Adaptation capacity of coastal disasters due to climate change to strengthen southwest area of Taiwan

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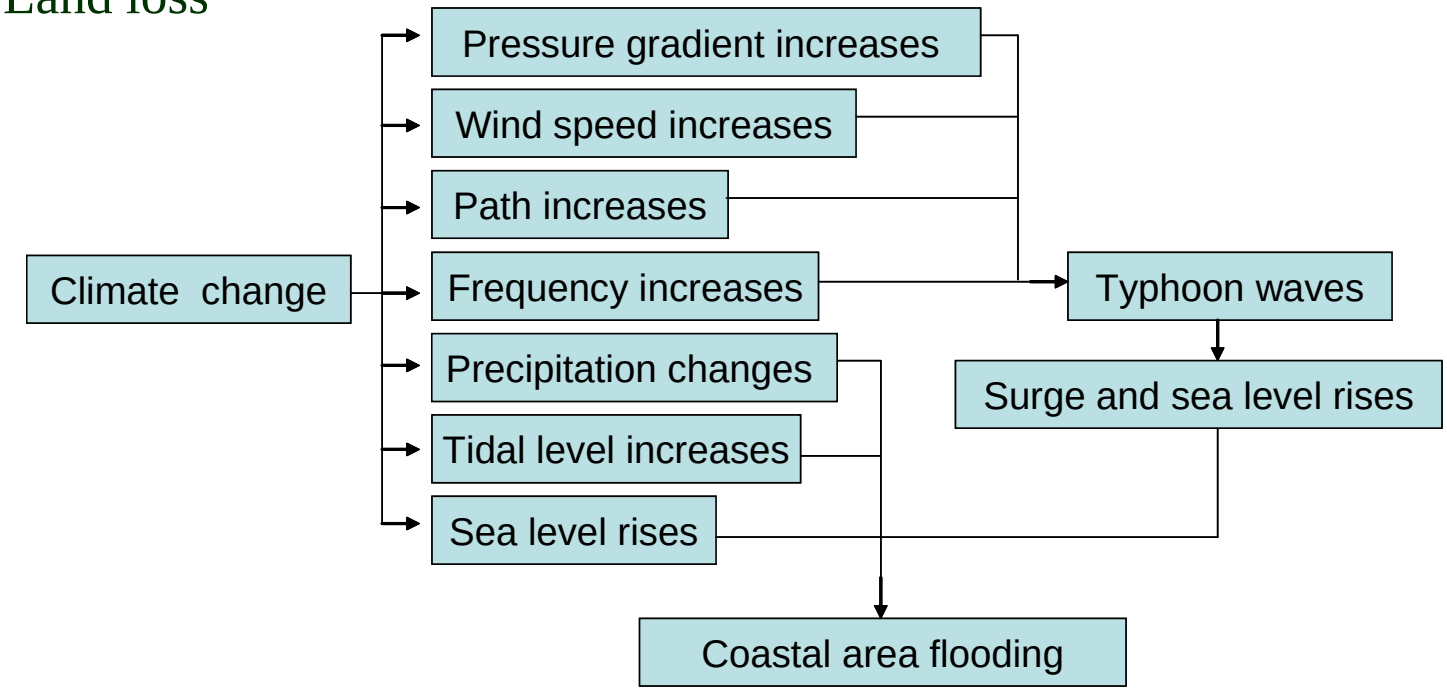
Introduction

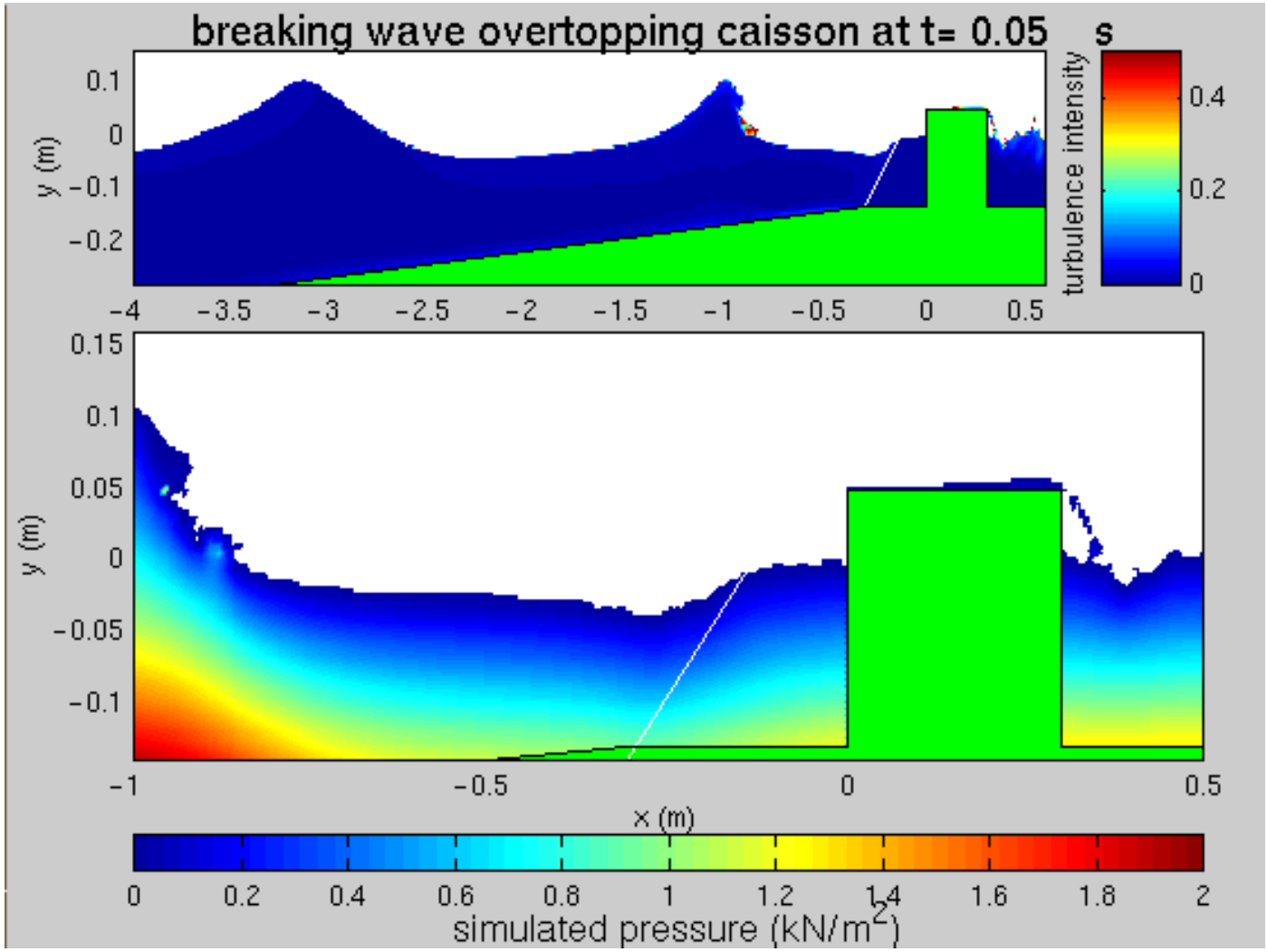
- **The Impact of climate change on coastal areas**

1. Wave breaking line migrates shoreward
2. The increase of probability of wave run up and overtopping
3. Flooding area becomes larger
4. Land loss



Introduction

➢ **Sea level rise — typical example of wave overtopping**



Purposes

1. Construction of the disaster warning system on southwest coasts in Taiwan
2. Model development for scenario analysis of environmental factors
3. Impact assessment and indefinite analysis on disasters, and vulnerability and risk estimation on coastal disasters

Coastal Vulnerability and Risk Assessment

Definition of Vulnerability and Risk and Their Operating Model

Vulnerability

►Consisting of exposure, sensitivity and adaptation

Level of risk

►Including vulnerability and hazard analysis

►In addition to the physical aspects of the problem, the economic, social and environmental problems are also considered

►*Risk* = *V* (*vulnerability*) × *H* (*hazard*)

Coastal Vulnerability Relative Research

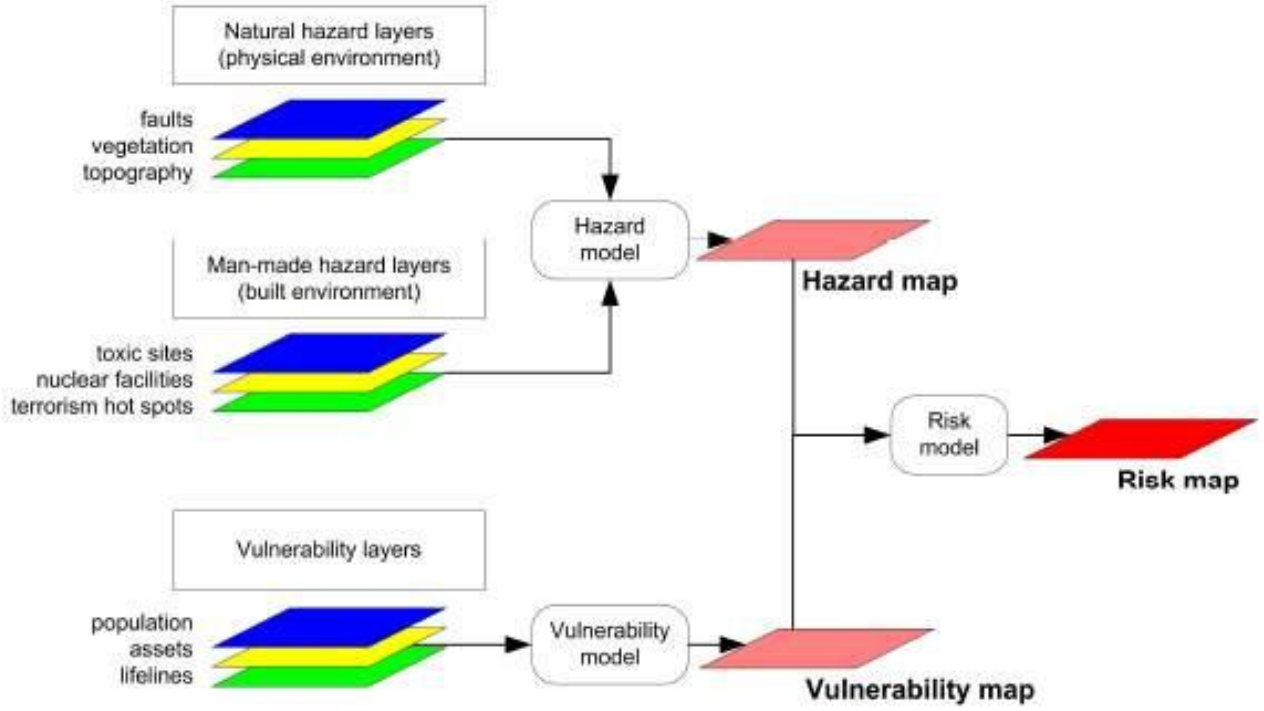
- United States Geological Survey（USGS）adopted coastal vulnerability assessment, which was proposed by Thieler and Hammar-Klose(1999), to analyze the influence of United States coastal line caused by sea level rises。
- There are six variables involved in the assessment : topography, shoreline change, coastal slope, relative sea level changes, significant wave height and tidal range.
- CVI's Formula：

$$\mathrm{CVI} = \sqrt{\frac{a \times b \times c \times d \times e \times f}{6}}$$

a= topography ，b= shoreline change ，c=coastal slope ，d=relative sea level changes ，e=mean significant wave height ，f=mean tidal range 。

