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ASSESSING THE LEVEL OF VULERABILITY DUE TO CLIMATE CHANGE IN EXTREMELY POOR COASTAL COMMUNES IN QUANG BINH, QUANG TRI, AND THUA THIEN HUE PROVINCES, VIETNAM

Ocena poziomu wrażliwości ze względu na zmianę klimatu w wyjątkowo ubogich gminach nabrzeżnych w prowincjach Quang Binh, Quang Tri i Thua Thien Hue w Wietnamie

Abstract: Climate change has been severely affected the lives of people in coastal areas of Vietnam, particularly in the poor communes in the Central region, namely Quang Binh, Quang Tri, and Thua Thien Hue. This report focuses on analyzing and assessing the vulnerability caused by climate change in the extremely poor communes in Quang Binh, Quang Tri, and Thua Thien Hue province, including five levels: Very low, low, medium, high, very high. Through the IPCC vulnerability assessment method, which includes three components: exposure, sensitivity, and adaptive capacity, the results in the study area showed that the medium level accounted for 19.64%, the high level accounted for 30.48%, and the very high level made up 37.35% of the area.

Key words: vulnerability, climate change, coastal, Vietnam

INTRODUCTION

Currently, "vulnerability" has been defined in various ways, so the use of concepts related to this has not been agreed. Vulnerability often occurs with natural hazards such as floods, droughts, and social risks such as poverty, diseases… This concept is widely used in climate change to represent the amount of damage an area is likely to suffer from the effects of climate change. There have been many studies on Vulnerability all over the world. The viewpoints of Vulnerability also differ among

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scientists: Chamber (1983) believes that Vulnerability has two sides: On the one hand, there are some external risks that individuals or households suffering from the effects of climate change; and on the one hand, it is about the internal aspect: the inability of protection, which means that they lack means to cope with the climate change. O'brien and Mileti (1992) concluded that people's resilience to the impacts of climate change on the environment, resources, and health of the population plays an essential decisive role in Vulnerability. Blaikie *et al.* (1994) defined Vulnerability as the characteristics of an individual or a group of people in terms of their ability to anticipate, cope with, withstand and recover from the effects of natural hazards. Vulnerability can be assessed through tolerance and sensitivity.

Meanwhile, Watson *et al.* (1996) believe that Vulnerability can be regarded as degree to which climate change can damage or damage a system. According to Adger (1999), Vulnerability is the degree to which a natural or social system is vulnerable to climate change. And Kasperson (2001) argues that Vulnerability is the degree of Vulnerability to damage from the impacts of a disturbance or stress and lack of capacity or measures to deal with, restore or adapt mechanically copies to become a new system or will be lost forever. The United States Environment Protection Agency (USEPA) (2006) defines the Vulnerability of a system as the extent to which the system is lost under certain external or internal pressure.

In Intergovernmental Panel on Climate Change reports (IPCC), this concept is still used differently from time to time. IPCC has introduced different concepts of vulnerability to climate change (IPCC 1992; IPCC 1996; IPCC 2001). In 2007, the IPCC's Fourth Report (AR4) defined vulnerability to climate change impacts as the extent to which a system is sensitive or unable to withstand the harmful effects of climate change, including climatic fluctuations and extreme climatic phenomena. Vulnerability is a function of the characteristics, intensity, and extent (extent) of the climate changes and fluctuations to which the system is exposed and the system's sensitivity and adaptive capacity (IPCC 2007). By 2014, IPCC's 5th Assessment Report (AR5) on climate change had analyzed and supplemented details on impacts, adaptation and vulnerability to climate change impacts. According to this new definition, when adaptation measures are strengthened, vulnerability is gradually reduced.

It can be seen that there have been several definitions of vulnerability given by scientists and research organizations. The report of IPCC (2007, 2014) showed the universality of the indicators affecting the vulnerability and allowed us to quantify research results, so we selected and applied.

The Vietnamese government regulates especially difficult coastal communes to have the following criteria: Having a poverty rate of 15% or more or a poor household of 10% or more according to the multidimensional poverty line in the period. 2021–2025; Missing at most minuscule 02 infrastructure works to access essential social services, serving the people's livelihood or more; Communes meeting at least 15 criteria for new rural areas.

From 2021 to 2025, the Prime Minister of VietNam has decided on the communes with particular poor in Vietnam. Especially difficult coastal communes in Quang Binh, Quang Tri, and Thua Thien Hue provinces, Vietnam, with a total natural area of 898.24 km², including 51 communes in 13 districts and towns. The terrain is mainly sand dunes and a small plain. The soil includes mainly white sand, sandy soil, and alluvial soil. Monsoon humid tropical climate, with a relatively cold winter (Son *et al.* 2017). The population in 2019 was 272,437 people, accounting for 10.59% of the total population in the province of Quang Binh, Quang Tri, and Thua Thien Hue, Vietnam. Agricultural production is considered the main income of their lives. We use the term "extremely poor communes" because these communes are identified by the Vietnamese government in the period 2021–2025 as disadvantaged areas that need supportive policies. We identified this area for study because it is the economically poor coastal region most affected by climate change.

Located in the transitional boundary of Vietnam's northern and southern natural geographic regions, the Quang Binh, Quang Tri, and Thua Thien Hue provinces are the most sensitive and vulnerable to climate change. (Son *et al.* 2013; Son *et al.* 2014). In recent years, the coastal natural resources

