Assessing the Potential for the Sustainable Development of the Lower Andaman Sub-region in Thailand Using AHP and PSA Techniques

Natthita Rojchanaprasart[a*], Chanyut Sudthongkong[a], Woraporn Tarangkoon[a], Supannee Keawchaum[b], Prasert Tongnunui[a], Rattanaporn Anantasuk[a] and Kwanruetai Boonyasana[c]

[a]Faculty of Science and Fisheries Technology, Rajamangala University of Technology Srivijaya, Trang Campus
179 Moo 3, Sikao, Trang 92150, Thailand

[b]College of Innovation and Management, Songkhla Rajabhat University
160 Moo 4 Kanchanavanich Road, Khao Rup Chang Sub-district, Mueang District, Songkhla 90000, Thailand

[c]Faculty of Business Administration, Rajamangala University of Technology Phra Nakhon
86 Phitsanuloke Road, Dusit District, Bangkok 10300, Thailand

[*]Corresponding author. E-mail address: natthita.r@rmutsv.ac.th

Received: 20 February 2023; Revised: 6 May 2023; Accepted: 15 May 2023

Abstract

Most human and city settlement is known to be in or near coastal zones. Consequently, the intense demand for coastal resource exploitation has negatively impacted coastal ecosystems. As a result of both economic development and conservation of the ecosystems, sustainability challenges have inevitably arisen. The objective of this study was to assess the potential of the sustainable development of the lower Andaman sub-region in Thailand in order to gain information for future economic development planning based on existing marine and coastal resources. The AHP and PSA techniques were used to assess the area potential. From the pairwise comparison of the important factors by experts, it was found that the most important factors were marine resources and the environment (37.6%), followed by the economy (marine fisheries and coastal tourism) and the well-being of society (32.4 and 30.0%, respectively). Moreover, the first important sub-factors were the mean of agricultural and fishery income (baht per household/per month) and mangroves (29.7 and 29.4%, respectively), followed by the number of marine animals landing at major fishing ports (tons) and income from foreign tourists (28.4 and 22.7%, respectively). Three provinces (Krabi, Trang, Satun) had the potential for marine resources and the environment and the well-being of society at a high level. Further, Krabi province had the potential for coastal tourism at a moderate level, while those of Trang and Satun provinces were at a low level. Moreover, Satun province had the potential for marine fisheries at a moderate level, but those of Krabi and Trang provinces were at a low level.

Keywords: Potential Assessment, Sustainable Development, Lower Andaman Sub-region in Thailand

Introduction

Utilization of marine and coastal resources for economic development has gained more significance in all regions of the world, both in terms of direct utilization (fisheries and aquaculture) and indirect utilization (tourism, ports, boat transport, carbon dioxide absorption, etc.). Many countries have shown interest in the utilization of marine and coastal resources as a new area of economic development. The OECD (2016) estimated the value of marine and ocean activities in 2010 at 1.5 trillion US dollars, covering the employment of more than 31 million positions. It was expected that by the year 2030, the value would increase two times, to be more than 3 trillion US dollars, and employment would add around 10 million persons. Moreover, the World Bank Group (2016) identified that the economic system based on marine and coastal resources would be key to improving people's quality of life in the countries located on the coast and small islands. In those countries where the economy was already strong, the marine and coastal resource-based economies would be an important basis of sustainable economic growth. The most important challenge of an economy based on marine and coastal resources is sustainability, because the higher is the value of marine and coastal resource-based economy, the more it will be a driver and place pressure on greater use of resources as well. The World Bank Group (2016) summarized the problems of a marine and coastal resource-based economy that are expected to have impact on humans as follows.

1. Overfishing, which is a result of more advanced technology, coupled with oversight that was still not fully controlled. It had been estimated that, in the past, about 11 to 26 million tons of illegal fish were caught annually, with a value of more than 10-22 billion US dollars.

2. Deterioration of coastal habitats as a result of the directionless development of the coast, mangrove destruction, mining, and emissions.

3. Climate change, which directly affects sea level and marine ecology. A clear example of this is the change in temperature and acidity of seawater that significantly affects marine life.

In order to obtain information for marine and coastal resource-based economic development planning in the lower Andaman sub-region, it is interesting to use the analytical hierarchy process and potential surface analysis to evaluate the sustainable development potential in the lower Andaman sub-region (Krabi, Trang, and Satun).

Objective

To evaluate the sustainable development potential in the lower Andaman sub-region (Krabi, Trang, and Satun).

Literature Review

Sustainable Development

It is widely accepted that coastal zones have high value of ecosystem and economic. Coastal and marine ecosystems provide a wide range of benefits and consequences to humans: i.e. food supplies; fuel wood; energy resources and natural products; flood protection; storm protection; climate control; nutrient control; detoxification of polluted water; waste disposal; cultural services and facilities; support for cultural activities, tourism and recreation; housing supply, nutrient cycling, primary productions, and soil formation. Therefore, ecosystems are not only important to local communities residing in the coastal areas, but to the country and global economy as well. This contributes to the needs for public participation to enhance coastal stabilization (UNEP, 2006 as cited in Oikonomou & Yiannakopoulou, 2021).

Most human and city settlement is known to be in or near coastal zones. Consequently, there is an intense demand for coastal resources to support economic activities that have negative impacts on coastal ecosystems. In respect of both economic development and conservation of the ecosystems, sustainability challenges have inevitably arisen. In other words, the economic and social developments do not compromise the country's natural resource abundance and the value of the coastal areas (Varghese et al., 2551 as cited in Oikonomou & Yiannakopoulou, 2021).

The concept of sustainable development is based on the principles of economy, well-being, social justice, and environment. These principles cannot be separated. Sustainable coastal area management is committed to maximizing long-term social benefits related to environmental, economic, social and cultural aspects. It is also committed to promoting social equality through the distribution of opportunities among the present populations and between the present generation and the next generation (Oikonomou & Yiannakopoulou, 2021).