Coastal Vulnerability and Risk Assessment

- **Using CEDIM method to create vulnerability and risk maps**



CEDIM's risk map designation process (Muller et al., 2006)

Coastal Vulnerability Assessment

GIS data base

DTM grid generation

Calculation of vulnerability index in each grid

Normalized vulnerability index

Calculation of vulnerability index in each face

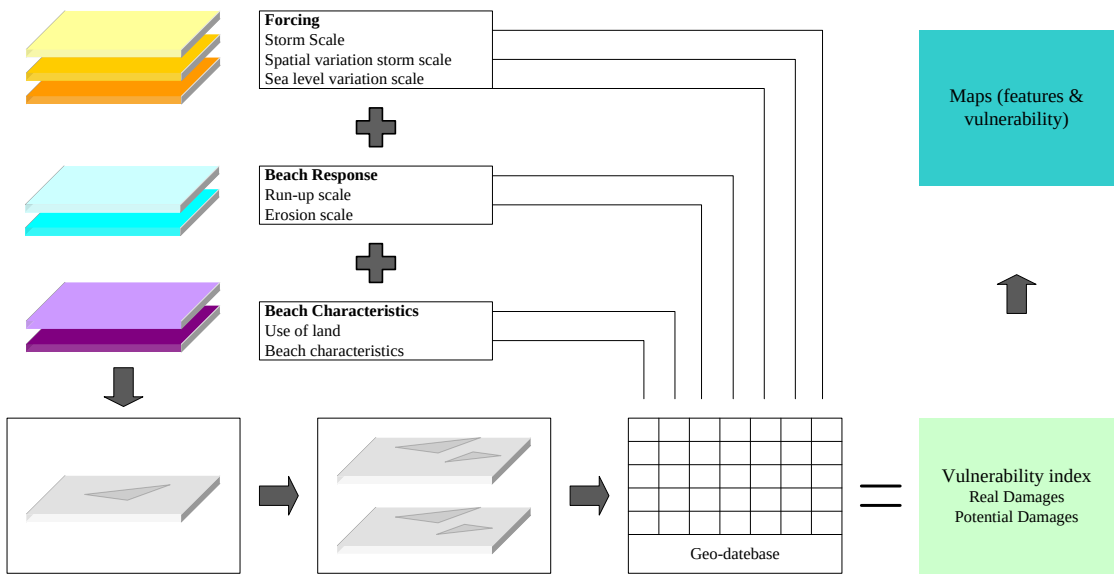
Calculation of combined index

Regression / Combination / Quantity transformation

Result display

$$F_i = \sum_{j=1}^{J_i} w_{(i,j)} \times R^*_{(i,j)}$$

$$CVI = \sum_{i=1}^{3} p_{(i)} \times F_{(i)}$$



(Quintana, 2008)

Results

AHP Evaluation on the Index Weighting of Vulnerability Analysis In Southwest Coastal Area of Taiwan

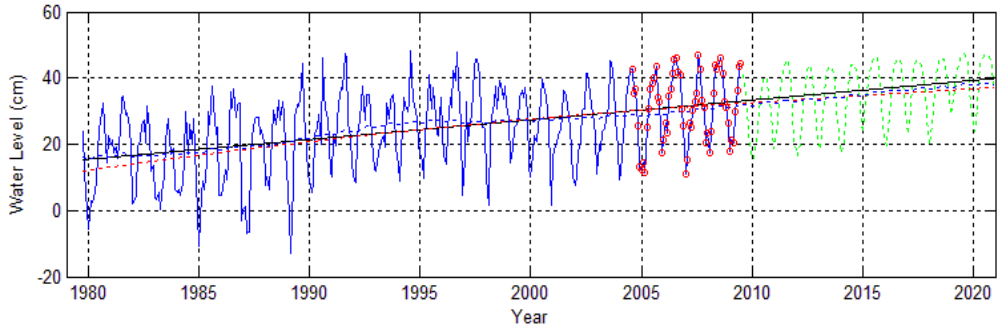
Level	Domain	Weighting	Index	Weighting
Vulnerability	Artificial Facilities	0.328	Relative ratio of seawall length	0.257
			Relative ratio of seawall height	0.499
			Relative ratio of tidal gate	0.244
	Environmental Geography	0.548	Elevation	0.139
			Slope	0.098
			Tidal range	0.086
			Rate of land subsidence	0.226
			Rate of coastal erosion	0.359
			Land use	0.093
	Socioeconomic	0.125	Population density	0.415
			The relative value of education	0.223
			The rate for giving support to the elder	0.166
			Enterprise return	0.196

PS：C.R. = 0.02 < 0.1

Results - The estimation of sea level trends

Methods of the estimate

1. **Regression analysis**
2. **Fourier series decomposition**
3. **EEMD method**
4. **Artificial Neural Network**
5. **Satellite data analysis**



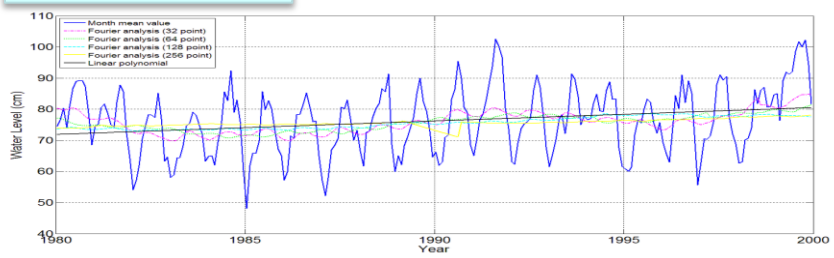
The analysis of sea level in southwest coast of Taiwan

Results - The estimation of sea level trends

◘ In 2039, the prediction of mean sea rise in southwest coast of Taiwan

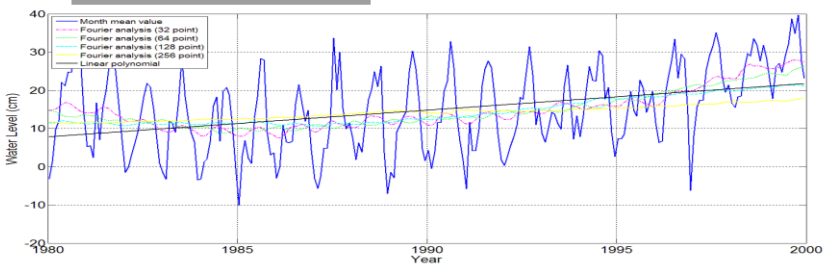
➢ Comparison of measured data by FFT and regression analysis

• Kaohsiung



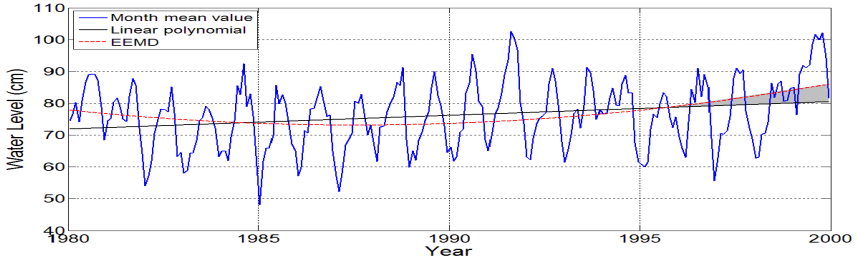
• Xunguangzui

Unit: cm

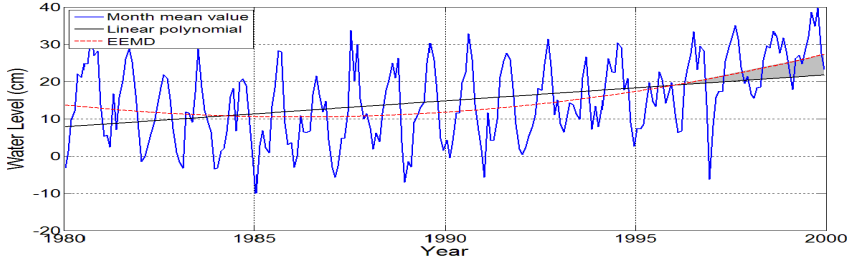


➢ Trend prediction of the regression analysis and EEMD method

• Kaohsiung



• Xunguangzui

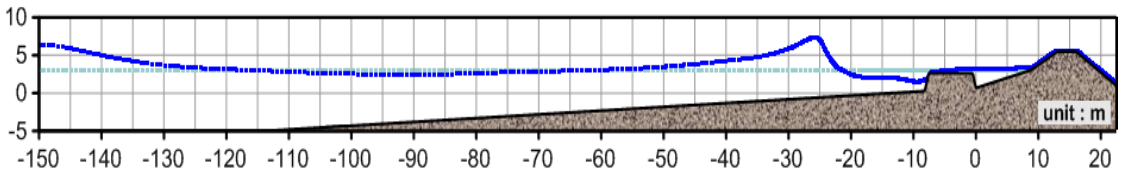


Tidal Station	Base Period	Regression	FFT	EEMD	Average
Kaohsiung	**1980-1999**	8.57	7.84	8.20	**8.20**
Xunguangzui	**1980-1999**	13.91	15.54	13.60	**14.35**

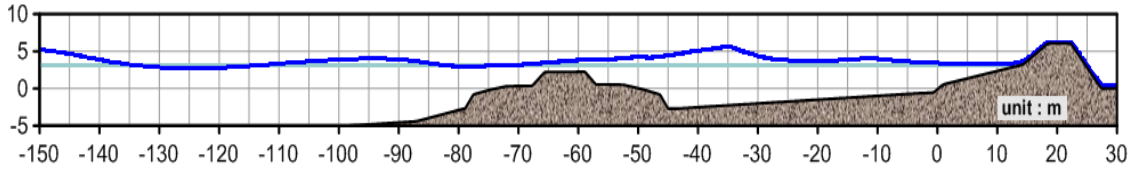
Results - The environmental factor of run-up and over-topping analysis in southwest coast

- **The wave run-up model simulates the wave form evolution with sea level rise from 2020 to 2039 when the 250-years return period typhoon wave attacks the southwest coast.**

