100% acceptance. Reasons for the response were recorded. Confidence level on whether the beachgoers would actually be able to pay the amount they stated was asked to measure the sincerity of their answers. If they were not sure (confidence level lower than 50%), we could assume that they were not sincere with their answers and their responses were excluded from further analysis (Amirnejad et al., 2006).

The last section contained personal social, economic and demographic information of the respondents such as gender, marital status, age, income level, residence location, educational level, and frequency of beach visit per month.

An analysis of the stated WTP provides an opportunity a) to check whether expectations as per economic theory hold, b) to study the content and context validity of the questionnaire, c) to study if the questions were correctly understood by the respondents, and d) if they responded to what they were asked (Amirnejad et al., 2006; Hadker et al., 1997). One rule of thumb is to accept the WTP as theoretically valid if independent variables believed to be theoretical determinants of people’s demand for the good being valued are statistically significant and have the expected signs (Michell and Carson, 1989; Urama and Hodge, 2006).

3. Results

A presentation of results starts with a historical shoreline investigation, followed by an erosion prediction at Nam Rin beach. Physical process of port-induced erosion was described. Mean and median individual WTP for the beach were calculated based on logit and probit models.

3.1. Coastal engineering study results

3.1.1. Overlaying of historical aerial photographs

An overlay of shoreline positions showed obvious evidence that the presence of MTP port induced drastic shoreline erosion (Fig. 3). Between 1975 and 1981, the shoreline positions were almost unchanged. If the port was not constructed in 1989, the coastline would have continued its shape. After the port construction, significant erosion was noticed with the magnitude of roughly 100 m.

Nam Rin beach located 4200 away from the port is a local recreational destination in Ban Chang and MTP districts, and is currently experiencing erosion. The overlay of historical shoreline positions revealed that the construction of MTP port also created the erosion at Nam Rin beach (Fig. 3).

Many coastal structures were inserted into the coastal system. A jetty approximately 400 m from MTP port was constructed some time between 1996 and 2001. A small harbor (2100 m from the port) was built in 2002. A wrecked ship was towed to the site in 2003. Additionally, many natural coastal features such as a creek and outcropping rocks at Nam Rin point are present (Fig. 4).

3.1.2. Future shoreline prediction and coastal physical processes at MTP area

Wave patterns are altered by the presence of MTP port. Waves travelling from SW are diffracted and reflected by the port, increasing the magnitude of wave height because the reflected waves add up the incident waves (Fig. 5). This phenomenon obviously has a potential to create beach erosion at the location with higher waves. An interview with local government (Ban Chang Local Administration, personal communication, 2006) revealed that the erosion at Nam Rin beach started to happen after the construction of the port but IEAT did not do anything to protect the beach. A mitigation measure by the local government involved temporarily armorining the beach

Fig. 3 – Shoreline comparison of year 1975, 1981, 1996, and 2001.
with cylindrical concrete piles (Fig. 4). The LITPACK model was then calibrated with a jetty, a local creek, a small harbor, a wrecked ship, outcropping rocks and beach armoring by the local government included (Fig. 4).

Future shoreline erosion along the west side of MTP port in 2011 was forecasted (Fig. 4). The simulation suggested that Nam Rin beach would be eroded at the magnitude of 13 m in the next 5 years, enough to destroy the beauty and infrastructures along the beach. The predicted erosion would start from 4600 m and stop at 5100 m from the port. Beyond this point, the erosion would not occur. A site re-visit along Nam Rin beach confirmed the prediction and enabled us to

Fig. 4 – LITPACK calibration in 2006 and future shoreline prediction in 2011.

Fig. 5 – Wave height (H_{rms}), affected by the presence of the port, SW incoming waves.
conclude that the erosion was not due to natural phenomena such as sea level rise or seasonal storms (if it was, the whole stretch of the beach would experience the erosion at the same rate) (Fig. 4).

Simulation investigations of coastal objects suggested that an effect of each object is location-limited. In other words, structures away from Nam Rin beach do not influence the Nam Rin’s erosion (Fig. 6). However, outcropping rocks and beach armoring at Nam Rin point, together acting like a small beach protection structure, play a significant role in retarding the erosion. If there were no rocks, the Nam Rin point would have been beheaded many years ago (Fig. 6).