Analytic Hierarchy Process

Analytic Hierarchy Process (AHP) is the most popular method for Multi-Criteria Decision Making (MCDM) specifically used for formulating and analyzing decision. This technique is used to rank alternative sets for selecting the best options in alternative sets (Ramanathan, 2006 as cited in Oikonomou & Yiannakopoulou, 2021). It enables decision-makers to manage complex structure problems in the form of a simple hierarchy and to systematically assess a large number of quantitative and qualitative factors under a number of conflict criteria (Kubde & Bansod, 2012 as cited in Oikonomou & Yiannakopoulou, 2021). The technique is also capable of systematically and quickly evaluating quantitative and qualitative factors in decision-making process by judging the relative importance of the decision criteria and calculating the weights of the criteria and priorities of the alternatives (Hongmei et al., 2018 as cited in Oikonomou & Yiannakopoulou, 2021). The steps of AHP are as follows: 1) structure a hierarchical decision problem, 2) collect data from the experts, 3) create pairwise comparison matrix, 4) find the priorities of each criterion, 5) calculate consistency ratio (Awang et al., 2020).

Potential Surface Analysis

Potential Surface Analysis (PSA) is a technique used for analyzing the potential development of the areas. It was developed in 1969 for "Nottinghamshire/Derbyshire Sub-regional Study" to systematically analyze the development potential at the regional level by the use of quantitative data to consider the index or factors in determining the potential of the areas. This technique evolved from traditional overlay technique into sieve mapping analysis (Peeraphan, 2006). Sieve mapping is an easy technique to use, to read and to interpret because the information is displayed in graphic (Rangsirak, 1976 as cited in Upala et al., 2008). PSA is a method for improving graphic through sieve mapping technique to display numerical results. The importance lies in the weighting of each factor or variable, making it possible to measure data and combine factors based on mathematical equations for physical, economic, social, and environmental characteristics. The results of PSA showed the developmental potential of every area on the map in order from the lowest to the highest levels, and it can be used to analyze the areas at all levels (Upala et al., 2008). The steps of PSA are as follows: 1) determine relevant factors for potential consideration, 2) determine the criteria for significance of the factors, 3) calculate the weighted score value, 4) display factor values on the map.

Research Methodology

Area of Study

This research was conducted in the lower Andaman sub-region covering the territorial sea of three provinces: Krabi, Trang, Satun.

Population and Samples

The population was comprised of experts that had knowledge in four fields: coastal tourism, marine and coastal resources, marine fisheries, and social science, as well as knowledge in assessing the sustainable development potential of the lower Andaman sub-region as a whole. The samples were 20 experts selected using purposive sampling in order to obtain five experts in each field.

Research Instrument

The research instrument was a score table for the main factors in four aspects: coastal tourism, marine resources and the environment, marine fisheries, the well-being of society, and a score table for the sub-factors in each aspect.

Data Collection

The experts were interviewed in four aspects: coastal tourism, marine resources and the environment, marine fisheries, and the well-being of society. The experts performed a pairwise comparison and rated the weight of importance in all four aspects.

Analyzed Area's Potential

Spatial potential analysis suitable for developing the lower Andaman sub-region was used the Analytic Hierarchy Process (AHP) in order to find the importance of the weight of the main and sub-factors. Moreover, Potential Surface Analysis (PSA) was also used to evaluate the potential of the area. Data were analyzed using the Excel program.

The process of the area potential analysis suitable for developing the lower Andaman sub-region was as follows:

Step 1: Evaluate the Importance of the Main and Sub-factors Using the APH Technique

1. Identified variables that affected the potential of the lower Andaman sub-region as the main and sub-factors. The main factors used a sustainable development framework that consisted of the economy (coastal tourism and marine fisheries), the environment (marine resources and the environment), and the well-being of society. Therefore, there were four aspects of the main factors: 1) coastal tourism, 2) marine resources and the environment, 3) marine fisheries, and 4) the well-being of society, which had sub-factors of 8, 7, 5, 10 variables, respectively. As a result, there was a total of 30 variables. The structure of the main and sub-factors is shown in Figure 1.

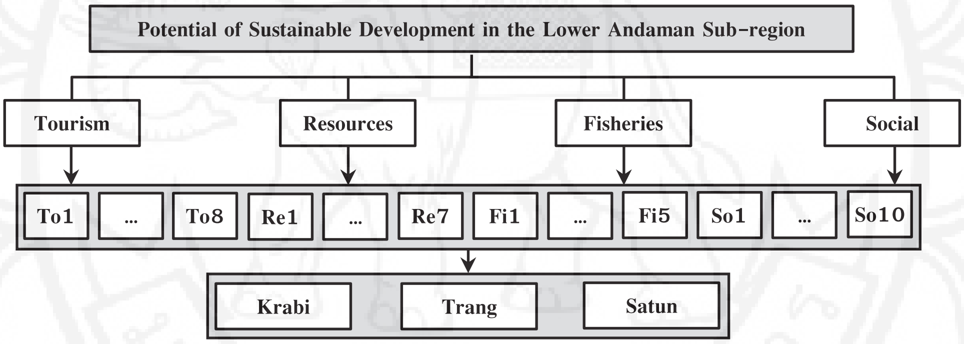

Figure 1 The AHP Hierarchical Structure Shows the Factors in the Sustainable Development of the Lower Andaman Sub-region.

2. Conducted a Pairwise Comparison

All 20 experts evaluated the importance of the weight of the main factors in four aspects: coastal tourism, marine resources and the environment, marine fisheries, and the well-being of society. On the other hand, the sub-factors of each aspect were evaluated by five experts in each field.

The experts performed a pairwise comparison and gave a score for all aspects. The top of the diagonal matrix provided the relationship the weight of each pair, while the bottom gave the relationship weight of each reciprocal pair. The diagonal of the matrix had a value of 1, as shown in Table 1. (Awang et al., 2020)

Table 1 The Pairwise Comparison and Importance of the Weights

Criteria	Coastal Tourism	Marine Resources and Environment	Marine Fisheries	Well-being of Society
Coastal Tourism	1.00	1/2	2.00	1/3
Marine Resources and Environment	2.00	1.00	1.00	1/4
Marine Fisheries	1/2	1.00	1.00	1/4
Well-being of Society	3.00	4.00	4.00	1.00

3. Calculated the Weight of Each Factor

3.1 Find the sum of each column (in Table 2).

3.2 Take the sum from item 3.1 to divide the vertical numbers in its own column, where the sum of each column equals 1.

3.3 Find the sum of each horizontal row.

3.4 Find the horizontal mean by dividing the sum from item 3.3 by the number of criteria used in decision-making, which equals 4. The obtained eigenvalues are shown in Table 3.