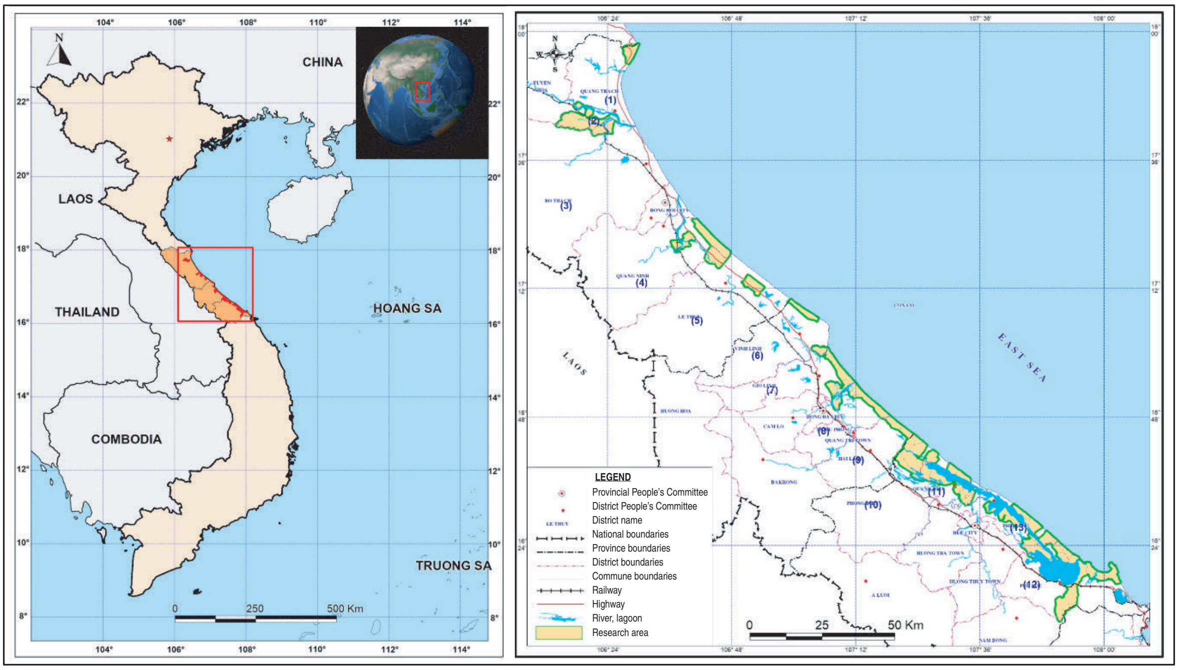


Figure 1. Study area location
Source: Institute of Geography, Vietnam Academy of Science and Technology.
Ryc. **1**. Lokalizacja obszaru badań
Źródło: Instytut Geografii, Wietnamska Akademia Nauki i Technologii.

and environment in Quang Binh, Quang Tri, and Thua Thien Hue provinces have been damaged, depleted and seriously threatened people's livelihoods. Risks from natural disasters such as storms, floods, high waves have broken the bank, causing erosion, saltwater invading inland, long-term heat and heat have made the groundwater level low, causing widespread droughts (Son *et al.* 2016). All of this has made people in extremely poor communes in the coastal areas of Quang Binh, Quang Tri, and Thua Thien Hue provinces encounter many obstacles, incredibly severely impacting the lives of thousands of people.

Based on the reality, to improve people's lives and develop sustainably socio-economic in coastal communes with extreme difficulties in the context of climate change impacts, it is necessary to have adaptive measures to limit the risks caused by this issue.

OBJECTIVES OF THE STUDY

The study aims to assess the vulnerability caused by the impacts of climate change in highly disadvantaged communes in the coastal areas of Quang Binh, Quang Tri, and Thua Thien Hue provinces of Vietnam. To the above goal, it is necessary to perform specific objectives:

– An overview analysis of research works on assessing vulnerability caused by climate change impacts in the world and Vietnam.

– Select a method and develop a set of criteria to assess the level of vulnerability caused by the impacts of climate change following the study area.

– Collect data, data related to criteria, variables belonging to the criteria.

– Building maps of variables, superimposed to form component maps and assessment maps of vulnerability caused by climate change impacts.

SELECTING INDICATORS AND DATA RESOURCES

Identifying assessment indicators

According to the IPCC (2007), vulnerability is a function of the characteristics, intensity, and magnitude of climate fluctuations to a system, its sensitivity, and resilience, including three components: Exposure (Exposure, Sensitivity and Adaptive Capacity, these are denoted by the formula: $V = f(E, S, AC)$.

In which:

- Exposure (E) can be considered direct hazards (e.g., stresses), the nature and scale of changes in climate variations in an area (e.g., temperature, precipitation, extreme weather hazards).
- Sensitivity (S) shows the extent to which social and environmental conditions affect the natural hazards to aggravate or lessen them.
- Adaptive Capacity (AC) Illustrates the applicability of adaptive solutions to prevent potential impacts.

Identifying variables in the assessment

a) Sensitivity variables (S – Sensitivity):

The sensitivity index shows the sensitivity of the research subject to the given criteria. The variables included in the assessment of the sensitivity index include four variables: access to traffic, the influence of residential areas, the result of industrial zones, and the degree of dependence on the community. The areas with the higher the parameters index show the more significant adverse effects, and the variables are evaluated through direct effects. So:

– For elements with the lowest possible index, that parameter (that class of information) is preserved during normalization, use formula (1).

– For the parameters with the index as high as possible, use formula (2) to inverse.

Access to traffic: Based on the traffic access variable, it is shown that the further from the road is, the lower the vulnerability is, and vice versa. The traffic access variables is based on land use status quo maps to separate road layers. Then, the distance value will be calculated, with a maximum value of 10 km.

Impact of residential areas: This means that the further from the production place to the residential area, the lower the vulnerability. The impact variable of the residential areas depends on land use status quo maps to separate the residential land layer, then calculate the distance with a value of 15 km.

Impact of industrial zones: This means that the further the production place to the industrial zone, the lower the vulnerability is. The construction of impact variables of industrial zones depends on land use status quo maps to separate industrial land layers. The distance is calculated with a value of 25 km.

Dependency level of community: The lower the level of dependence of the community on production, the lower the vulnerability is. Through criteria, the community dependency variable depends on the labor force, number of employees,/or total population. The higher this ratio shows, the greater community's dependence on production, the more susceptible and vulnerable.

b) Exposure variables (E – Exposure):

The detailed climate change scenario in 2016 was announced by the Ministry of Natural Resources and Environment of Vietnam. These are the latest scenarios announced by the Vietnamese government. Scenarios are built based on hydrometeorological data and sea level of Vietnam, updated to 2014; topographic data updated to March 2016; the latest method in the 5th Climate Assessment Report of IPCC; high-resolution global climate models and regional climate models; according to the method of detailed dynamics combined with statistical correction of model products. There are two climate change scenarios regarding temperature, precipitation, and sea-level rise: RCP 4.5 and RCP 8.5.