It can be concluded that the erosion at Nam Rin beach is a combined effect of the port-induced erosion, outcropping rocks, and, to a lesser extent, concrete piles. Before the port was constructed, the rock outcrops at Nam Rin point were buried underneath the sand. Initiated by the port construction, the erosion progressed towards Nam Rin beach and unearthed the rock outcrops at Nam Rin point (Fig. 3). The erosion could not progress further because of the protection provided by the rocks. However, the protective function of the rocks does not extend far enough to cover the whole beach. As a result, the port-induced erosion has been nibbling Nam Rin beach (4600 to 5000 m from the port) to satisfy its sediment hunger (Fig. 4). In short, the erosion at Nam Rin beach would have never occurred if there was no trigger event such as created by the port (interested readers can learn about coastal physical processes in Basco (2006) or Kamphuis (2000)).

3.2. Nam Rin beach valuation

3.2.1. Model specifications of measuring WTP in single-bounded DC valuation

We consider an individual’s direct utility function as,

$$U = V + \epsilon$$

where $U$ is a direct utility function, $V$ is an indirect utility function, and $\epsilon$ is independently distributed random error with zero mean.

Assuming that the indirect utility function is a function of income ($Y$), other individual characteristics ($S$), and quality of the resource to be valued, the individual will accept a bid ($A$) to maximize his utility under the condition (Amirnejad et al., 2006; Hanemann, 1989; Hanemann et al., 1991; Lee and Han, 2002; Pyo, 2000),

$$V(1, Y - A(S)) + \epsilon \geq V(0, Y | S) + \epsilon_0 \quad \text{or} \quad \epsilon \leq A V$$

where $A V = V(1, Y - A(S)) - V(0, Y | S)$ and $\epsilon = \epsilon_0 - \epsilon_1$.

The DC format of CVM has a binary choice dependent variable. The logit and probit models were used to compare in this study because of their simplicity (Hanemann and Kanninen, 1999). For the logit model, the probability to say "yes" ($P$) of the individual is

$$P(\text{yes}) = P(\epsilon \leq A V) = \frac{1}{1 + \exp(-\alpha + \beta A)} \quad (1)$$

And for the probit model

$$P(\text{yes}) = P(\epsilon \leq A V) = \Phi(\alpha - \beta A) \quad (2)$$

where $\beta$ is a coefficient of bid parameter ($A$).

The logit and probit models in Eqs. (1) and (2) were then estimated using the maximum likelihood method (Davidson and Mackinnon, 1993; Gujarati, 1995; Kennedy, 1992). Since most random utility maximization models with non-negative preferences imply a skewed distribution of WTP, a point estimation of the median is more robust than the point estimate of the mean (Hanemann and Kanninen, 1999). To compare them, both the median WTP and the mean WTP were computed. The calculations were performed by LIMDEP software.

Socio-economic factors that were considered in this study included gender, marital status, age, education (measured in number of years in school or university), monthly income (in thousand baht), frequency of visit to Nam Rin beach per month, and residency location (whether the respondent lived or worked in MTP or Ban Chang area). Variables with statistical insignificance or those that were highly correlated (if any) were excluded to help derive the best models (Brouwer, 2006).

Fig. 6– Roles of coastal structures on Nam Rin beach.
If the WTP must be greater than or equal to zero, we obtain

\[
\text{Mean WTP for logit model} = \frac{\ln \left( \exp \left( a^* + 1 \right) \right)}{b}
\]

(3)

\[
\text{Median WTP for logit model} = \frac{a^*}{b}
\]

(4)

\[
\text{Median WTP and mean WTP for probit model} = \frac{a^*}{b}
\]

(5)

where \(a^*\) is the adjusted intercept which is added by socio-economic terms to the original intercept term of \(\alpha (a^* = \alpha + \gamma Y + \theta S)\) (Amirnejad et al., 2006).

We can expect the income coefficient (\(\gamma\)) to have a positive sign, and the coefficient of bid amount (\(\theta\)) to have a negative sign. For other socio-economic parameters (\(S\)), their coefficients (\(\theta\)) can be either positive or negative.

3.2.2. Individual WTP for Nam Rin beach

Socio-economic characteristics of the respondents were summarized in Table 1. Most beachgoers used Nam Rin beach to admire beach beauty and to relax with their families, including eating and swimming along the beach (Table 2). Responses of WTP were recorded and summarized in Table 3. Socio-economic parameters of the respondents were analyzed for their correlations. The analysis showed that no parameter was highly correlated with one another (Table 4).