Table 2 Sum of Each Column

Criteria	Coastal Tourism	Marine Resources and Environment	Marine Fisheries	Well-being of Society
Coastal Tourism	1.00	0.50	2.00	0.33
Marine Resources and Environment	2.00	1.00	1.00	0.25
Marine Fisheries	0.50	1.00	1.00	0.25
Well-being of Society	3.00	4.00	4.00	1.00
Total	**6.50**	**6.50**	**8.00**	**1.83**

Table 3 Calculation of Eigenvalues

Criteria	Coastal Tourism	Marine Resources and Environment	Marine Fisheries	Well-being of Society	Total	Eigenvalue Mean (Total in Row/4)
Coastal Tourism	0.154	0.077	0.250	0.182	0.663	0.166
Marine Resources and Environment	0.308	0.154	0.125	0.136	0.723	0.181
Marine Fisheries	0.077	0.154	0.125	0.136	0.492	0.123
Well-being of Society	0.462	0.615	0.500	0.545	2.122	0.531
Total	**1.000**	**1.000**	**1.000**	**1.000**		**1.000**

4. Examined the Consistency Ratio (CR)

Check the consistency ratio to see if the value of the comparison criteria of the experts used to calculate the eigenvalues was reasonable or not (Boonyasup & Chuchip, 2011).

If the CR value was less than or equal to 0.10, then the factor values were consistent. The eigenvalue could be used as a weight value.

If the CR value was greater than 0.10, then the factor values were inconsistent. Go back and recheck each weight value assigned as to the factors.

Formula $CR = \frac{CI}{RI}$

According to the pairwise comparison matrix in Table 1, the consistency ratio was calculated as follows (Defence Technology Institute, n.d.).

4.1 Multiplied the obtained matrix [A] with the eigenvalue from Table 3 in vector [B] to get vector [C].

$$\underset{[A]}{\begin{bmatrix} 1 & 1/2 & 2 & 1/3 \\ 2 & 1 & 1 & 1/4 \\ 1/2 & 1 & 1 & 1/4 \\ 3 & 4 & 4 & 1 \end{bmatrix}} \times \underset{[B]}{\begin{bmatrix} 0.166 \\ 0.181 \\ 0.123 \\ 0.531 \end{bmatrix}} = \underset{[C]}{\begin{bmatrix} 0.679 \\ 0.768 \\ 0.519 \\ 2.243 \end{bmatrix}}$$

4.2 Divided each number in vector [C] by vector [B] to get vector [D].

$$[D]=\begin{bmatrix} \frac{0.679}{0.166} & \frac{0.768}{0.181} & \frac{0.519}{0.123} & \frac{2.243}{0.531} \end{bmatrix}$$

$$=\begin{bmatrix} 4.099 & 4.248 & 4.220 & 4.227 \end{bmatrix}$$

4.3 Found λ_{max} value by finding the mean of numbers in vector [D].

$$\lambda_{max} = \frac{4.099 + 4.248 + 4.220 + 4.227}{4} = 4.198$$

4.4 Found the CI value from the formula where n=4 (number of factors).

$$CI = \frac{\lambda_{max} - n}{n - 1} = \frac{4.198 - 4}{4 - 1} = 0.066$$

4.5 Found the inconsistency indices (RI) from Table 4 when n = 4, RI = 0.90.

Table 4 Random Inconsistency Indices

n	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
RI	0	0	0.58	0.90	1.12	1.24	1.32	1.41	1.45	1.49	1.51	1.48	1.53	1.57	1.59

Source: Saaty, 1980 as cited in Muslimin et al., 2021

4.6 Determines the consistency ratio from formula.

$$CR = \frac{CI}{RI} = \frac{0.066}{0.900} = 0.073$$

Therefore, CR = 0.073 was less than 0.10, indicating that the weights provided by the experts were consistent.

The eigenvalue average and CR values of the main factors are shown in Table 5, and the eigenvalue and CR values of the main and sub-factors are shown in Table 6 (Saha & Paul, 2020).

Table 5 The Eigenvalue Average and CR of the Main Factors

Item	Eigenvalues				CR
	Coastal Tourism	Marine Resources and Environment	Marine Fisheries	Well-being of Society	
Expert 1	0.166	0.181	0.123	0.531	0.073
Expert 2	0.213	0.402	0.140	0.246	0.044
Expert 3	0.273	0.446	0.074	0.207	0.044
Expert 4	0.115	0.380	0.213	0.292	0.080
Expert 5	0.061	0.471	0.167	0.302	0.033
Expert 6	0.075	0.459	0.175	0.291	0.078
Expert 7	0.110	0.376	0.215	0.299	0.003
Expert 8	0.071	0.321	0.053	0.556	0.042
Expert 9	0.095	0.466	0.257	0.181	0.045
Expert 10	0.049	0.612	0.093	0.246	0.082
Expert 11	0.087	0.205	0.205	0.503	0.031
Expert 12	0.173	0.315	0.364	0.148	0.013

Table 5 (Cont.)

Item	Eigenvalues				CR
	Coastal Tourism	Marine Resources and Environment	Marine Fisheries	Well-being of Society	
Expert 13	0.057	0.525	0.308	0.110	0.045
Expert 14	0.359	0.235	0.293	0.113	0.087
Expert 15	0.296	0.246	0.211	0.246	0.022
Expert 16	0.087	0.298	0.142	0.473	0.024
Expert 17	0.132	0.249	0.239	0.380	0.091
Expert 18	0.043	0.238	0.134	0.585	0.088
Expert 19	0.317	0.463	0.178	0.042	0.071
Expert 20	0.048	0.633	0.075	0.244	0.081
Mean	**0.141**	**0.376**	**0.183**	**0.300**	**0.054**

Table 6 Weight (Eigenvalue) and CR of the Main Factors, Sub-factors, and Total Weight