Sea level rises up to 2100: Medium sea-level rise to 2100 is 53 cm for the regions of Quang Binh, Quang Tri, and Thua Thien Hue, Vietnam (MONRE 2016). Then, the DEM elevation numerical model will be run to show the affected areas in 2100 (Table 1).

Table 1. Sea level rise according to the scenarios in the study area (cm)
Tabela 1. Wzrost poziomu morza zgodnie ze scenariuszami na badanym obszarze (cm)

Scenario	Milestones in the 21st century							
	2030	2040	2050	2060	2070	2080	2090	2100
RCP4.5	13 (8÷18)	17 (11÷24)	22 (14÷32)	28 (17÷39)	34 (20÷47)	40 (24÷56)	46 (28÷65)	53 (32÷75)
RCP8.5	13 (9÷18)	19 (13÷26)	25 (17÷35)	33 (22÷46)	41 (28÷58)	50 (34÷71)	61 (42÷86)	72 (49÷102)

Source: Ministry of Natural Resources and Environment 2016.
Źródło: Ministerstwo Zasobów Naturalnych i Środowiska 2016.

Change in temperature to 2100: By 2100, the temperature increase will be from 1.3–2.7°C; The most common growth was 1.9°C under the RCP 4.5 scenario in the study area (MONRE 2016) (Table 2).

Table 2. Change of annual medium temperature (°C) compared to the baseline period
Tabela 2. Zmiana średniej rocznej temperatury (°C) w porównaniu z okresem odniesienia

Scenario RCP 4.5			Scenario RCP 8.5		
2016–2035	2046–2065	2080–2099	2016–2035	2046–2065	2080–2099
0.7 (0.4÷1.1)	1.4 (0.9÷2.0)	1.9 (1.3÷2.7)	0.8 (0.6÷1.2)	1.9 (1.3÷2.6)	3.3 (2.6÷4.5)

Source: Ministry of Natural Resources and Environment 2016.
Źródło: Ministerstwo Zasobów Naturalnych i Środowiska 2016.

Change of rainfall up to 2100: By 2100, the increase in rainfall will be from 15.4 ÷ 38.1%; The most common increase was 26.2% according to the RCP 4.5 scenario in the study area (MONRE 2016) (Table 3).

Table 3. Change of annual medium rainfall (mm) compared to the baseline period
Tabela 3. Zmiana średnich rocznych opadów (mm) w porównaniu z okresem odniesienia

Scenario RCP 4.5			Scenario RCP 8.5		
2016–2035	2046–2065	2080–2099	2016–2035	2046–2065	2080–2099
17 (10.4÷23.6)	22.5 (10.7÷34.3)	26.2 (15.4÷38.1)	16.5 (9÷23.3)	18.6 (12.9÷23.9)	21.2 (13.8÷28.2)

Source: Ministry of Natural Resources and Environment 2016.
Źródło: Ministerstwo Zasobów Naturalnych i Środowiska 2016.

c) Adaptive Capacity variables (AC)

Slope indicator: Based on the slope variable, the lower the slope is, the higher the vulnerability is. The implementation of this variable is through the results of the numerical modeling of the DEM elevation in the study area (Son *et al.* 2019b).

Morphology: The morphology shows that the lower the morphology indicator is, the higher the lesion level is, and vice versa. The generation of morphological variation through information retrieval from the vegetation cover map in the study area (Son *et al.* 2019a).

Method of standardized variables

Variables used in the assessment are implemented differently, so it is essential to standardize the same quantity value. Standardized variables from 0 – 100 through the formula (WWF, 2013):

In terms of variables shown as low as possible, apply formula (1) to normalize:

$$\text{Standardized value} = \frac{\text{Standardized value} - \text{Min value}}{\text{Max value} - \text{Min value}} \times 100 \tag{1}$$

In terms of variables shown as high as possible, apply formula (2) to normalize:

$$\text{Standardized value} = 100 - \frac{\text{Standardized value} - \text{Min value}}{\text{Max value} - \text{Min value}} \times 100 \tag{2}$$

Method of determining weight

There are many methods of multi-indicator assessment, but we use the pairwise comparison method. Saaty (1980) developed the pairwise comparison method in an Analytical Hierarchy Process (AHP). The AHP approach approaches the problem in two ways: a systematic approach through hierarchical diagrams and a causal approach through pairwise comparisons. This method has the following basic steps:

a) A Pairwise comparison matrix:

Pairwise comparison matrix: is a square matrix with n rows and n columns (n is the number of indicators) representing the process of assigning numerical values to subjective comparisons of the importance of the needles.

This comparison is made between pairs of indicators. The element aij represents the importance of row i compared to the criterion of column j. The relative importance level of indicator i to j is calculated according to the ratio k from 1 to 9, in contrast of indicator j to i is 1/k. So aij > 0, aij = 1/aji, aii = 1.

Table 4. Pairwise comparison matrix
Tabela 4. Macierz porównań parami

Features	X_1	X_2	X_3	X_n
X_1	1	a_{12}	a_{13}	a_{1n}
X_2	a_{21}	1	a_{23}	a_{2n}
X_3	a_{31}	a_{32}	1	a_{3n}
X_n	a_{n1}	a_{n2}	a_{n3}	1
Total	A_1	A_2	A_3	A_n

Source: Saaty 1980.
Źródło: Saaty 1980.

b) Determine the weight

Standarized matrix: Normalize the importance of the criteria matrix by dividing each cell's value in a column by the total value of that column (Table 5).

Standarized matrix:

Medium weight (Wi): is calculated by taking the sum of the weight of Xi relative to Xj after normalization divided by n (Table5).