Results of the logit and probit models were compared (Table 5). There were 4 variables being significant at 5% level

<table>
<thead>
<tr>
<th>Table 1 – Socio-economic information of respondents</th>
</tr>
</thead>
<tbody>
<tr>
<td>Respondent’s characteristic</td>
</tr>
<tr>
<td>Gender</td>
</tr>
<tr>
<td>- Male</td>
</tr>
<tr>
<td>- Female</td>
</tr>
<tr>
<td>Marital status</td>
</tr>
<tr>
<td>- Single</td>
</tr>
<tr>
<td>- Married</td>
</tr>
<tr>
<td>Visit frequency (per month)</td>
</tr>
<tr>
<td>- 1</td>
</tr>
<tr>
<td>- 2</td>
</tr>
<tr>
<td>- 3</td>
</tr>
<tr>
<td>- &gt;3</td>
</tr>
<tr>
<td>Living or working in Map Ta Phut Or Ban Chang District</td>
</tr>
<tr>
<td>- Yes</td>
</tr>
<tr>
<td>- No</td>
</tr>
<tr>
<td>Educational level</td>
</tr>
<tr>
<td>- 4th grade (6 years of education)</td>
</tr>
<tr>
<td>- 6th grade (8 years of education)</td>
</tr>
<tr>
<td>- 9th grade (11 years of education)</td>
</tr>
<tr>
<td>- High school (14 years of education)</td>
</tr>
<tr>
<td>- Diploma (16 years of education)</td>
</tr>
<tr>
<td>- Bachelor (18 years of education)</td>
</tr>
<tr>
<td>- Master (20 years of education)</td>
</tr>
<tr>
<td>- Doctoral (23 years of education)</td>
</tr>
<tr>
<td>Monthly income (baht)</td>
</tr>
<tr>
<td>Age (year)</td>
</tr>
<tr>
<td>Visit frequency (per month)</td>
</tr>
</tbody>
</table>

(Table 6). The estimated coefficient of bid amount was found statistically significant with the expected negative sign. This indicated that the probability of “yes” decreased as the amount of money asked increased, and vice versa. Younger people were willing to donate more than older people, as indicated by the negative sign of age coefficient. At the same time, the beachgoers with low educational levels were more likely to donate the money to the club than the ones with higher educational backgrounds. Finally, monthly income influenced the possibility to pay. Richer people tended to accept the bid more easily than the poorer ones, as represented by the expected positive coefficient of income variable. As the results, the median and mean WTP were calculated,

\[
\text{Mean WTP for logit model (Eq. (3))}
\]

\[
= \frac{\ln \left( \exp \left[ 3.8985 - 0.0389*31.51 - 0.0883*13.39 + 0.1066*9.62 \right] + 1 \right)}{0.0029}
\]

= 894.4 baht per year (about US$25.6)

Median WTP for logit model (Eq. (4))

\[
= \frac{3.8985 - 0.0389*31.51 - 0.0883*13.39 + 0.1066*9.62}{0.0029}
\]

= 867.5 baht per year (about US$24.8)

Median WTP and mean WTP for probit model (Eq. (5))

\[
= \frac{2.3078 - 0.0227*31.51 - 0.0526*13.39 + 0.0625*9.62}{0.0017}
\]

= 876.2 baht per year (about US$25.0).

4. Management implication of Nam Rin beach value

Coastal engineering in this study proves that erosion at Nam Rin beach was caused by MTP port construction. IEAT and

<table>
<thead>
<tr>
<th>Table 2 – Benefits that the beachgoers gain from Nam Rin beach</th>
</tr>
</thead>
<tbody>
<tr>
<td>Type of benefit gained</td>
</tr>
<tr>
<td>Eating on the beach</td>
</tr>
<tr>
<td>Admiring scenic beauty</td>
</tr>
<tr>
<td>Relaxing with family members</td>
</tr>
<tr>
<td>Swimming</td>
</tr>
<tr>
<td>Selling stuffs</td>
</tr>
<tr>
<td>Fishing</td>
</tr>
</tbody>
</table>

*Note that the total percentage is not 100% because respondents can select multiple choices.*
at Phi Phi Island, Thailand where its substitute is absent and is unique by itself, contributions from people outside the area will play a very significant role (Seenprayawong, 2003). In short, it may be improper to multiply the individual WTP with the number of population larger than the population in MTP and Ban Chang districts. Such calculation may lead to an overestimated beach value.