<table>
<tr><th colspan="3">Stage 1</th><th colspan="3">Stage 2</th><th rowspan="2">Total Weight</th></tr>
<tr><th>Criteria</th><th>Weight</th><th>CR</th><th>Sub-criteria</th><th>Weight</th><th>CR</th></tr>
<tr><td rowspan="8">1. Coastal Tourism</td><td rowspan="8">0.141</td><td rowspan="8">0.054</td><td>1.1 Tourism income from Thai people</td><td>0.175</td><td rowspan="8">0.091</td><td>0.025</td></tr>
<tr><td>1.2 Tourism income from foreigners</td><td>0.227</td><td>0.032</td></tr>
<tr><td>1.3 Number of foreign tourists (persons)</td><td>0.142</td><td>0.020</td></tr>
<tr><td>1.4 Number of Thai tourists (persons)</td><td>0.081</td><td>0.011</td></tr>
<tr><td>1.5 Boat passengers (persons/year)</td><td>0.086</td><td>0.012</td></tr>
<tr><td>1.6 Number of rooms</td><td>0.100</td><td>0.014</td></tr>
<tr><td>1.7 Electrical energy sold and used (kWh)</td><td>0.121</td><td>0.017</td></tr>
<tr><td>1.8 Internet usage (% of population)</td><td>0.068</td><td>0.010</td></tr>
<tr><td rowspan="7">2. Marine Resources and Environment</td><td rowspan="7">0.376</td><td rowspan="7"></td><td>2.1 Mangroves</td><td>0.294</td><td rowspan="7">0.069</td><td>0.110</td></tr>
<tr><td>2.2 Sea grass</td><td>0.164</td><td>0.062</td></tr>
<tr><td>2.3 Coral reefs</td><td>0.168</td><td>0.063</td></tr>
<tr><td>2.4 Rare marine animals</td><td>0.081</td><td>0.030</td></tr>
<tr><td>2.5 Artificial reefs (number/age)</td><td>0.059</td><td>0.022</td></tr>
<tr><td>2.6 Good or higher ratio of coastal water quality per total water quality</td><td>0.174</td><td>0.065</td></tr>
<tr><td>2.7 Carbon dioxide emissions of population (tons of CO_2)</td><td>0.060</td><td>0.023</td></tr>
<tr><td rowspan="5">3. Marine Fisheries</td><td rowspan="5">0.183</td><td rowspan="5"></td><td>3.1 Good or higher ratio of coastal water quality per total water quality</td><td>0.183</td><td rowspan="5">0.040</td><td>0.034</td></tr>
<tr><td>3.2 Number of registered fishing boats (boats)</td><td>0.102</td><td>0.019</td></tr>
<tr><td>3.3 Number of marine animals landing at major fishing ports (tons)</td><td>0.284</td><td>0.052</td></tr>
<tr><td>3.4 Artificial reefs (number/age)</td><td>0.134</td><td>0.024</td></tr>
<tr><td>3.5 Agricultural and fishery income (average per household per month) *(fishery excludes aquaculture), forestry, hunting, foraging, agricultural services</td><td>0.297</td><td>0.054</td></tr>
</table>

Table 6 (Cont.)

Stage 1			Stage 2			Total
Criteria	**Weight**	**CR**	**Sub-criteria**	**Weight**	**CR**	**Weight**
4. Well-being of Society	0.300		4.1 Average household income per month	0.138	0.059	0.041
			4.2 Average household expenses per month	0.103		0.031
			4.3 Unemployment rate for the working population in the labor force	0.102		0.031
			4.4 Population per physician	0.107		0.032
			4.5 Number of crimes	0.076		0.023
			4.6 Accidents (places)	0.074		0.022
			4.7 Average happiness	0.176		0.053
			4.8 Number of drug cases	0.078		0.023
			4.9 Electricity users (persons)	0.070		0.021
			4.10 Households with tap water use (%)	0.077		0.023

Step 2: Assess the Development Potential of the Lower Andaman Sub-region Using the PSA Technique

Assessing the development potential of the lower Andaman sub-region covered four aspects: coastal tourism, marine resources and the environment, marine fisheries, and the well-being of society. The Potential Surface Analysis (PSA) technique was used.

1. Identified Criteria for Rating Score of the Area

The rating scores were determined for four aspects: coastal tourism, marine resources and the environment, marine fisheries, and the well-being of society. The rating score or R value for high ability was 3, for moderate ability it was 2, and for low ability it was 1.

2. Determined the Potential of the Lower Andaman Sub-region

Determination of the potential of the lower Andaman sub-region in four aspects—coastal tourism, marine resources and the environment, marine fisheries, and the well-being of society—was as follows (Waenwong et al., 2022).

$$P = \sum_{i=1}^{n} W_i R_i$$

When P = Potential of area

W = Weighting of each variable

R = Rating of ability

n = Number of variables

The potential level of the lower Andaman sub-region was identified according to three levels: high, moderate, and low. The class interval was calculated with equal intervals as follows.

Range = Highest score-lowest score = 1.000 - 0.001 = 0.999

Class interval = Range/number of class = 0.999/3 = 0.333

Score Criteria and Potential Level

Score 0.668 - 1.000 High Potential

Score 0.335 - 0.667 Moderate Potential

Score 0.001 - 0.334 Low Potential

Step 3: Prepare the Maps

Prepare the maps showing the potential of the lower Andaman sub-region in four aspects—coastal tourism, marine resources and the environment, marine fisheries, the well-being of society—by using the Geographic Information System (GIS) technique.

Results

The results of this study are presented in two parts, the weight of the main and sub-factors and the potential of the lower Andaman sub-region, as follows.

1. Weight of the Factors Using the Analytic Hierarchical Analysis Technique

The analytic hierarchical analysis was used to analyze the potential of the lower Andaman sub-region for the benefit of economic development planning based on the marine and coastal resources discussed by the experts. It was found that the main factors were marine resources and the environment (37.6%), followed by the economy (32.4%), and the well-being of society (30.0%) which consisted of the economy of marine fisheries and coastal tourism (18.3% and 14.1%, respectively), as shown in Figure 2.

The first important sub-factors were agricultural and fishery income (average per household per month) and mangroves (29.7% and 29.4%, respectively), followed by the number of marine animals landing at major fishing ports (tons) and tourism income from foreigners (28.4% and 22.7%, respectively), as shown in Figure 3.

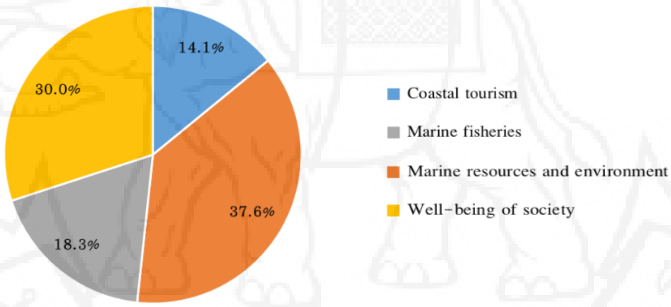

Figure 2 Percentage of Weight of the Main Factors.