Table 5. Normalize and calculate the weight of the pairwise comparison matrix
Tabela 5. Normalizuj i oblicz wagę macierzy porównań parami

Features	X_1	X_2	X_3	X_n	**Weight (W)**
X_1	$1/A_1$	a_{12}/A_2	a_{13}/A_3	a_{1n}/A_n	W_1
X_2	a_{21}/A_1	$1/A_2$	a_{23}/A_3	a_{2n}/A_n	W_2
X_3	a_{31}/A_1	a_{32}/A_2	$1/A_3$	a_{3n}/A_n	W_3
X_n	a_{n1}/A_1	a_{n2}/A_2	a_{n3}/A_3	$1/A_n$	W_n
Total	**1**	**1**	**1**	**1**	1

Source: Saaty 1980.
Źródło: Saaty 1980.

Table 6. Weight of Indicators
Tabela 6. Waga wskaźników

No.	**Indicator**	**Weight (W_i)**	**Sub indicator**	**Sub weight**
1	**Sentivity Indicator (S)**	0.248	Access to traffic	0.303
			Impact of residential areas	0.248
			Impact of industrial zones	0.193
			Dependency level of community	0.256
2	**Exposure Indicator (E)**	0.438	Sea level rise up to 2100	0.331
			Change in temperature to 2100	0.358
			Change in rainfall to 2100	0.310
3	**Adaptive Capacity Indicator (AC)**	0.314	Slope	0.458
			Morphology	0.542

Source: author's own elaboration.
Źródło: opracowanie własne.

Calculation method of vulnerability indicator

a) Main Indicators (S, E, AC)

The results of sensitivity, exposure and adaptive capacity indicator are determined by the following formula:

$$\frac{\sum_{i=1}^{n} a_i A_i}{n} \quad (3)$$

In which: ai: is the weight No. I calculated by the sub indicators, AiL is the value of the standardized sub-indicator No. I; n: total number of sub indicators.

b) Vulnerability Indicator (V)

Formula (V) (4):

$$V = \frac{S + E + AC}{3} \quad (4)$$

RESULTS OF VULNERABILITY ASSESSMENT

Variables of Sentivity Indicator (S)

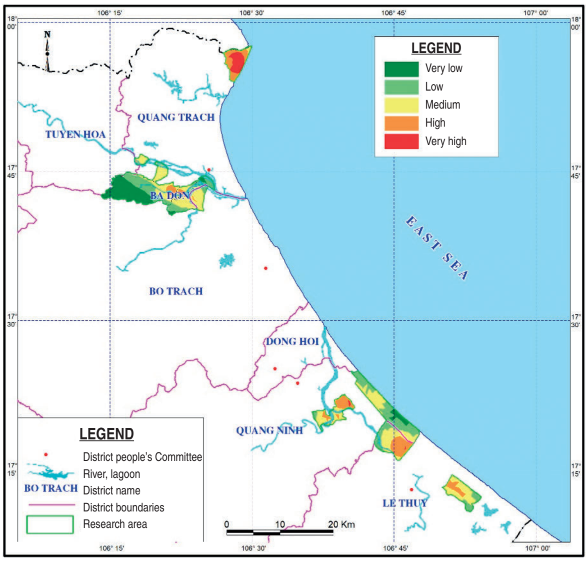
Sensitivity indicator shows the sensitivity of resources, environment, socio-economy to the given criteria. The areas in which indicator has higher parameters show a more significant negative impact on natural resources, environment, and socio-economy.

Table 7. Sensitivity indicator (S)
Tabela 7. Wskaźnik czułości (S)

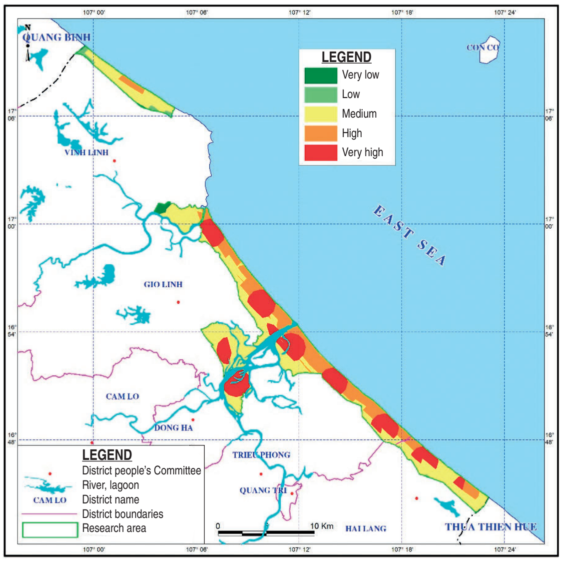
(Unit: ha)

No	District	Very low	Low	Medium	High	Very high	Total
1	Quang Trach	1672.46	92.64	199.81	202.57	39.37	2206.85
2	Ba Don town	6509.62	489.97	794.28	722.49	149.64	8666
3	Bo Trach	436.15	177.92	215.27	89.09	51.38	969.81
4	Quang Ninh	4322.51	291.81	608.56	665.65	126.1	6014.63
5	Le Thuy	3465.76	155.69	95.22	340.47	1054.77	5111.91
6	Vinh Linh	1623.5	16.08	98.63	489.81	0	2228.02
7	Gio Linh	1998.2	248.21	123.95	2436.01	76.65	4883.01
8	Trieu Phong	957.2	868.11	212.61	2596.56	1.69	4636.17
9	Hai Lang	1472.89	276.7	3.45	174.64	16.61	1944.28
10	Phong Dien	1.77	0.86	5744.31	4457.01	0	10203.95
11	Quang Dien	0	0	972.95	10153.16	0	11126.11
12	Phu Loc	751.38	3165.07	14157.01	0	0	18073.46
13	Phu Vang	0	0	14558.53	430.87	0	14989.41
Total		**23211.44**	**5783.06**	**37784.58**	**22758.32**	**1516.22**	**91053.6**
Rate (%)		**25.49**	**6.35**	**41.5**	**24.99**	**1.67**	**100**