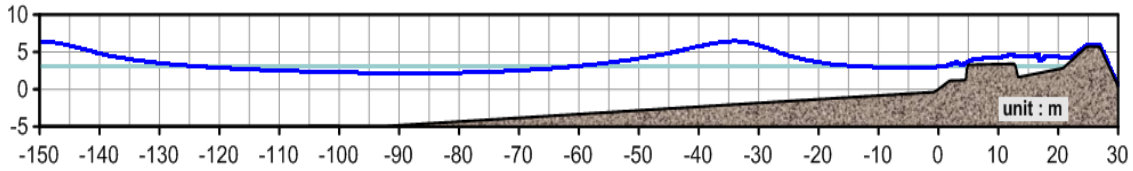
Mituo Dist., Kaohsiung City
250-yesrs return period
Deep wave height 10.75m, period 13.6s
Tide level 2.75m



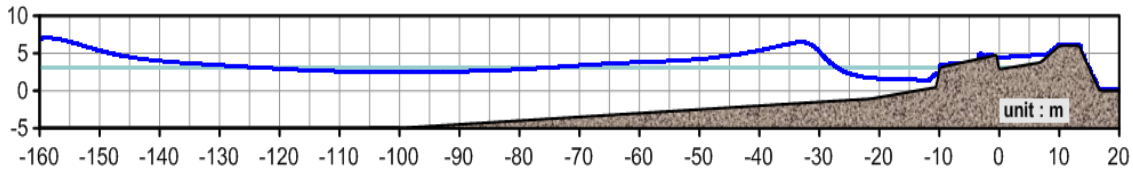
Shuili Village, Pingtung County
250-yesrs return period
Deep wave height 9.94m, period 13.1s
Tide level 2.91m



Fangliao Township, Pingtung County
250-years return period
Deep ave height 10.27m, period 13.3s
Tide level 2.88m



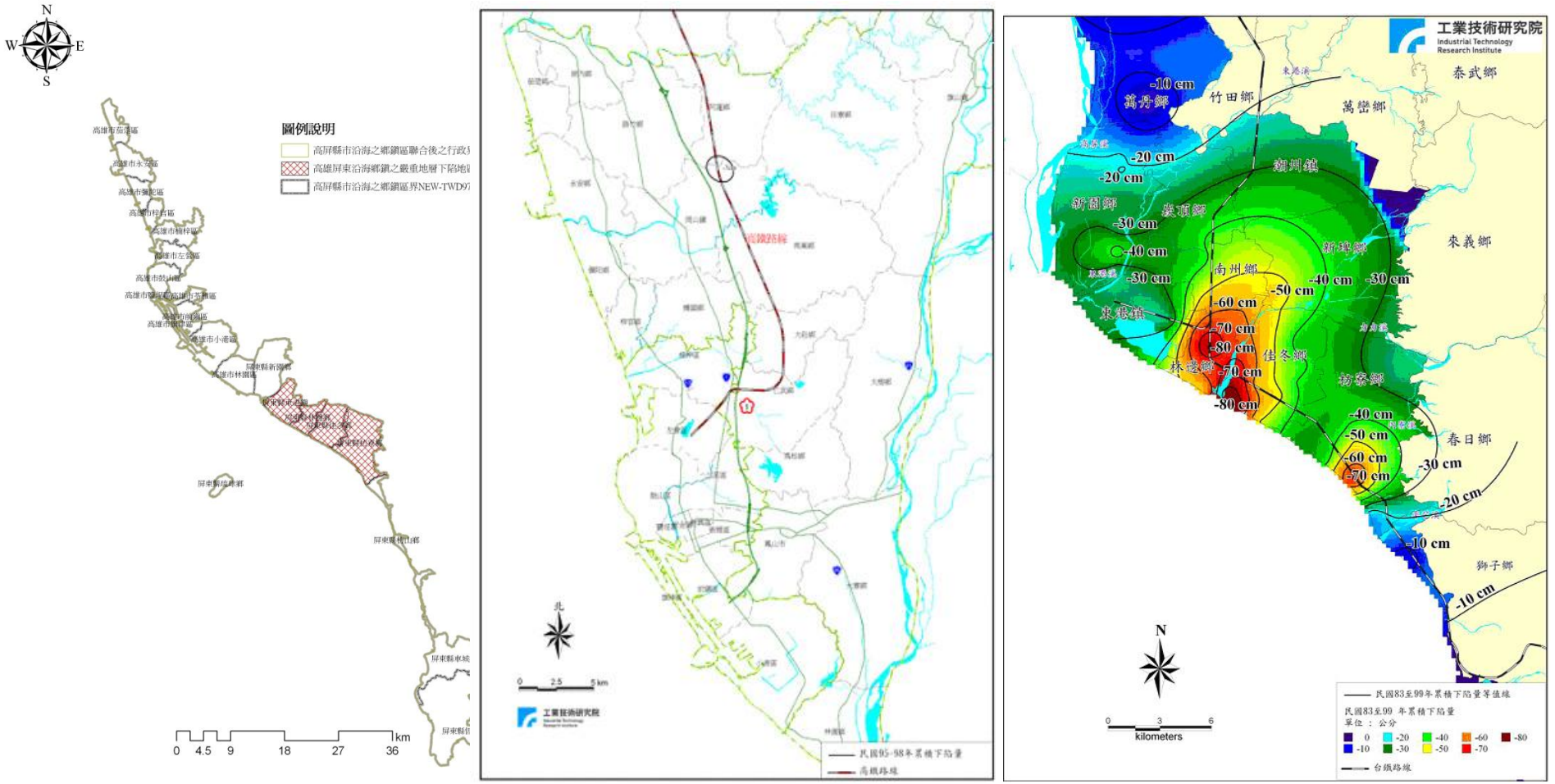
Fangshan Township, Pingtung County
250-years return period
Deep ave height 10.27m, period 13.3s
Tide level 2.88m



PS：**Sea level rise 0.59m from 2020 to 2039 (the most serious scenario)**

Results - Subsidence Area

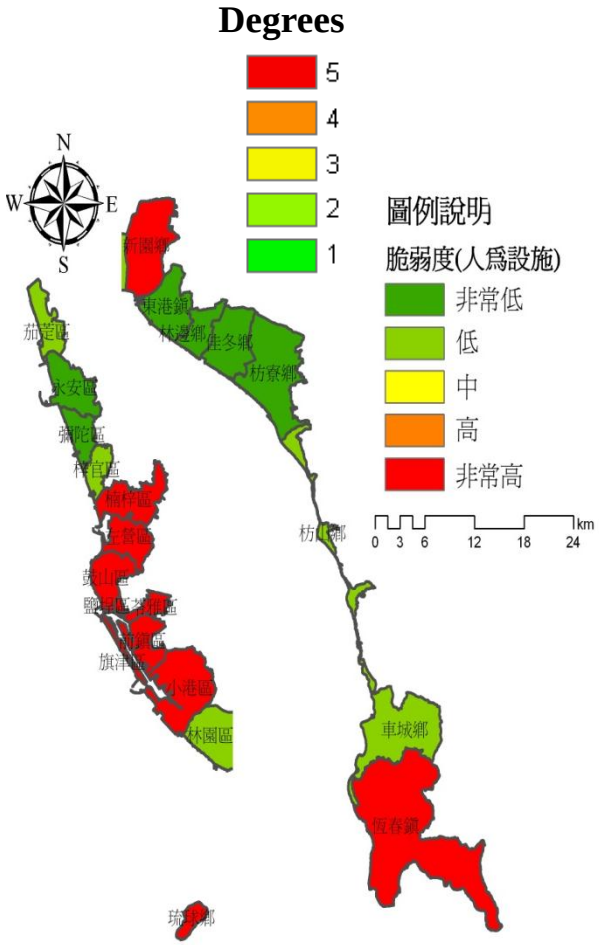
- **Subsidence Area**



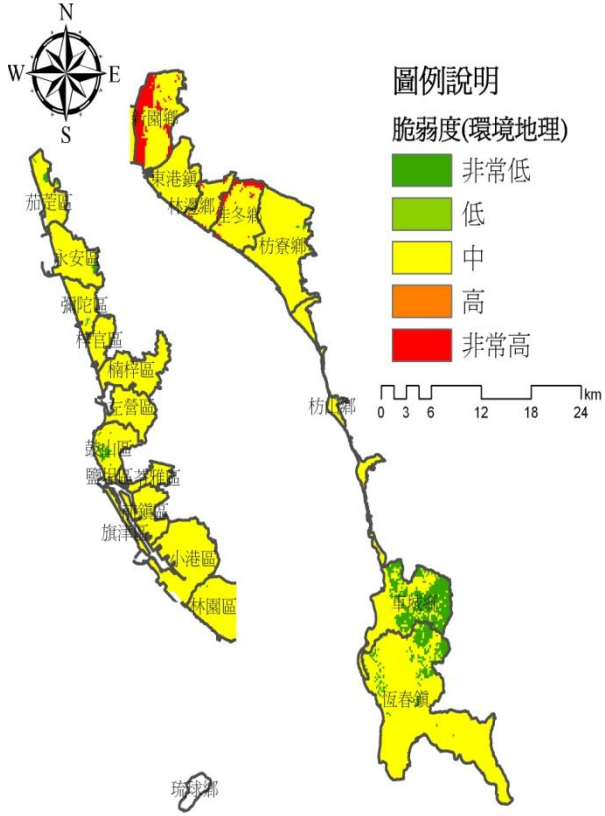
Severe Subsidence Area **Kaohsiung, form 1991 to 2009** **Pingtung, form 1994 to 2010**

Results – Vulnerability Analysis

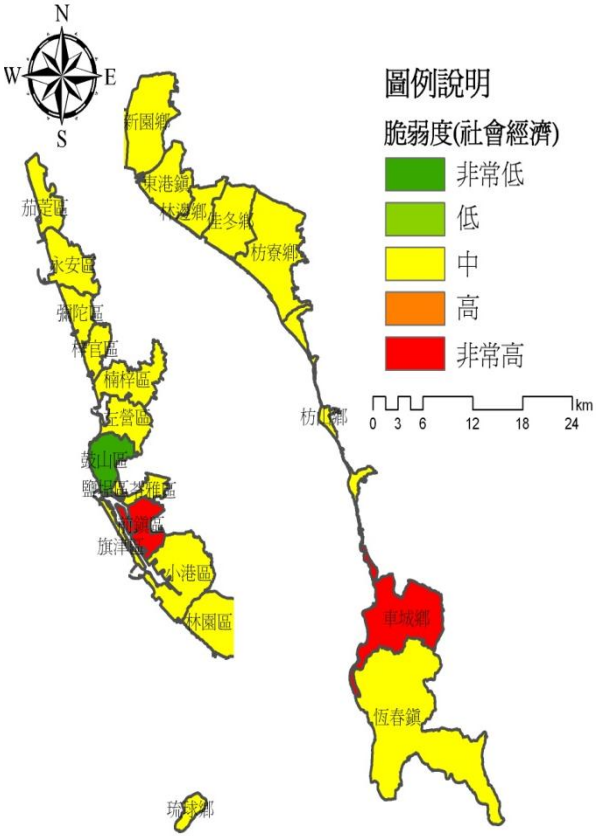
- **The results of vulnerability analysis of three domains of Kaohsiung and Pingtung coastal area - (present & equal weighting)**