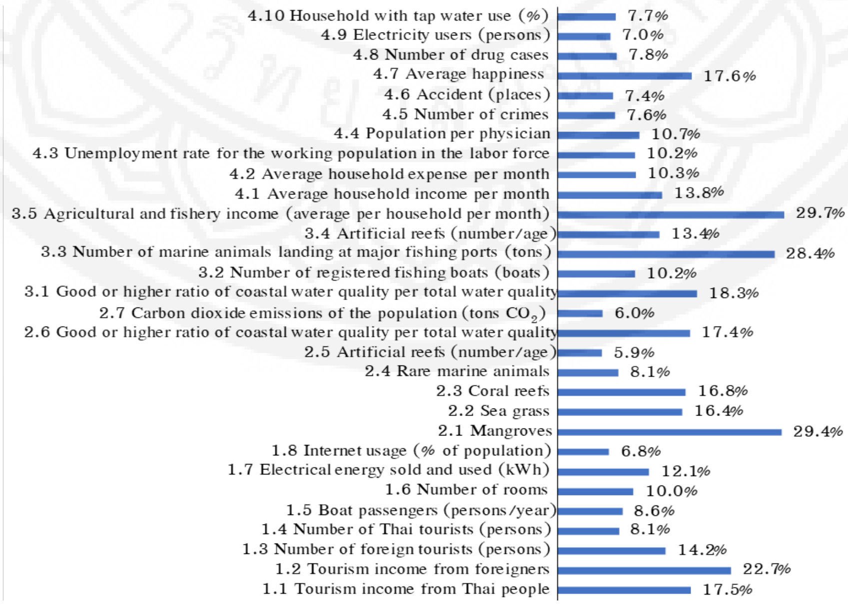

Figure 3 Importance of the Weight of the Sub-factors.

2. The Sustainable Development Potential of the Areas Using the Potential Surface Analysis Technique

The sustainable development potential of the lower Andaman sub-region consisted of four aspects, as follows.

2.1 The Spatial Potential of Coastal Tourism

The evaluation of the spatial potential of the lower Andaman sub-region regarding coastal tourism showed that Krabi province had coastal tourism potential at a moderate level, while Trang and Satun provinces were at a low level, as shown in Table 7.

Table 7 Evaluation of the Spatial Potential Level of the Coastal Tourism Aspect of Lower Andaman Sub-region Coastal Tourism

Province	Calculation	Potential Level
Krabi	= (0.025 x 3) + (0.032 x 3) + … + (0.10 x 3) = 0.407	Moderate
Trang	= (0.025 x 1) + (0.032 x 2) + … + (0.10 x 1) = 0.248	Low
Satun	= (0.025 x 1) + (0.032 x 2) + … + (0.10 x 2) = 0.241	Low

2.2 The Spatial Potential of Marine Resources and the Environment

Regarding the evaluation of the spatial potential of the lower Andaman sub-region regarding marine resources and the environment, it was found that all three provinces had marine resources and environmental potential at a high level, as shown in Table 8.

Table 8 Evaluation of the Spatial Potential Level of Marine Resources and the Environmental Aspect of the Lower Andaman Sub-region

Province	Calculation	Potential Level
Krabi	= (0.110 x 2) + (0.062 x 2) + … + (0.023 x 2) = 0.765	High
Trang	= (0.110 x 2) + (0.062 x 2) + … + (0.023 x 3) = 0.712	High
Satun	= (0.110 x 3) + (0.062 x 1) + … + (0.023 x 2) = 0.889	High

2.3 The Spatial Potential of Marine Fisheries

The evaluation of the spatial potential of the lower Andaman sub-region regarding marine fisheries revealed that Satun province had marine fisheries potential at a moderate level, while Krabi and Trang provinces were at a low level, as shown in Table 9.

Table 9 Evaluation of the Spatial Potential Level of the Marine Fisheries Aspect of the Lower Andaman Sub-region

Province	Calculation	Potential level
Krabi	= (0.034x3) + (0.019 x 2) + … + (0.054 x 2) = 0.323	Low
Trang	= (0.034x2) + (0.019 x 1) + … + (0.054 x 1) = 0.293	Low
Satun	= (0.034x3) + (0.019 x 2) + … + (0.054 x 2) = 0.399	Moderate

2.4 The Spatial Potential of the Well-being of Society

The evaluation of the spatial potential of the lower Andaman sub-region regarding the well-being of society showed that all three provinces had a well-being of society potential at a high level, as shown in Table 10.

Table 10 Evaluation of the Spatial Potential Level of the Well-being of Society Aspect of the Lower Andaman Sub-region

Province	Calculation	Potential level
Krabi	= (0.041 x 3) + (0.031 x 3) + … + (0.023 x 3) = 0.747	High
Trang	= (0.041 x 2) + (0.031 x 2) + … + (0.023 x 2) = 0.691	High
Satun	= (0.041 x 2) + (0.031 x 2) + … + (0.023 x 2) = 0.676	High

It can be concluded that the sustainable development potential of the lower Andaman sub-region in the four discussed aspects were as shown in Table 11 and Figures 4-5.

Table 11 Level of the Sustainable Development Potential of the Lower Andaman Sub-region

Items	Sustainable Development Potential		
	Krabi	**Trang**	**Satun**
Coastal Tourism	Moderate	Low	Low
Marine Resources and Environment	High	High	High
Marine Fisheries	Low	Low	Moderate
Well-being of Society	High	High	High

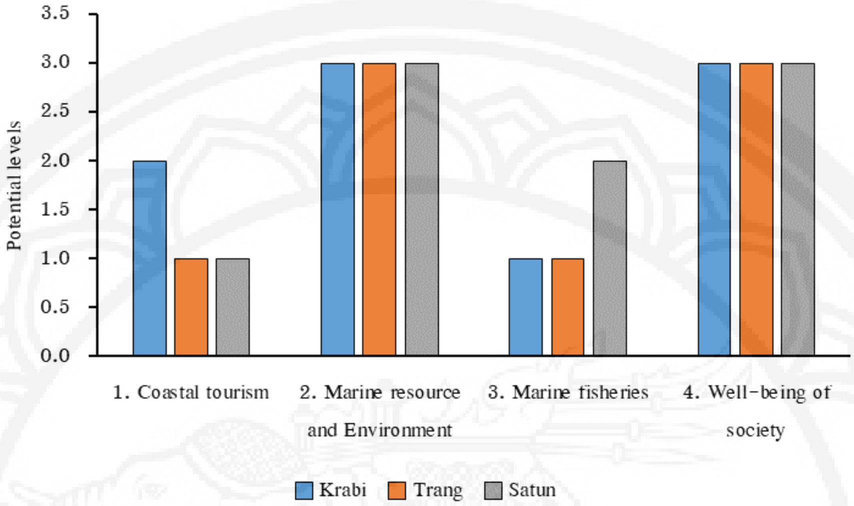

Figure 4 Level of the Sustainable Development Potential of the Lower Andaman Sub-region (Trang, Krabi, and Satun).