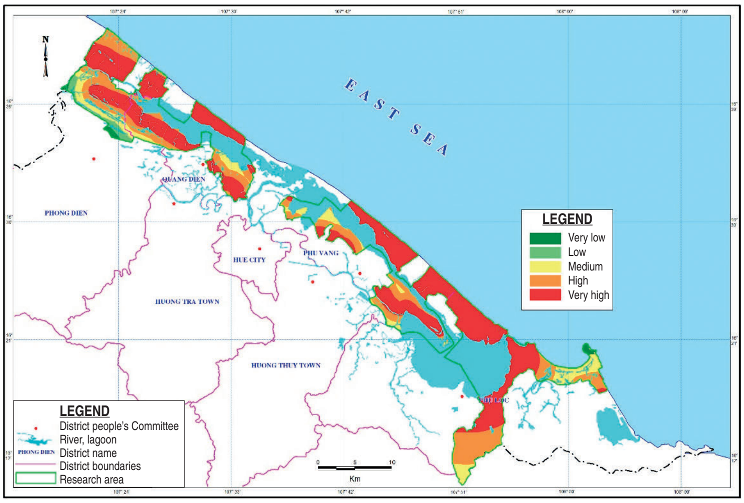
Source: Data from the Map of Sensitive Indicator (S).
Źródło: Dane z mapy wrażliwego wskaźnika (S).



a) Quang Binh



b) Quang Tri



c) Thua Thien Hue

Figure 2. Map of Sentivity Indicator (S)
Source: author's own elaboration.
Ryc. **2**. Mapa wskaźnika czułości (S)
Źródło: opracowanie własne.

The sensitivity indicator includes four indicators namely access to traffic, impact of residential areas, impact of industrial zones, dependency level of community. This indicator in assessing the level of vulnerability at a very high-level accounts for 38.24% of the total natural area, including Quang Dong (Quang Trach district), Duy Ninh (Quang Ninh district), Hong Thuy (Le Thuy district) communes, all extremely poor communes in Gio Linh, Trieu Phong, Hai Lang, Phong Dien, Quang Dien, Phu Loc, Phu Vang. The sensitivity indicator at the high-level accounts for 25.31% of the total natural area; the medium level makes up 24.71%, the low-level accounts for 7.62%, and the very low-level accounts for 4.12% of the total area. Thus, 88.26% of the total natural area has a sensitivity indicator at a medium level or higher in the study area. This is an alarm signal that agricultural activities have a very high sensitivity towards traffic, residential areas, industrial zones, and communities in the study area (Table 7).

Variables of Exposure Indicator (E)

Sea level rise, changes in temperature, and rainfall are key indicators of climate change. The IPCC has demonstrated increased heat, increased rainfall leading to sea-level rise. Therefore, three main indicators are included to assess the vulnerability. Using a low medium emission scenario (RCP 4.5) in 2100 took into account the vulnerability assessment.

Table 8. Exposure Indicator (E)
Tabela 8. Wskaźnik ekspozycji (E)

(Unit: ha)

No	District	Very low	Low	Medium	High	Very high	Total
1	Quang Trach	1672.46	92.64	199.81	202.57	39.37	2206.85
2	Ba Don town	6509.62	489.97	794.28	722.49	149.64	8666
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10	Phong Dien	1.77	0.86	5744.31	4457.01	0	10203.95
11	Quang Dien	0	0	972.95	10153.16	0	11126.11
12	Phu Loc	751.38	3165.07	14157.01	0	0	18073.46
13	Phu Vang	0	0	14558.53	430.87	0	14989.41
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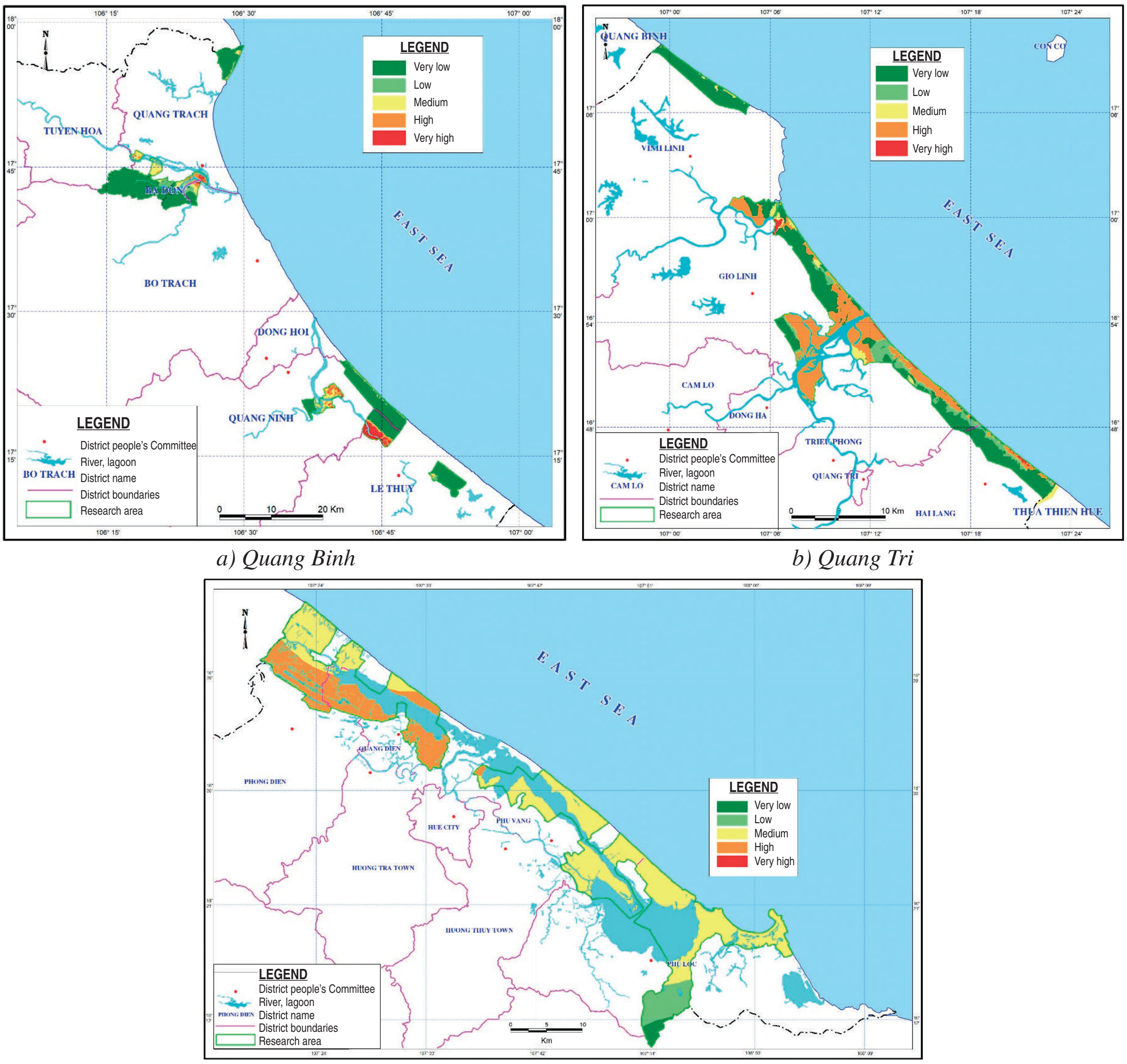
Rate (%)		**25.49**	**6.35**	**41.5**	**24.99**	**1.67**	**100**