(a) Artificial facilities



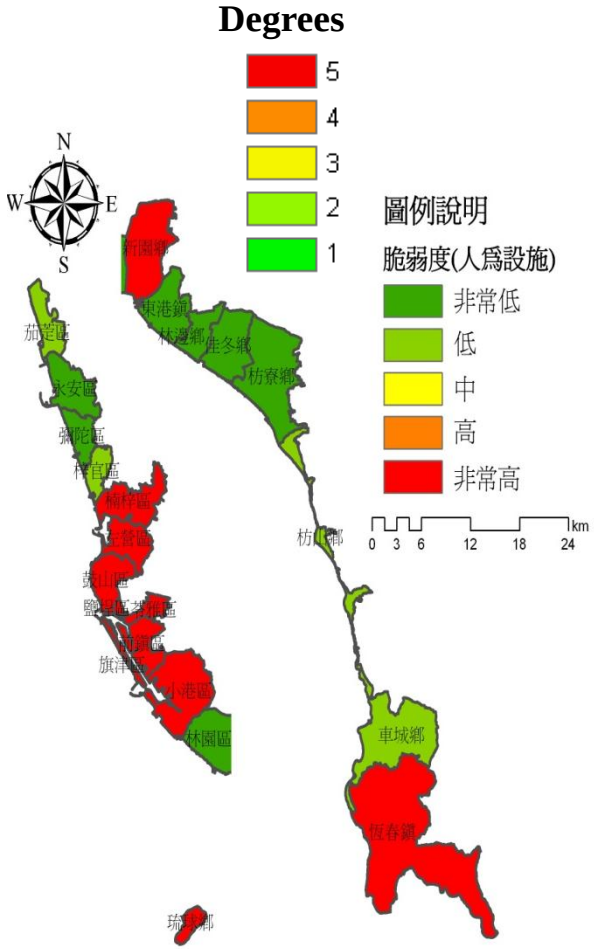
(b) Environmental Geography



(c) Socio-economic

Results – Vulnerability Analysis

- **The results of vulnerability analysis of three domains of Kaohsiung and Pingtung coastal area - (present & AHP weighting)**



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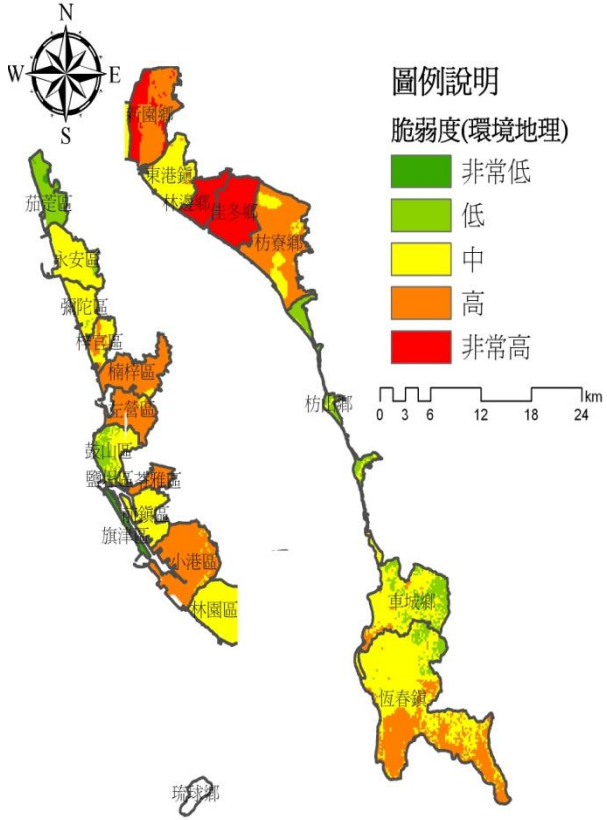

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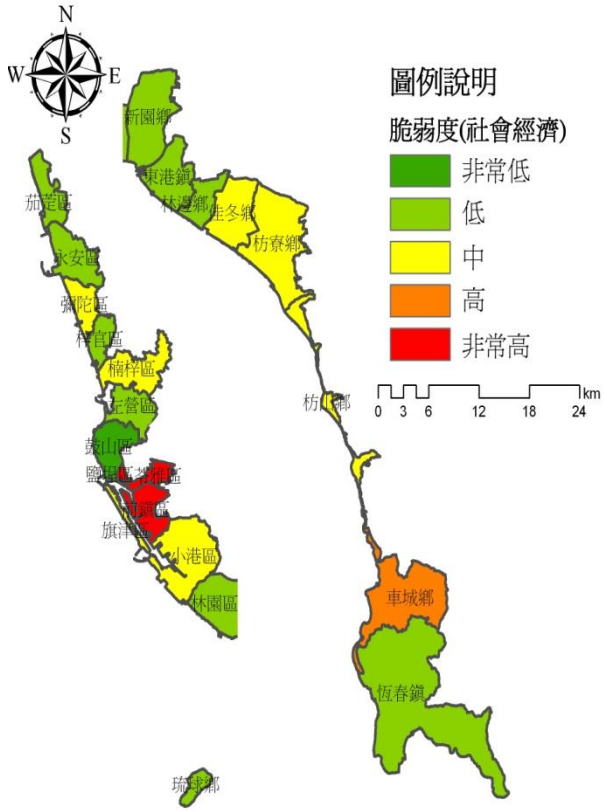
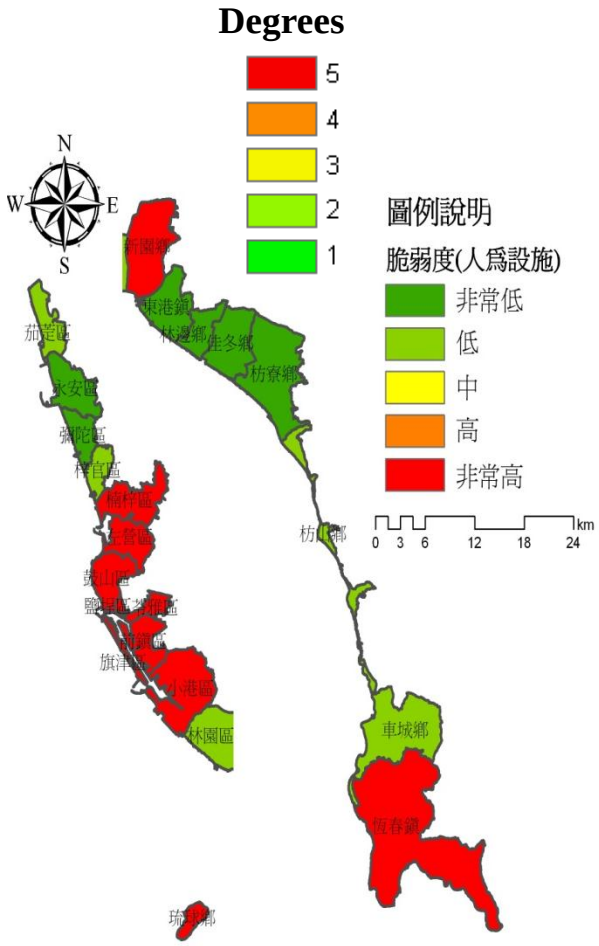


(c) Socio-economic

Results – Vulnerability Analysis

- **The results of vulnerability analysis of three domains of Kaohsiung and Pingtung coastal area - (scenario & equal weighting)**



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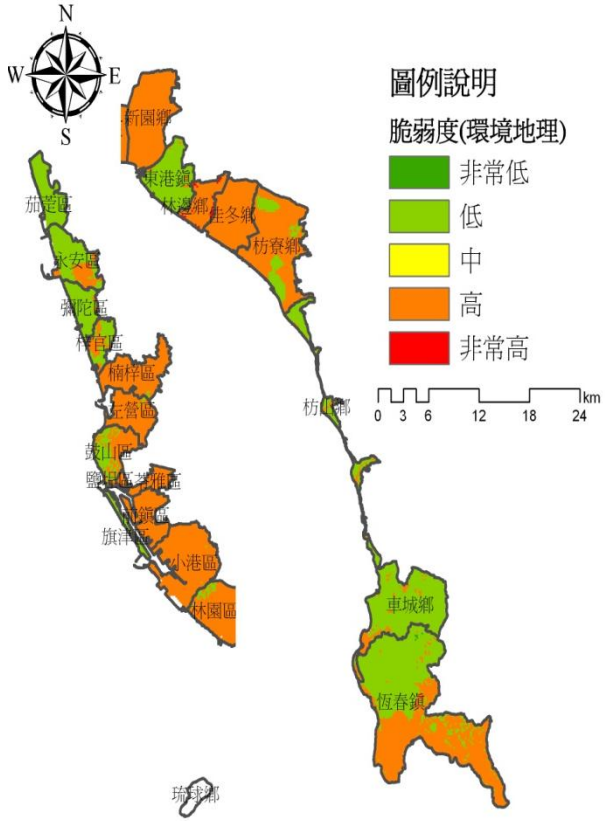