Value of Nam Rin beach is a summation of use and non-use values. To separate them, it is necessary to approximate the actual number of Nam Rin beachgoers. Based on interviews with food shops and stalls on the beach, there were approximately 150 to 200 beachgoers each day and around 500 to 700 beachgoers on weekends. Therefore, Nam Rin beach was visited (150 × 5 + 500 × 2) × 52 = 91,000 times annually. On average, the beachgoers went to the beach 3 times a month, being 36 times a year (Table 1). Thus, there were about 2528 individuals visiting the beach each year, resulting in the use value of 867.5 × 2528 or 2.2 million baht (US$ 63,000) annually. The non-use value of the beach then became 71.8 million baht or approximately US$ 2.05 million.

Numerous alternatives of beach protection are available. “Hard” options include constructions of coastal structures (e.g. seawalls, groins, or breakwaters) while “soft” option such as beach nourishment (dumping sand onto the beach) is also possible (New South Wales Government, 1990). Each alternative is different in terms of level of protection, negative effects, beauty, social acceptance, and, of course, the costs of implementation. For example, in the case of beach nourishment using offshore sand, the cost of 5-meter beach widening is estimated to be 4 million baht annually (or US$ 114,000/year).

If a decision whether to protect the beach solely depends on the BC analysis and if the use value of the beach is considered only, Nam Rin beach may not be protected since the BC ratio is smaller than unity (63,000/114,000 = 0.55). Including non-use value of the beach, the BC ratio becomes

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**Table 4 – Correlations of socio-economic parameters**

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Gender</th>
<th>MarSta</th>
<th>Age</th>
<th>Education</th>
<th>MonInc</th>
<th>VisFre</th>
<th>ResLoc</th>
</tr>
</thead>
<tbody>
<tr>
<td>Gender (male=0, female=1)</td>
<td>1.000</td>
<td>0.095</td>
<td>-0.092</td>
<td>0.061</td>
<td>-0.181</td>
<td>-0.047</td>
<td>0.004</td>
</tr>
<tr>
<td>Martial status (MarSta) (single=0, married=1)</td>
<td>1.000</td>
<td>0.471</td>
<td>-0.218</td>
<td>0.102</td>
<td>0.089</td>
<td>-0.023</td>
<td>0.655</td>
</tr>
<tr>
<td>Age (year)</td>
<td>1.000</td>
<td>-0.231</td>
<td>0.244</td>
<td>0.124</td>
<td>-0.165</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Education (number of years in school)</td>
<td>1.000</td>
<td>0.462</td>
<td>-0.146</td>
<td>-0.199</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Monthly income (MonInc) (×1000 baht)</td>
<td>1.000</td>
<td>-0.087</td>
<td>-0.141</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Frequency of beach visit (VisFre) (times per month)</td>
<td>1.000</td>
<td>0.158</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Residency location (ResLoc) (outside MTP=1, inside MTP=1)</td>
<td>1.000</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

---

**Table 5 – Results of logit and probit models, including all variables**

<table>
<thead>
<tr>
<th>Parameters</th>
<th>Coefficient (logit)</th>
<th>P-value (Logit)</th>
<th>Coefficient (probit)</th>
<th>P-value (probit)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Constant</td>
<td>3.8160</td>
<td>0.0004</td>
<td>2.2671</td>
<td>0.0003</td>
</tr>
<tr>
<td>Bid</td>
<td>-0.0029</td>
<td>0.0000</td>
<td>-0.0017</td>
<td>0.0000</td>
</tr>
<tr>
<td>Gender</td>
<td>-0.0067</td>
<td>0.9830</td>
<td>-0.0345</td>
<td>0.8485</td>
</tr>
<tr>
<td>MarSta</td>
<td>-0.2676</td>
<td>0.4505</td>
<td>-0.1541</td>
<td>0.4510</td>
</tr>
<tr>
<td>Age</td>
<td>-0.0362</td>
<td>0.1078</td>
<td>-0.0212</td>
<td>0.1049</td>
</tr>
<tr>
<td>Education</td>
<td>-0.0919</td>
<td>0.0564</td>
<td>-0.0526</td>
<td>0.0597</td>
</tr>
<tr>
<td>MonInc</td>
<td>0.1159</td>
<td>0.0049</td>
<td>0.0661</td>
<td>0.0048</td>
</tr>
<tr>
<td>VisFre</td>
<td>0.0592</td>
<td>0.1799</td>
<td>0.0263</td>
<td>0.2101</td>
</tr>
<tr>
<td>ResLoc</td>
<td>-0.0348</td>
<td>0.9185</td>
<td>-0.0083</td>
<td>0.9665</td>
</tr>
<tr>
<td>McFadden R²</td>
<td>0.2457</td>
<td>0.2445</td>
<td></td>
<td></td>
</tr>
<tr>
<td>% of correct prediction</td>
<td>77.86</td>
<td>77.50</td>
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<td></td>
</tr>
</tbody>
</table>