Source: Data from Map of Exposure Indicator (E).
Źródło: Dane z mapy wskaźnika narażenia (E).

Exposure indicator includes three indicators, namely sea-level rise, temperature changes, and rainfall to 2100. In the study area, exposure indicator in assessing the level of damage in very high level accounts for 1516.22 ha (equivalent to 1.67% of the total natural area of the extremely difficult coastal communes in Quang Binh, Quang Tri and Thua Thien Hue province, focusing on the extremely poor communes in Quang Trach district, Quang Ninh, Hai Lang and Quang Minh, Quang Trung, Quang Van communes (Ba Don town), My Trach commune (Bo Trach district), Hong Thuy (Le Thuy district), Trung Giang commune (Gio Linh district), Trieu An, Trieu Van (Trieu Phong district); the high level is 22758.32 ha (equivalent to 24.99% of the total natural area); the largest medium accounts for 41.5% of the total natural area of the extremely difficult coastal communes in Quang Binh, Quang Tri and Thua Thien Hue province, Vietnam (with an area of 37758.32 ha), a low level accounts for 6.35% of the total natural area (area 5783.0 6 ha) and very low level accounts for 25.49% of the total natural area (area is 23211.44 ha) (Table 8).



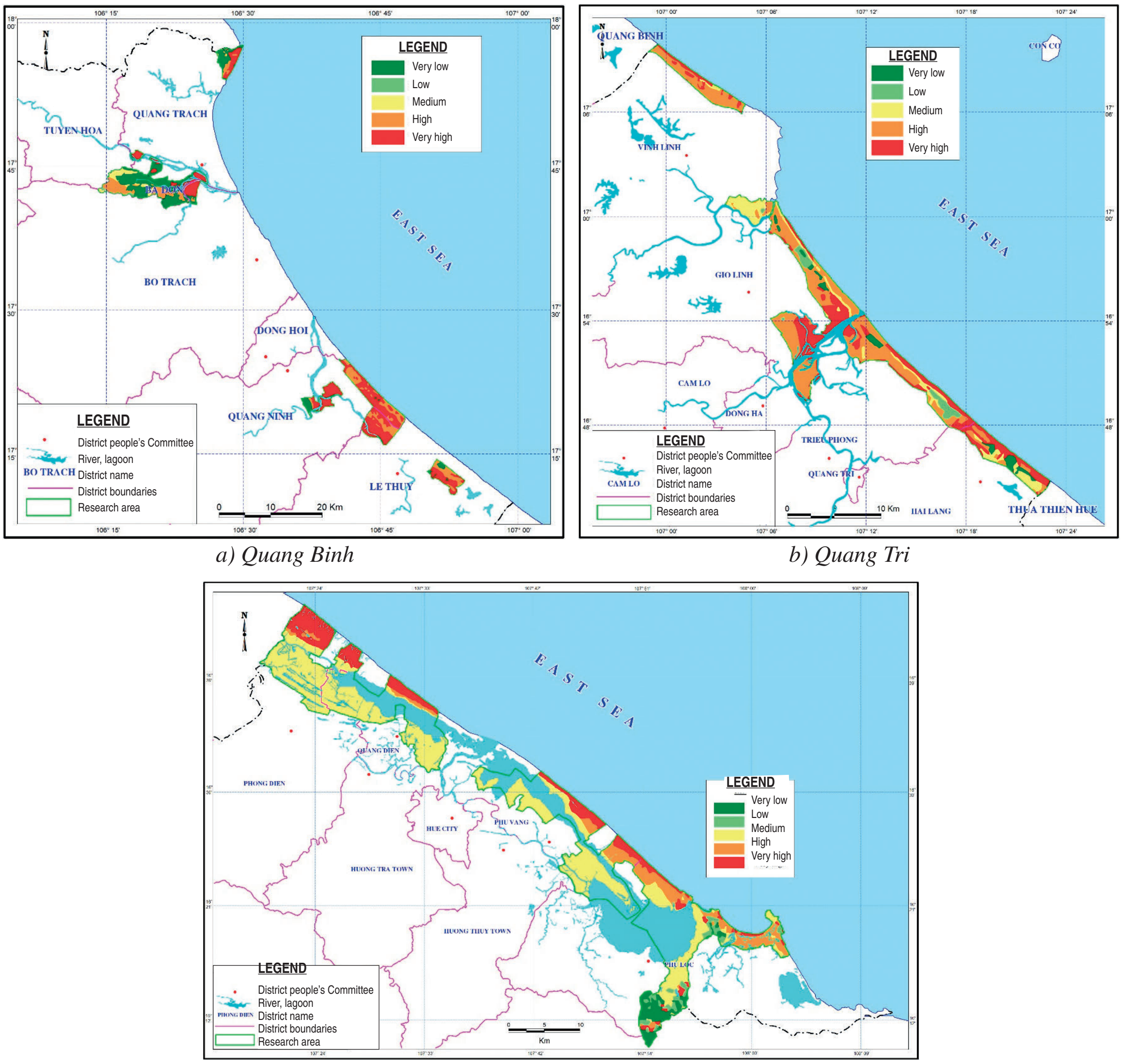
a) Quang Binh *b) Quang Tri*

c) Thua Thien Hue

Figure 3. Map of Exposure Indicator (E)
Source: author's own elaboration.
Ryc. **3**. Mapa wskaźnika ekspozycji (E)
Źródło: opracowanie własne.