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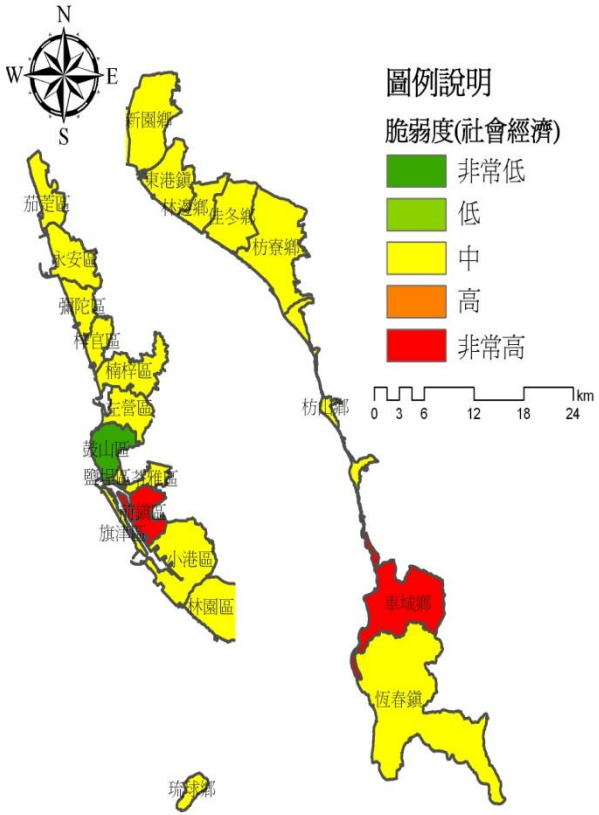
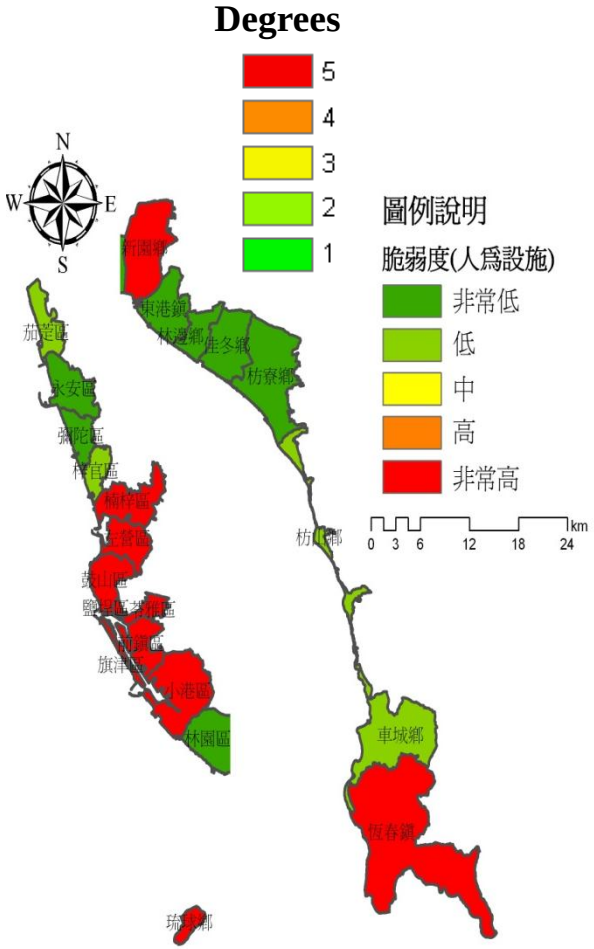


(c) Socio-economic

Results – Vulnerability Analysis

- **The results of vulnerability analysis of three domains of Kaohsiung and Pingtung coastal area - (present & AHP weighting)**



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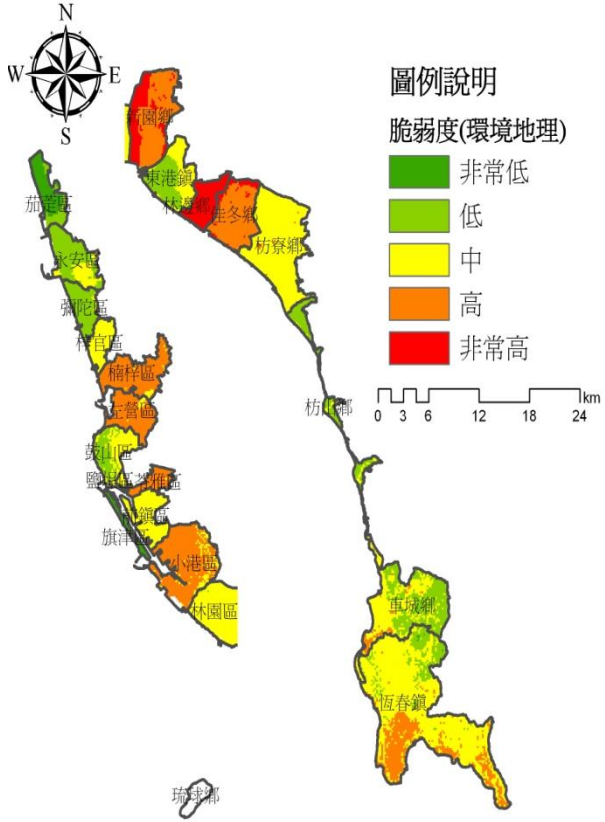
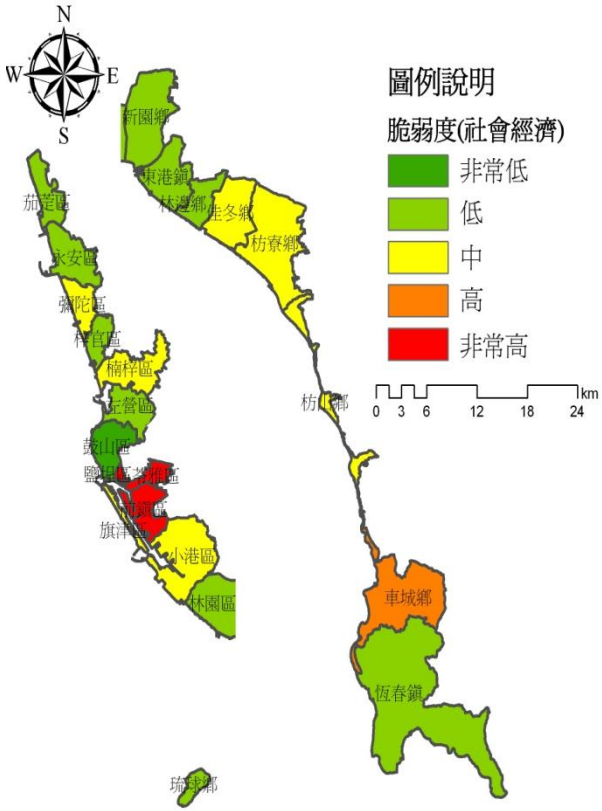


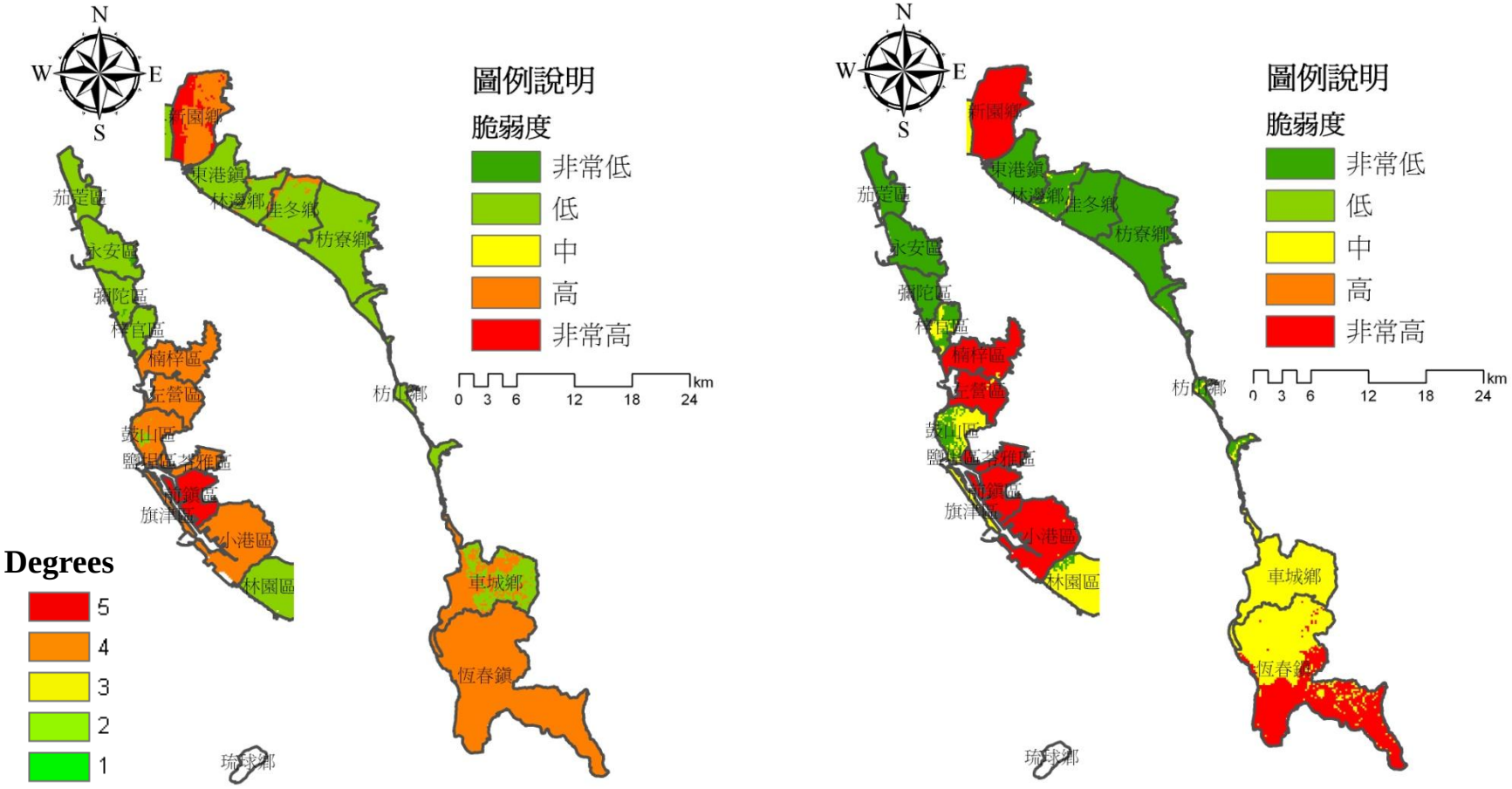
(b) Environmental Geography



(c) Socio-economic

Results – Vulnerability Analysis

- **The result of vulnerability analysis of Kaohsiung and Pingtung coastal area - (equal weighting)**