---

**Table 6 – Results of logit and probit models, excluding statistically insignificant variables**

<table>
<thead>
<tr>
<th>Parameters</th>
<th>Coefficient (logit)</th>
<th>P-value (logit)</th>
<th>Coefficient (probit)</th>
<th>P-value (probit)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Constant</td>
<td>3.8985</td>
<td>0.0000</td>
<td>2.3078</td>
<td>0.0000</td>
</tr>
<tr>
<td>Bid</td>
<td>-0.0029</td>
<td>0.0000</td>
<td>-0.0017</td>
<td>0.0000</td>
</tr>
<tr>
<td>Age</td>
<td>-0.0389</td>
<td>0.0518</td>
<td>-0.0227</td>
<td>0.0506</td>
</tr>
<tr>
<td>Education</td>
<td>-0.0883</td>
<td>0.0516</td>
<td>-0.0526</td>
<td>0.0466</td>
</tr>
<tr>
<td>MonInc</td>
<td>0.1066</td>
<td>0.0060</td>
<td>0.0625</td>
<td>0.0056</td>
</tr>
<tr>
<td>McFadden R²</td>
<td>0.2377</td>
<td>0.2377</td>
<td></td>
<td></td>
</tr>
<tr>
<td>% of correct prediction</td>
<td>76.07</td>
<td>75.71</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
18.5 (2,110,000/114,000), which is large enough to initiate the beach protection program.

5. Conclusion

This study emphasizes the fact that a multi-disciplinary approach is important in environmental management. It attempts to integrate coastal engineering and environmental economics in managing port-induced coastal erosion that is occurring at a local public beach, called Nam Rin. A function of coastal engineering is to raise awareness that the beach will disappear and to propose alternatives to protect it. However the decision to choose the protection methods from various alternatives is influenced by benefit-cost analysis. Environmental economics uses a realistic scenario (which is a prerequisite for establishing a hypothetical market), derived from the coastal engineering study, to elicit the value of the beach. The beach value can be regarded as the benefit of beach protection.

This study also points out the vital role of environmental economics in protecting unpopular rural non-tourism natural resources. Ordinary market-based value of the Nam Rin beach may not be large enough to initiate the beach protection program. If the environmental economics is not brought in, the beach will never be protected since the BC ratio will be much lower than one (if the decision whether to protect is solely based on the BC analysis).

The MTP port alters wave and sediment transport patterns, finally leading to shoreline erosion. MTP port’s decision is exclusively based on the BC analysis.

Future shoreline positions were forecasted, showing that Nam Rin beach would be eroded away in the near future. Evidence provided by a site visit suggested that the erosion was not caused by natural phenomena.

Nam Rin beach is used for recreational purposes by residents who either live or work in MTP and Ban Chang districts. Since the recreational use of the beach is non-marketed and the beach itself is a common resource that holds non-use value, the CVM was used to elicit beach value. Single-bounded dichotomous choice approach was selected since it does not suffer from yes-saying effect, indignation and guilt effect, and weariness effect.

Individual WTP for Nam Rin beach was 867.5 baht/year (35 baht=US$ 1), making the beach value become approximately US$ 2.11 million annually when considering populations in MTP and Ban Chang districts. Since the polluters do not gain revenue from the beach but have a responsibility to protect it, they may consider the WTP-derived beach value as a proxy for the benefit of beach protection.

"Soft" or "hard" beach protection options that not only have potential in social and engineering senses but are also economically feasible may be chosen based on further in-depth BC studies (Zanuttigh et al., 2005).

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REFERENCES