Variables of Adaptive Capacity Indicator (AC)

The adaptability index includes two indicators representing slope and morphology. Research results show that there are 19805.74 ha (21.75%) damaged at a very high level (focusing mainly on Quang Ninh districts with 3665.23 ha, Le Thuy district with 3072.06 ha, Gio Linh district with 1848.67 ha, Phu Vang district has 1585.08 ha, and Trieu Phong district has 1269.12 ha); There are 17546.28 ha (19.27%) highly vulnerable (in which the most districts are Phu Loc district 3790.11 ha, Phong Dien district 3254.72 ha, Trieu Phong district 2622.75 ha); There are 41722.92 ha (accounting for 45.82% of the total natural area) with medium damage; There are 2148 ha (equivalent to 2.36% of the total natural area) with low damage and very low damage, accounting for 10.8% of the total natural area (9830.66 ha) (Table 9).



a) Quang Binh *b) Quang Tri*

c) Thua Thien Hue

Figure 4. Map of Adaptive Capacity Indicator (AC)
Source: author's own elaboration.
Ryc. 4. Mapa wskaźnika zdolności adaptacyjnej (AC)
Źródło: opracowanie własne.

Vulnerability Indicator (V)

Table 10, the vulnerability indicator results show that 34004.11 ha of extremely difficult coastal communes in Quang Binh, Quang Tri and Thua Thien Hue provinces are at very high risk of vulnerability (37.35% of the total natural area of the extremely difficult coastal communes in Quang Binh, Quang Tri and Thua Thien Hue provinces, Vietnam). The high vulnerability was 27755.02 ha (30.48% of the total natural area). The medium vulnerability accounts for 17884.07 ha (corresponding to 19.64% of the total natural area). The low vulnerability accounts for 8755.83 ha (9.62% of the total natural area), and the very low vulnerability makes up 2654.57 ha (2.92% of the total natural area). Particularly, the high and very high vulnerability level is as follows:

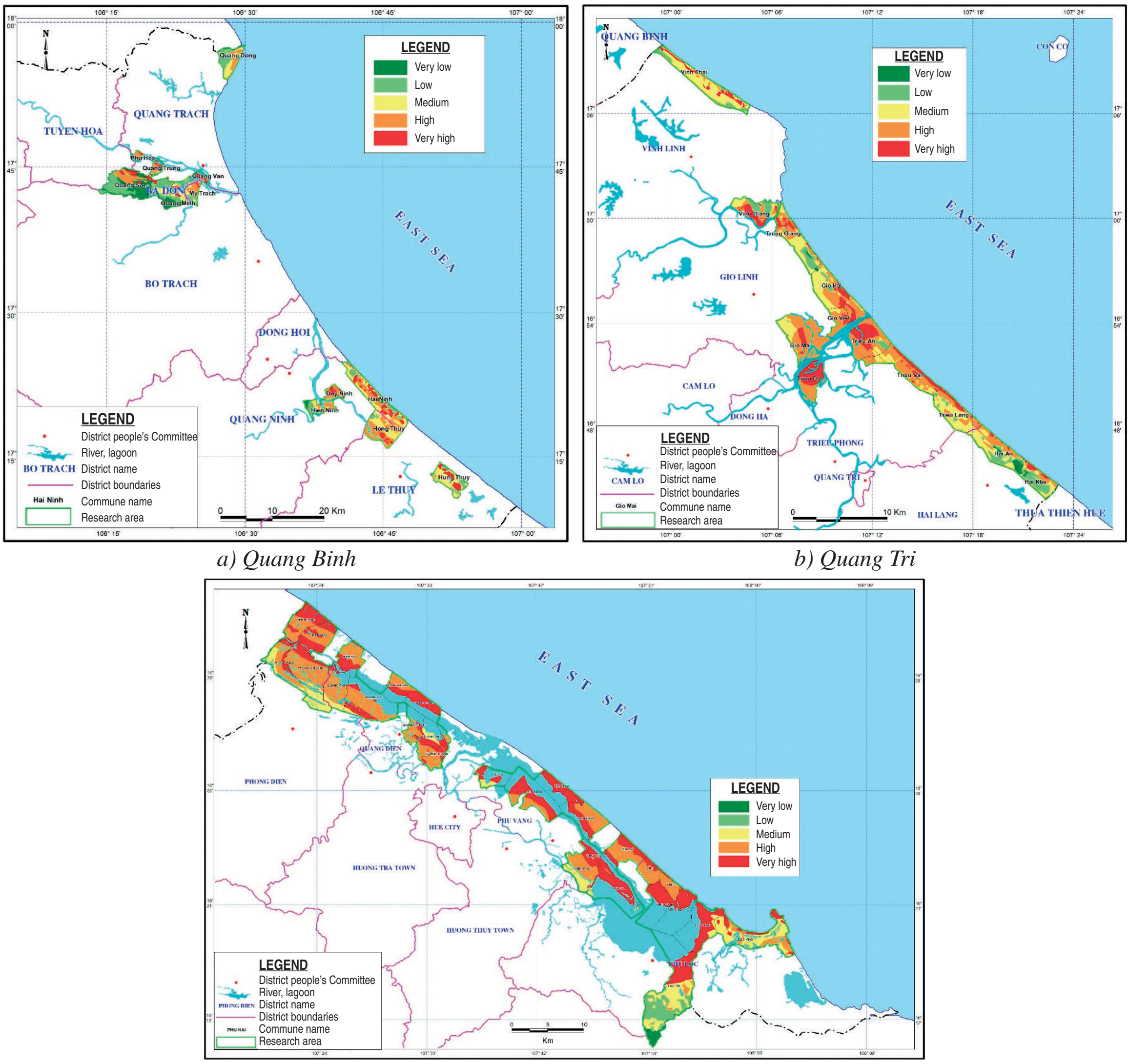
Table 9. Adaptive Capacity Indicator (AC)
Tabela 9. Wskaźnik pojemności adaptacyjnej (AC)