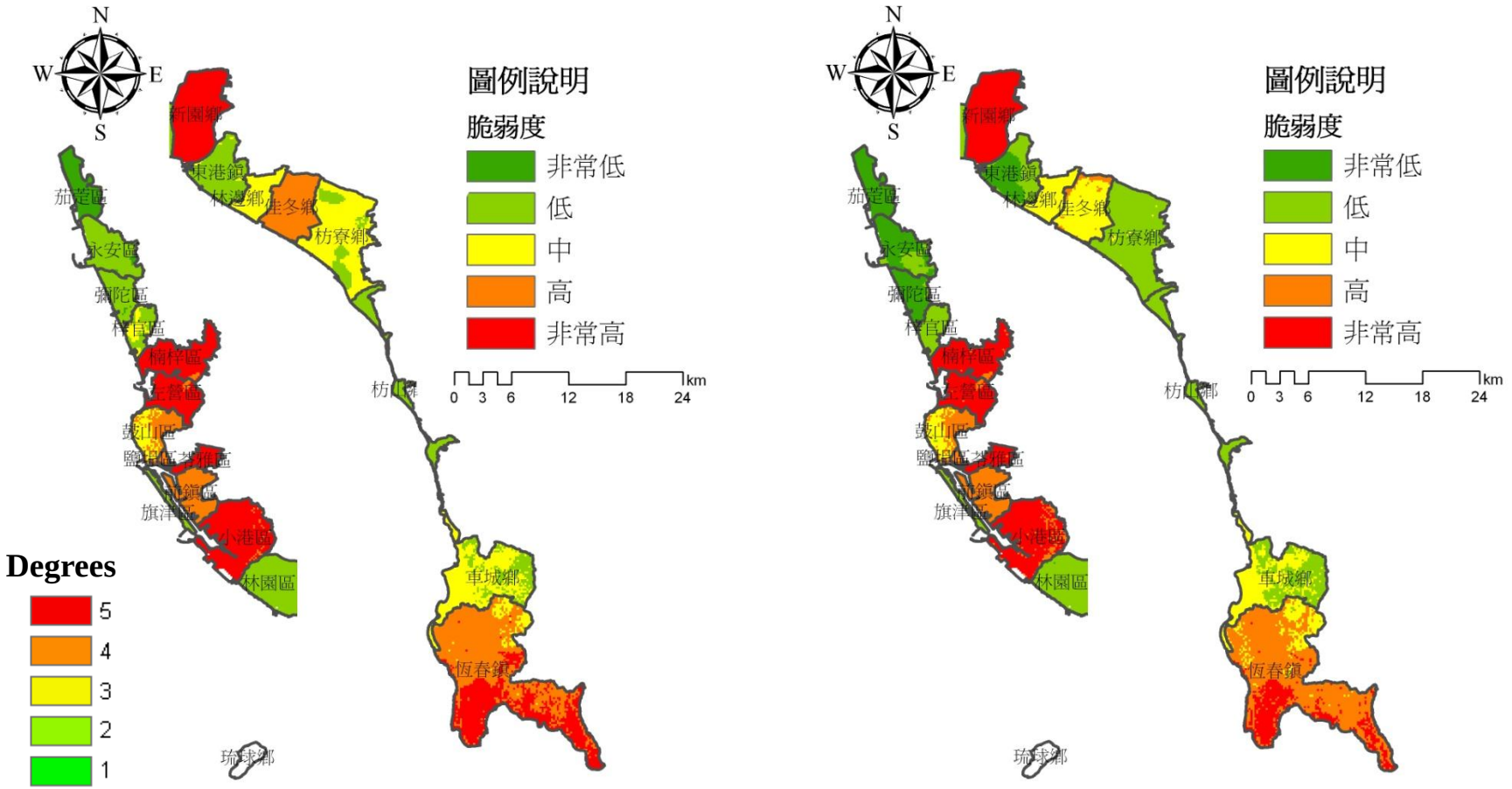


(a) Present & equal weighting

(b) Scenario & equal weighting

Results – Vulnerability Analysis

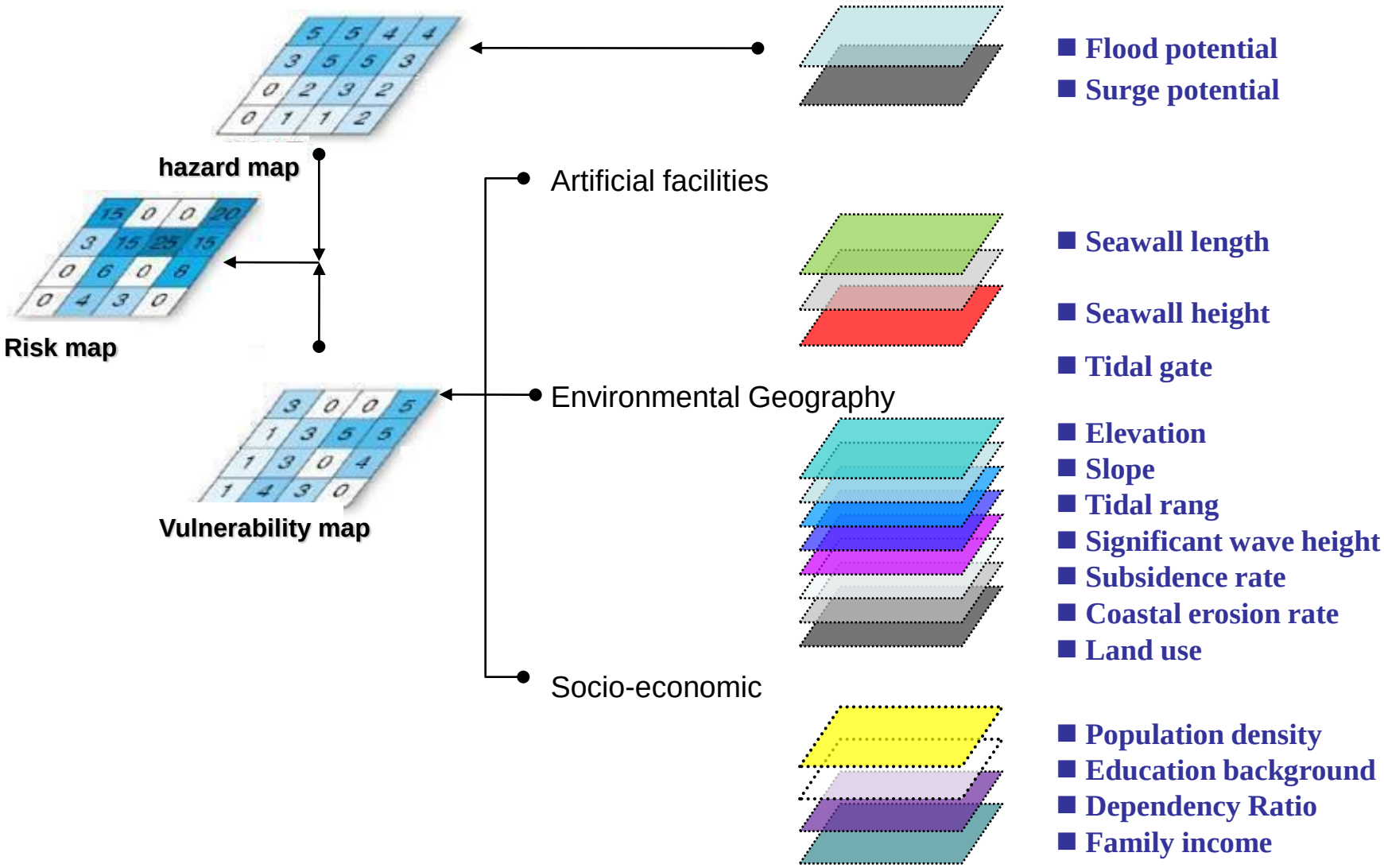
- **The result of vulnerability analysis of Kaohsiung and Pingtung coastal area - (AHP weighting)**



(a) Present & AHP weighting

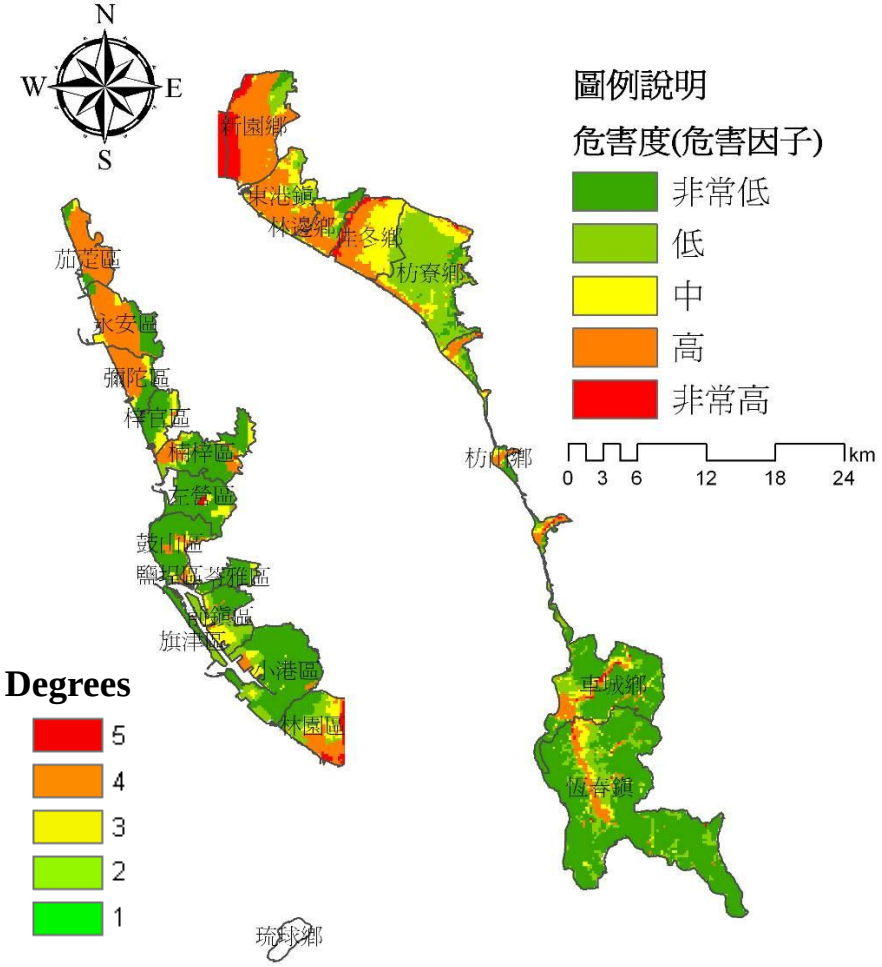
(b) Scenario & AHP weighting

Coast Disaster Risk Assessment

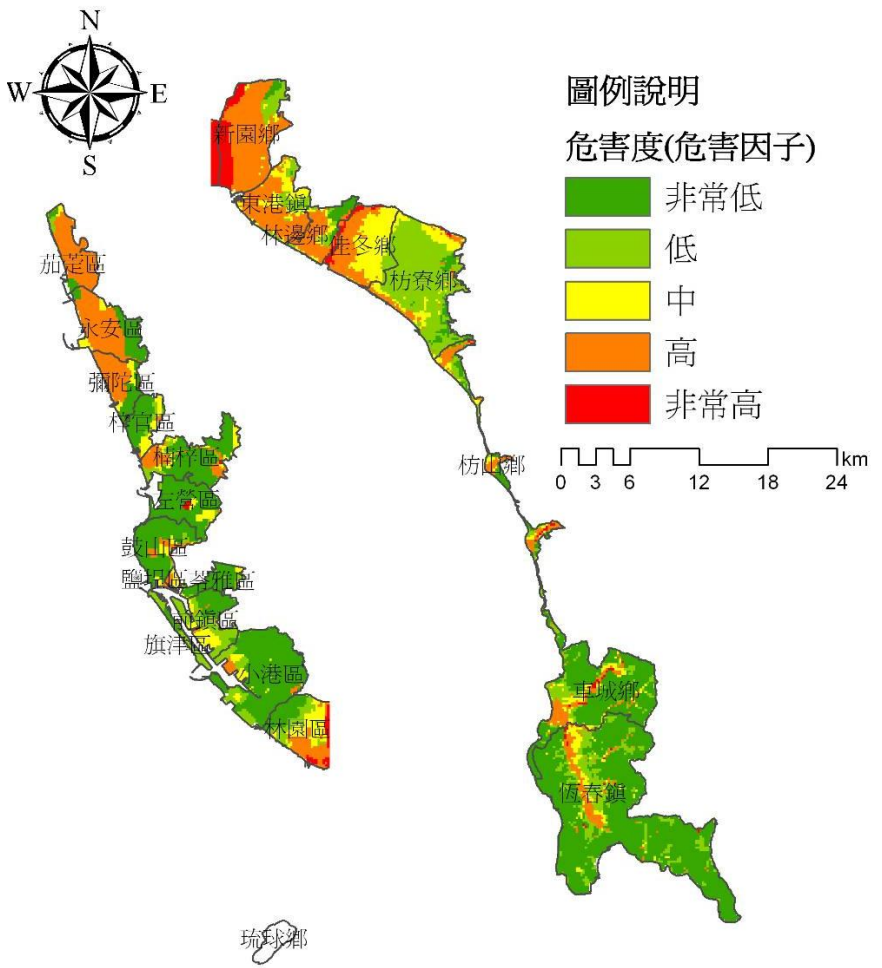


Results - The risk assessment of coastal disaster because of climate change

- Hazard factor - (equal weighting)