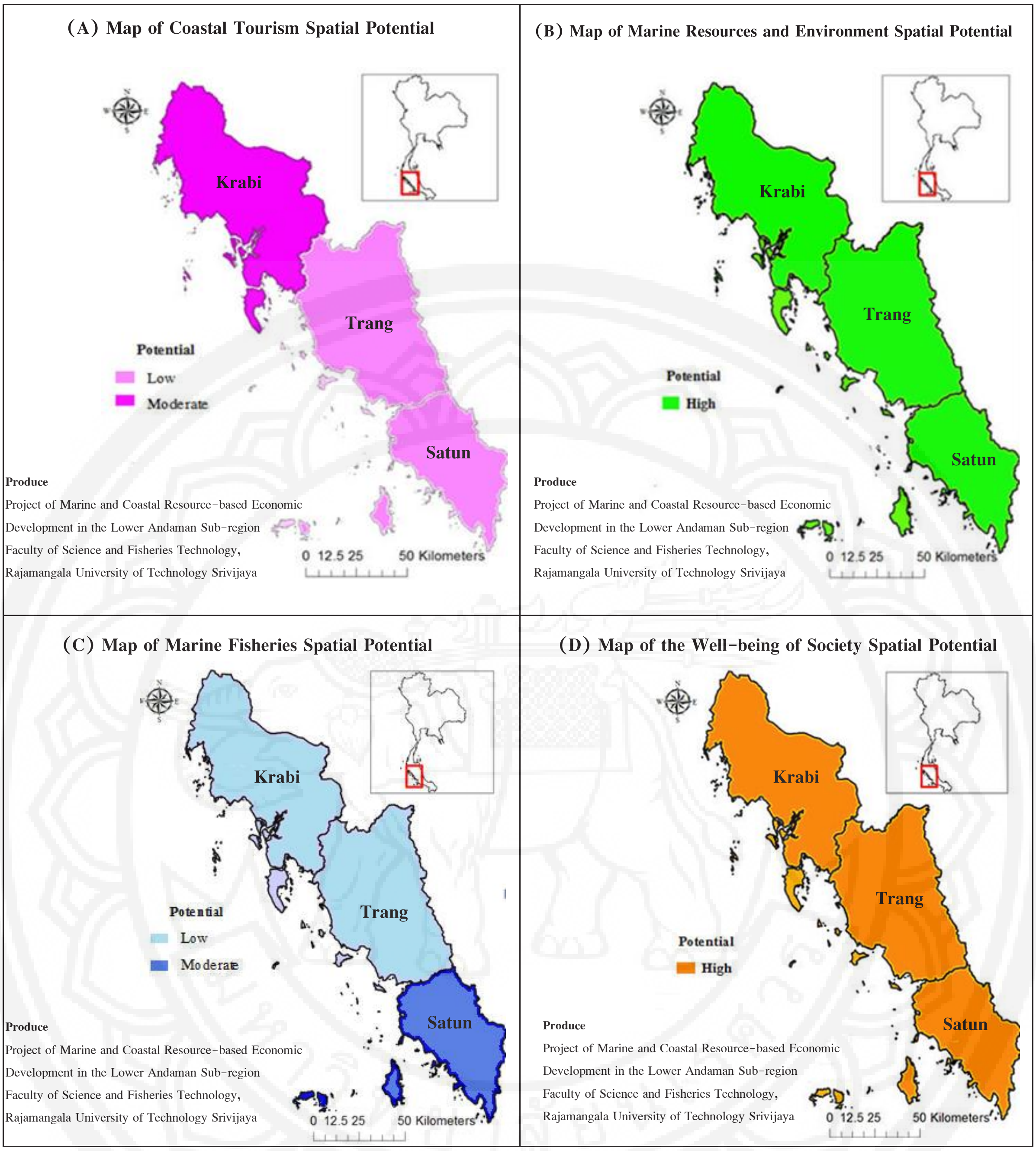

Figure 5 The Sustainable Development Potential of the Lower Andaman Sub-region
(A) Coastal Tourism, (B) Marine Resources and Environment, (C) Marine Fisheries, and (D) Well-being of Society.

Conclusion

The analysis of the sustainable development potential of the lower Andaman sub-region, which would provide information for further economic development planning, based on marine and coastal resources, was conducted by using the AHP and PSA techniques. The experts conducted a pairwise comparison and found that all three provinces (Krabi, Trang, Satun) had potential in terms of marine and coastal resources and the environment and the well-being of society at a high level. Krabi province had coastal tourism potential at a moderate level, while those of Trang and Satun were at a low level. Satun province had a marine fisheries potential at a moderate level, while those of Krabi and Trang provinces were at a low level. Therefore, the focuses of sustainable spatial potential development of each province should be designed based on this information in order to create equality in potential development.

Discussion

This research used a multi-criteria analysis with AHP. The main factors used the sustainable development framework, consisting of the economy (coastal tourism and marine fisheries), society (well-being of society), and the environment (marine resources and the environment), divided into four main factors: coastal tourism, marine resources and the environment, marine fisheries, and the well-being of society. All of the factors were analyzed using AHP and PSA techniques.

The evaluation of the lower Andaman sub-region potential used the sustainable development framework in three aspects—the economy, the environment, and the society. This was consistent with research on coastal areas that used three main factors, the economy, the environment, and the society, for example in Muslimin et al. (2021), who studied the sustainability of the seafood supply chain in Indonesia, and Oikonomou and Yiannakopoulou (2021), who studied the sustainability of coastal area management. In addition, there has been research that has used the main factors (the economy, society, and the environment), along with other main factors. Examples include Orencio and Fujii (2013), who studied the local disaster resistant index using the main factors of the environment and natural resources, sustainable livelihoods, social protection, and research planning in coastal areas; Awang et al. (2020), who studied the sustainability assessment of the fisheries industry in Malaysia using the main factors of ecology, the economy, society, and politics; Liaghat et al. (2013), who studied the analysis of coastal tourism locations using the main factors of society, the economy, and accessibility; Sandhyavitri et al. (2020), who studied the determination and prioritization of coastal risk areas using the main factors of the economy, the environment, the socio-cultural element, strategic issues, and technique; and Navale and Bhagat (2022), who studied the impact assessment of coastal tourism in India using the main factors of geography, the environment, ecology, economics, and society and culture.