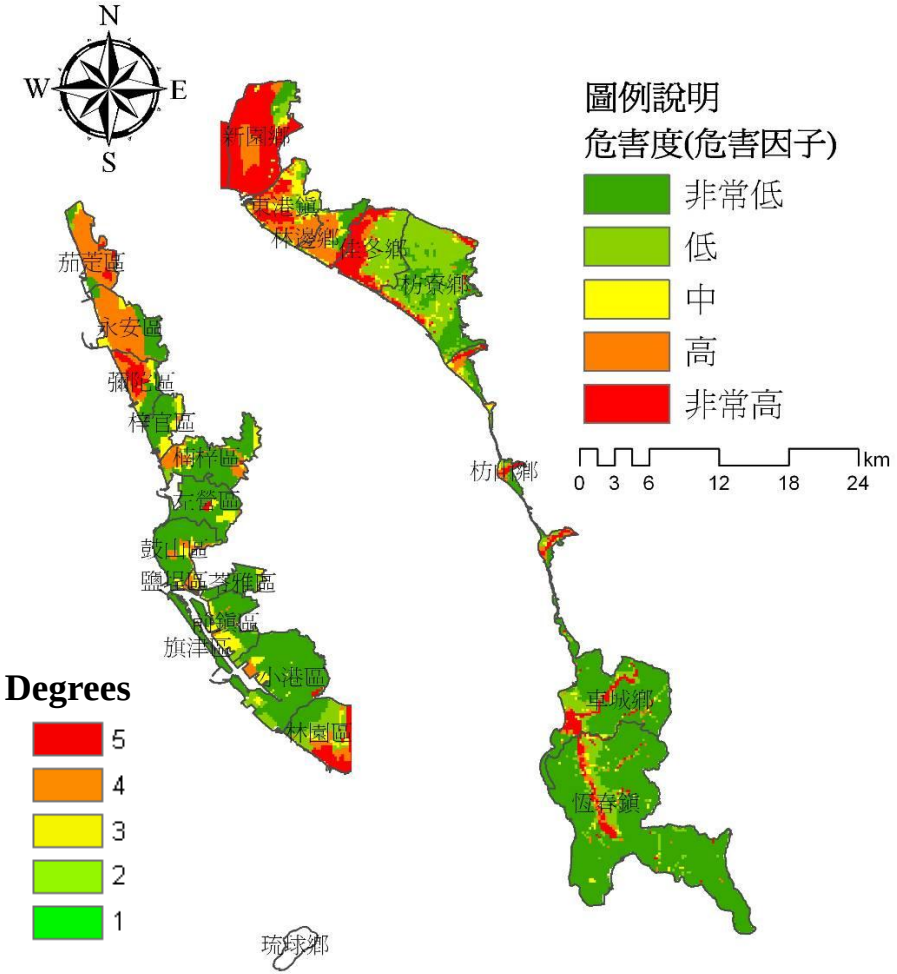
(a) Present & equal weighting



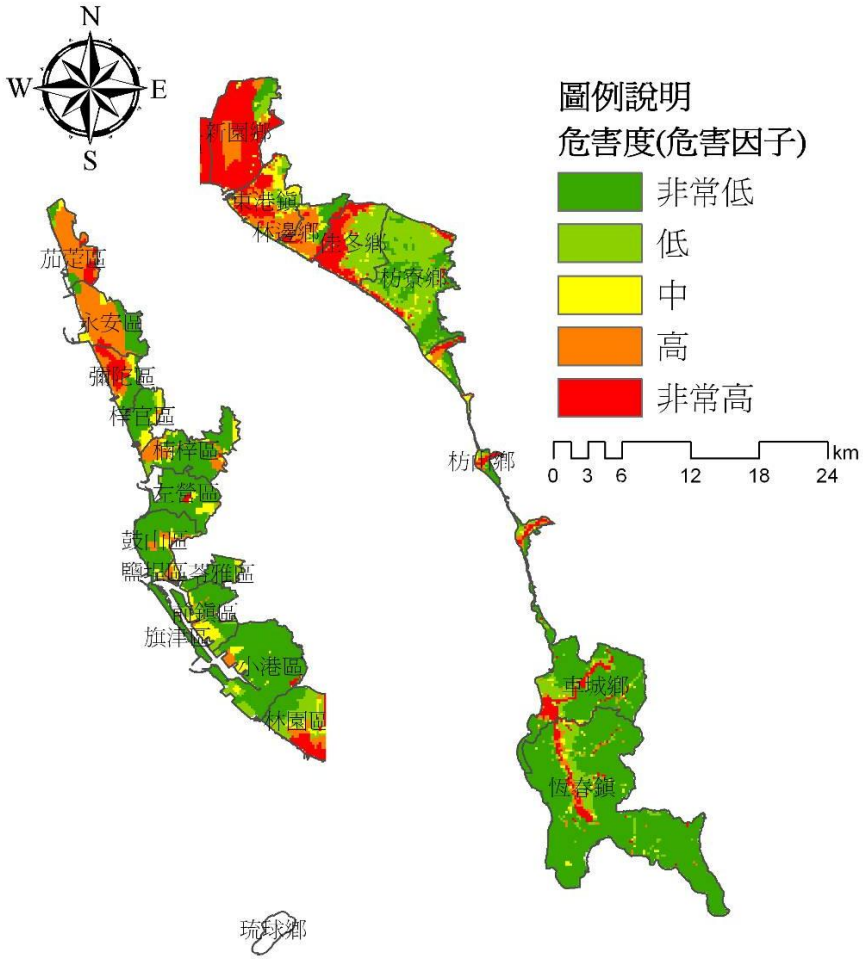
(b) Scenario & equal weighting

Results - The risk assessment of coastal disaster because of climate change

- Hazard factor - (AHP weighting)



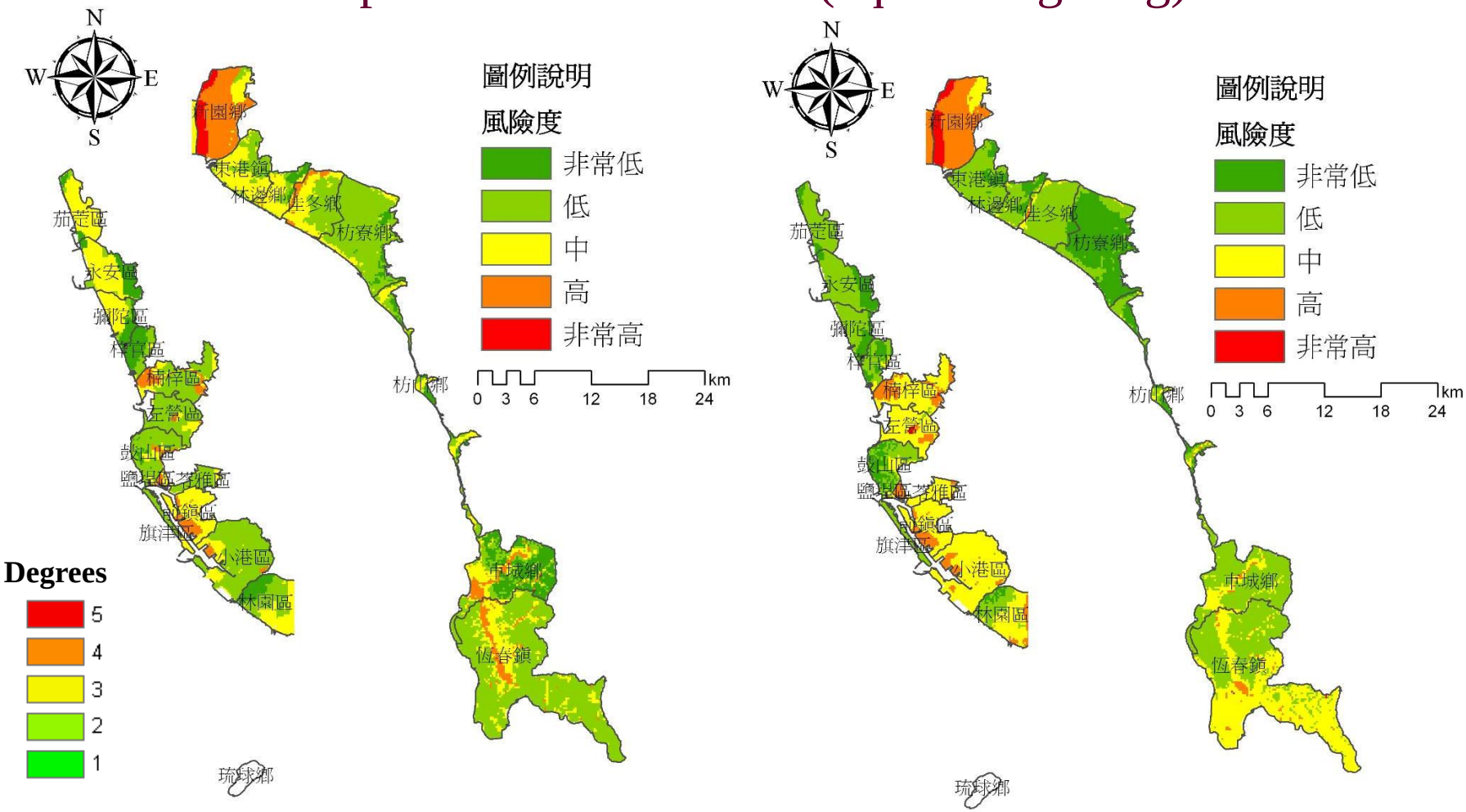
(a) Present & AHP weighting



(b) Scenario & AHP weighting

Results - The risk assessment of coastal disaster because of climate change

- The risk map of coastal disaster - (equal weighting)