The weight of the main and sub-factors was assessed using the pairwise comparison method. That is, coastal tourism, marine resources and the environment, marine fisheries, and the well-being of society were evaluated by all five experts in each aspect, for a total of 20 persons. This was consistent with the work of Wang et al. (2016) and Liu et al. (2019), who used expert assessment. On the other hand, Muslimin et al. (2021) used evaluation by stakeholders, including fishers, fish collectors, transporters, retailers, etc.; Zeraatkish (2016) used assessment by fishery stakeholder groups and fishery management systems; Suwasono and Rosana (2013) used assessment based on individual opinion; and Navale and Bhagat (2022) used field surveys with questionnaires and interviews in order to assess the impact of coastal tourism development.

The most important factors were marine resources and the environment (37.6%), followed by the economy (marine fisheries and coastal tourism) (32.4%) and the well-being of society (30.0%), respectively. Muslimin et al. (2021) also found that the most important factors were environment followed by social and economy, respectively.

In terms of coastal tourism, it was found that Krabi province had a coastal tourism potential at a moderate level, while Trang and Satun provinces were at a low level. This corresponds with statistical data from the database of the Ministry of Tourism and Sports (n.d.) of Thailand, which reported that the number of both Thai and foreign tourists in Krabi was significantly higher than that in Trang and Satun province, whereas Trang and Satun provinces had a similar number of tourists at about four million, one million, and nine hundred thousand persons, respectively. Therefore, Krabi province's tourism income was higher than those of Trang and Satun provinces accounting for 80 million baht, 8,000 million baht, and 7,000 million baht respectively. Krabi had the fourth highest tourism income while Trang and Satun provinces were ranked at 19th and 20th, respectively. This made other sub-factors in tourism aspect of Krabi to have potential at moderate level, when compared with Trang and Satun provinces that had tourism potential in low level.

In terms of marine fisheries, it was found that Satun province had a marine fisheries potential at a moderate level, while those of Krabi and Trang provinces were at a low level. This is consistent with Thailand's Ocean Health Index assessment scores, which showed that catching aquatic animals and marine farming criteria were also low. Therefore, it is vital to communicate with people in the areas about the sustainable use of fishery or coastal resources (Halpern et al., 2012).

The potential of the lower Andaman sub-region (Krabi, Trang, and Satun) in coastal tourism, marine fisheries, marine resources and the environment, and the well-being of society, would benefit stakeholders (the government, the private sector, communities, non-governmental organizations, and academics) to jointly plan economic development based on marine and coastal resources in the future. Research using the AHP technique in coastal areas has many following benefits.

Regarding coastal tourism, Saha and Paul (2020) stated that these results would help politicians and stakeholders consider existing tourism challenges and to create action plans or sustainable growth strategies for the tourism industries. Wang et al. (2016) mentioned that the central government responsible for coastal tourism might adapt this framework to assess the overall performance of each sub-agent. Moreover, local governments might adapt this assessment framework to review the strengths and weaknesses of the current coastal tourism development so that better management plans could be directed towards sustainable coastal tourism. Nouri et al. (2017) stated that this study showed that a well-structured Spatial Decision Support System (SDSS) could provide a comprehensive framework to assist decision makers in developing sustainable tourism.

In terms of marine fisheries, Awang et al. (2020) stated that the results of this study would be of great help to fishery stakeholders in taking any possible action to access a sustainable fishery industry. The successful AHP model could be applied to fishery management problems by using it for the prioritization of global complex problems involving multiple criteria.

Regarding coastal resources, Liaghat et al. (2013) stated that the study results would be useful for analyzing the suitability of land use based on GIS in land use planning and future development plan. Further, Sandhyavitri et al. (2020) stated that the most important aspect of the AHP method was the criteria for determining the priority of coastal risk areas, i.e. the national strategic coastal areas. In addition, Baby (2013) also mentioned that the AHP/ANP model was the most appropriate strategy for policy making effectiveness to solve coastal degradation.

Suggestions

1. Suggestions for Research

The economic development planning based on marine and coastal resources in the lower Andaman sub-region (Krabi, Trang, Satun) needs to develop and upgrade the potential in each aspect as follows: Krabi and Trang provinces should develop higher marine fishery potential, whereas Trang and Satun provinces should improve their coastal tourism potential.

2. Suggestions for the Assessment and Utilization of Area Development Potential Using the AHP Technique

2.1 The assessment of the sustainable development potential of the lower Andaman sub-region was conducted using the AHP technique by experts in each area: coastal tourism, marine fisheries, marine resources and the environment, and the well-being of society. The main factors were weighted by pairwise comparison. As for the assessment of the area potential using the PSA technique, the potential level criteria were created from secondary data. Therefore, the communities could participate in the assessment of the areas' potential. In future research, local stakeholders should participate in weighting with pairwise comparison and should use the method of establishing potential level criteria by collecting actual data in the areas.

2.2 Although the aim of the assessment of the areas' potential was to obtain information for economic developing planning based on marine and coastal resources, the information used for economic development plans in the areas should not be viewed only in the economic dimension. That is, economic development in the areas will be effective only when the information is provided in three dimensions: the economy, the environment, and society.

2.3 The agencies related to tourism, fisheries, and coastal resources and communities at local, district, and provincial levels could use the results of this study as a guideline for further development of the areas.

Acknowledgements

This study was financial supported by the Thailand Science Research and Innovation (SIP62A0019).

References

Awang, A., Mohd, W. R. W., Abdullah, L., & Lee, S. T. (2020). Assessing the Sustainable Fishery-based Industry in Malaysia Using the Analytic Hierarchy Process (AHP). In *14th International UMT Annual Symposium, IOP Conference Series: Earth and Environmental Science, Volume 494, Terengganu, Malaysia, 23-25 July 2019* (012005). http://doi.org/10.1088/1755-1315/494/1/012005

Baby, S. (2013). AHP Modeling for Multicriteria Decision-making and to Optimise Strategies for Protecting Coastal Landscape Resources. *International Journal of Innovation, Management and Technology*, *4*(2), 218-227. http://doi.org/10.7763/IJIMT.2013.V4.395

Boonyasup, N., & Chuchip, K. (2011). Appropriate Forest Corridor Classification in Eastern Forest Complex Using Remote Sensing Techniques and GIS. In *The Proceedings of 49th Kasetsart University Annual Conference: Natural Resources and Environment, 1-4 February 2011* (pp. 211-218). Retrieved from https://kukr.lib.ku.ac.th/proceedings/index.php?/KUCON/search_detail/result/12744

Defence Technology Institute. (n.d.). *Analytic Hierarchy Process: AHP*. Retrieved from https://www.dti.or.th/download/150319174753_3ahp4.pdf

Halpern, B. S., Longo, C., Hardy, D., McLeod, K. L., Samhouri, J. F., Katona, S. K., … Zeller, D. (2012). An Index to Assess the Health and Benefits of the Global Ocean. *Nature*, *488*, 615-620. http://doi.org/10.1038/nature11397

Liaghat, M., Shahabi, H., Deilami, B. R., Ardabili, F. S., Seyedi, S. N., & Badri, H. (2013). A Multi-criteria Evaluation Using the Analytic Hierarchy Process Technique to Analyze Coastal Tourism Sites. *APCBEE Procedia*, *5*, 479-485. https://doi.org/10.1016/j.apcbee.2013.05.081

Liu, R., Wang, Y., & Qian, Z. (2019). Hybrid SWOT-AHP Analysis of Strategic Decisions of Coastal Tourism: A Case Study of Shandong Peninsula Blue Economic Zone. *Journal of Coastal Research*, *94*(SP1), 671-676. https://doi.org/10.2112/SI94-133.1

Ministry of Tourism and Sports. (n.d.). *Tourism Statistics 2018*. Retrieved from https://www.mots.go.th/news/category/497

Muslimin, Mangun, N., Rombe, E., Taqwa, E., Sutomo, M., & Hadi, S. (2021). AHP Structure for Determining Sustainable Performance of Indonesian Seafood Supply Chain from Stakeholders Perspective. *Journal of Management Information and Decision Sciences*, *24*(S2), 1-10. Retrieved from https://www.abacademies.org/abstract/ahp-structure-for-determining-sustainable-performance-of-indonesian-seafood-supply-chain-from-stakeholders-perspective-11796.html

Navale, S. B., & Bhagat, V. S. (2022). Use of AHP based Weighted Analysis for Impact Assessment of Coastal Tourism in Ratnagiri District, Maharashtra (India): Respondents' Point of View. *Journal of Geographical Studies*, *6*(1), 1-32. https://doi.org/10.21523/gcj5.22060101

Nouri, J., Arjmandi, R., Aleshekh, A. A., & Tari, Z. S. (2017). Applying IO and AHP to Locate Coastal Tourism Sites Using GIS: A Case Study of Mazandaran Province, Iran. *Environmental Engineering and Management Journal*, *16*(12), 2707-2718. Retrieved from http://eemj.eu/index.php/EEMJ/article/view/3441

OECD. (2016). *The Ocean Economy in 2030*. Paris: OECD Publishing. http://doi.org/10.1787/9789264251724-en

Oikonomou, E. K., & Yiannakopoulou, E. (2021). Sustainable Coastal Zone Management of Strymonikos Gulf: Implementation of the Analytic Hierarchy Process Through an Application Designed Using the Programming Language C# (Sharp). *World Review of Science, Technology and Sustainable Development*, *17*(1), 54-80. https://doi.org/10.1504/WRSTSD.2021.114021

Orencio, P. M., & Fujii, M. (2013). A Localized Disaster-resilience Index to Assess Coastal Communities Based on an Analytic Hierarchy Process (AHP). *International Journal of Disaster Risk Reduction*, *3*, 62-75. https://doi.org/10.1016/j.ijdrr.2012.11.006

Peeraphan, W. (2006). *Potential Surface Analysis*. Retrieved from http://pioneer.chula.ac.th/~pwannasi/psa.pdf

Saha, J., & Paul, S. (2020). Sustainable Tourism Development Strategies Using SWOT-AHP on Newly Developed Coastal Tourism Destinations. *Romanian Review of Regional Studies*, *XVI*(2), 15-26.

Sandhyavitri, A., Fatnanta, F., & Husaini, R. R. (2020). Identification and Prioritization of Coastal Vulnerability Areas Based on Coastal Vulnerability Indexes (CVI) and Analytical Hierarchy Process (AHP). In *AIP Conference Proceeding 2230* (pp. 040002-1-040002-6). https://doi.org/10.1063/5.0005007

Suwasono, B., & Rosana, N. (2013). The Application of GIS-AHP to Develop a Strategic Planning for an Urban Farming: Fishery and Aquaculture. In *Proceedings of the International Symposium on the Analytic Hierarchy Process 2013 (ISAHP 2013), Kuala Lumpur, Malaysia, 23-26 June 2013*. https://doi.org/10.13033/isahp.y2013.084

Upala, P., Phongkwan, C., & Phatjakrang, K. (2008). Potential Surface Analysis for Residential Development: A Case Study of Phranakhonsriayutthaya Province. *Journal of the Faculty of Architecture, King Mongkul's Institute of Technology Ladkrabang*, *8*(1), 47-56. Retrieved from https://so04.tci-thaijo.org/index.php/archkmitl/article/view/4204

Waenwong, T., Triwiset, A., & Salukkham, E. (2022). Potential Surface Analysis for Urban Expansion Case Study: Pak Chong Town Municipality and Vicinity. In *The 14th Thai Students Symposium on Geography and Geo-infomatics (14th TSG), 21-22 January 2022*. Bangkok: Faculty of Social Sciences, Srinakharinwirot University. Retrieved from https://sites.google.com/g.swu.ac.th/tsg14/proceedings

Wang, S.-H., Lee, M.-T., Château, P.-A., & Chang, Y.-C. (2016). Performance Indicator Framework for Evaluation of Sustainable Tourism in the Taiwan Coastal Zone. *Sustainability*, *8*(7), 652. http://doi.org/10.3390/su8070652

World Bank Group. (2016). *Oceans 2030 Financing the Blue Economy for Sustainable Development: Blue Economy Development Framework*. Retrieved from https://thedocs.worldbank.org/en/doc/446441473349079068-0010022016/original/AMCOECCBlueEconomyDevelopmentFramework.pdf

Zeraatkish, S. Y. (2016). Utilization of Analytic Hierarchy Process (AHP) to Meet Management Objectives in Fishery Industry of the Sea of Oman. *Iranian Journal of Fisheries Sciences*, *15*(4), 1379-1387. Retrieved from https://jifro.ir/article-1-1876-en.html