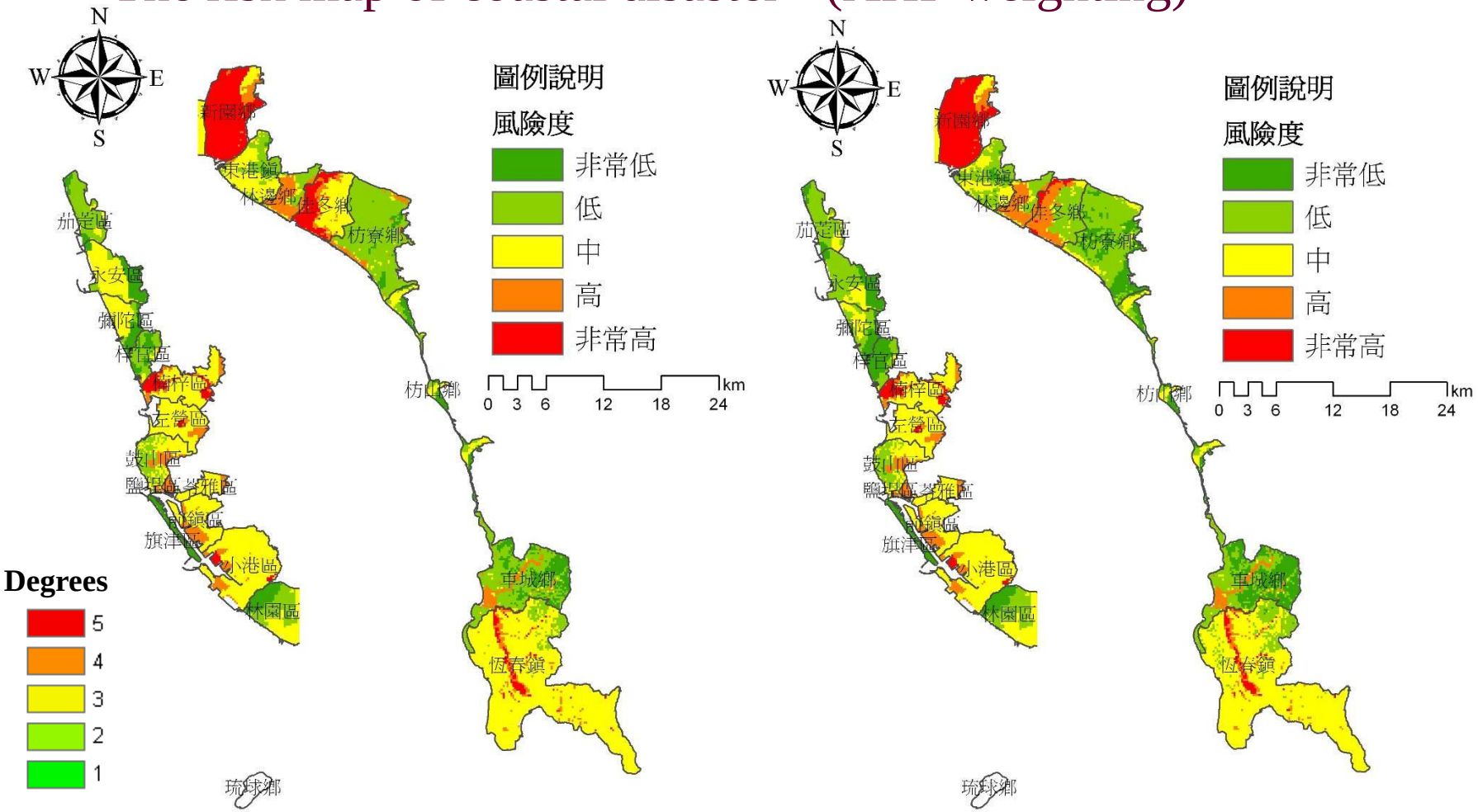


(a) Present & equal weighting

(b) Scenario & equal weighting

Results - The risk assessment of coastal disaster because of climate change

- The risk map of coastal disaster - (AHP weighting)



(a) Present & AHP weighting

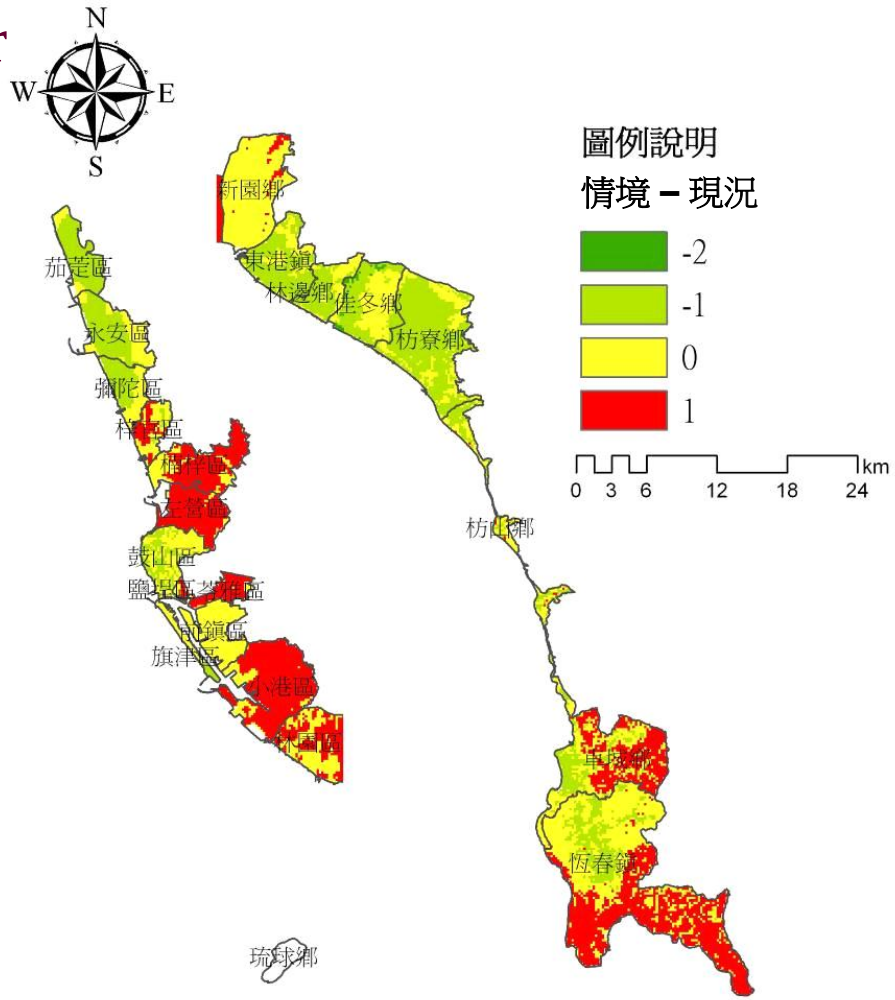
(b) Scenario & AHP weighting

Results - The risk assessment of coastal disaster because of climate change

- The risk map of coastal disaster

Area difference analysis of present coastal disaster risk and target year(2039) scenario

scenario – present (Degree)	Area difference (km^2)
-2	1.68
-1	177.32
0	246.72
1	191.8



The analysis result of difference between the present and the scenario

Results - Adaptive strategies and suggestion

- **Assessment of coastal vulnerability and disaster risk**

Kaohsiung City

Region	Vulnerability		Hazard Factor		Disaster Risk	
	Scenario (equal weighting)	Scenario (AHP)	Scenario (equal weighting)	Scenario (AHP)	Scenario (equal weighting)	Scenario (AHP)
Qieding Dist.	1	1	1、3	1~4	1~3	1~3
Yongan Dist.	1	1、2	1、3	1~4	1~3	1~3
Mituo Dist.	1	1、2	1、3	1~4	1~3	1~3
Ziguan Dist.	1、3	2	1、2	1、2	1、2	1~3
Nanzi Dist.	3、5	4、5	2~4	2~5	3~5	3~5
Zuoying Dist.	3、5	4、5	2~4	2~5	3~5	3~5
Gushan Dist.	1、3	3、4	2~4	2~5	1~3	2~4
Yancheng Dist.	5	4、5	3、4	4、5	4、5	4、5
Lingya Dist.	5	5	2、3	2、3	3、4	3、4
Qianzhen Dist.	5	4	3、4	3、4	3、4	3~5
Qijin Dist.	3	2	2、3	2、3	2、3	2、3
Xiaogang Dist.	3、5	4、5	3~5	3~5	3~5	3~5
Linyuan Dist.	1、3	2	2、3	1~4	1~4	1~3

Degree: 1 - very low, 2 – low, 3 - medium, 4 – high, 5 – very high.

Results - Adaptive strategies and suggestion

- **Assessment of coastal vulnerability and disaster risk**

Pingtung county

Region	Vulnerability		Hazard Factor		Disaster Risk	
	Scenario (equal weighting)	Scenario (AHP)	Scenario (equal weighting)	Scenario (AHP)	Scenario (equal weighting)	Scenario (AHP)
Xinyuan Township	5	5	2~5	1~5	3~5	3~5
Donggang Township	1	1、2	2、3	1~4	1~3	1~3
Linbian Township	1、3	3	2~4	2~5	1~4	2~4
Jiadong Township	1	3、4	1~4	1~5	1~3	3~5
Fangliao Township	1	2、3	1~4	1~4	1~3	1~3
Fangshan Township	1、3	3	1~4	1~5	1~4	1~3
Checheng Township	3	2、3	2~5	2~5	2~4	1~4
Hengchun Township	3、5	3、4	2~5	2~5	2~5	1~5

Degree: 1 - very low, 2 – low, 3 - medium, 4 – high, 5 – very high.

Conclusions

1. In respect to the trend estimation of sea level rise, Three different numerical methods were used to analyze the change of sea level rise in southwest coastal area of Taiwan. The result shows that the sea level rises are in the range of 8.2 to 14.35 cm from 2020 to 2039.
2. For the vulnerability of coastal hazard under climate change and risk assessment, this project studies on the economic lost of coastal area hazard, land use and the socioeconomic environmental investigation.

Conclusions

3. The impact analysis and risk assessment due to climate change can provide required data for adaptation capacity of coastal disasters due to climate change.

4. This project is lack of the sea meteorology data (typhoon wind field, typhoon wave, surge, sea level rise etc.) from such as NCDR etc.. The breaking wave and the wave are estimated by the available data. If NCDR can provide the full metrological data, we suggest that estimate can be kept going on for the vulnerability and risk analysis again for the consistence.