(Unit: ha)

No	District	Very low	Low	Medium	High	Very high	Total
1	Quang Trach	861.55	0	25.76	330.63	915.26	2133.2
2	Ba Don town	4924.23	147.76	866.95	1879.7	658.92	8477.56
3	Bo Trach	297.61	0	0	50.42	614.43	962.46
4	Quang Ninh	631.99	0	4.16	1516.23	3665.23	5817.61
5	Le Thuy	330.57	0	0	1562.81	3072.06	4965.44
6	Vinh Linh	0	19.56	753.31	1237.93	237.35	2248.15
7	Gio Linh	202.18	216.2	293.22	2366.63	1848.67	4926.9
8	Trieu Phong	128.79	333.32	323.98	2622.75	1269.12	4677.97
9	Hai Lang	316.58	0	513.35	387.21	744.69	1961.83
10	Phong Dien	0	0	6781.67	259.71	3254.72	10296.1
11	Quang Dien	0	0	10022.96	343.79	860.01	11226.76
12	Phu Loc	2137.15	1431.15	9796.13	3790.11	1080.21	18234.75
13	Phu Vang	0	0	12341.43	1198.35	1585.08	15124.86
Total		**9830.66**	**2148**	**41722.92**	**17546.28**	**19805.74**	**91053.6**
Rate (%)		**10.8**	**2.36**	**45.82**	**19.27**	**21.75**	**100**

Source: Data from the map of Adaptative capacity Indicator (AC).
Źródło: Dane z mapy wskaźnika zdolności adaptacyjnej (AC).

The vulnerability is high at 46635.57 ha (accounting for 51.22% of the total natural area of the extremely difficult coastal communes of Quang Binh, Quang Tri, and Thua Thien Hue provinces, Vietnam). Mainly occurs in Phong Dien, Quang Dien, Phu Vang, Gio Linh, and Phu Loc districts. In which, the district with the highest vulnerability was Phong Dien with 5316.05 ha, equivalent to 19.15% of the area; the high vulnerability was mainly in Phong Chuong with 1983.31 ha, Phong Binh with 885.2 ha, Dien Huong with 845.25 ha, Dien Hoa with 819.13 ha, Dien Mon with 783.14 ha. Quang Dien district with 5,305.3 ha, corresponding to 19.11% of the area of high vulnerability, mainly in Quang Loi commune with 1,684.48 ha, Quang Thai with 1322.08 ha. Phu Vang district with 3470.51 ha, equivalent to 12.5% of the area of high vulnerability, focusing on Vinh Xuan communes with 1005.18 ha, Vinh Thai with 1004.36 ha. Gio Linh district has 2633.94 ha, corresponding to 9.49% of the area of high vulnerability, mainly concentrated in Gio Mai commune with 1257.5 ha and Gio Hai commune with 640.51 ha. Phu Loc district has an area of 2253.64 ha, equivalent to 8.12% of the highly vulnerable area, mainly concentrated in Loc Vinh communes with 777.95 ha, Loc My with 650.07 ha, Vinh Hai with 618.5 ha. Trieu Phong district with 2209.02 ha, equivalent to 7.96% of the area of high vulnerability. Quang Ninh district, with an area of 1851.07 ha, equivalent to 6.67% of the area, is highly vulnerable. Le Thuy district with 1463.59 ha, equivalent to 5.27% of the highly vulnerable region. Ba Don town with 1333.82 ha; the remaining districts all occupy an area of less than 800 ha, including Quang Trach with 659.68 ha; Hai Lang with 521.28 ha; Bo Trach with 444.31 ha and the smallest is in Vinh Linh with 292.83 ha.



a) Quang Binh *b) Quang Tri*

c) Thua Thien Hue

Figure 5. Map of Vulnerability indicator (V)
Source: author's own elaboration.
Ryc. **5**. Mapa wskaźnika podatności (V)
Źródło: opracowanie własne.

The high vulnerability occupies 34004.11 ha, accounting for 37.35% of the total natural area of the extremely difficult coastal communes of Quang Binh, Quang Tri, and Thua Thien Hue provinces, Vietnam. The largest area is Phu Vang district with 10319.5 ha, equivalent to 30.35% of the area of high vulnerability (especially Vinh Xuan communes with 2374.52 ha, Vinh Ha with 2339.19 ha, Phu Dien with 1584.63 ha, Vinh Xuan with 954.21 ha). Phu Loc district covers an area of 9863.68 ha, equivalent to 29.01% of the highly vulnerable region, mainly in Loc Binh with 2657.29 ha, Loc Tri with 2344.73 ha, Vinh Hien with 2211.95 ha, Vinh Giang with 1840.7 ha. Quang Dien district has an area of 4862.45 ha, equivalent to 14.3% of the area of high vulnerability, mainly in Quang Loi communes with 1325.27 ha, Quang Cong with 1278.9 ha, Quang Ngan with 699.32 ha, Quang An with 598.43 ha. Phong Dien district has an area of 3420.45 ha, equivalent to 10.06% of the area of high vulnerability; the communes

Table 10. Vulnerability indicator (V)
Tabela 10. Wskaźnik podatności (V)

(Unit: ha)

District	Commune	Very low	Low	Medium	High	Very high	Total
Quang Trach	Phu Hoa	0	21.16	24.98	185.78	92.91	324.82
	Quang Dong	0	769.78	540.82	473.9	1.12	1785.63
	Total	*0*	*790.94*	*565.8*	*659.68*	*94.03*	*2110.45*
Ba Don town	Quang Minh	483.78	606.75	415.88	211.06	139.84	1857.31
	Quang Son	1508.69	2299.34	422.00	809.84	419.89	5459.77
	Quang Trung	0	149.96	70.05	243.4	154.01	617.42
	Quang Van	0	100.66	22.19	69.52	281.84	474.21
	Total	*1992.47*	*3156.71*	*930.12*	*1333.82*	*995.58*	*8408.71*
Bo Trach	My Trach	0	270.35	201.22	444.31	38.78	954.66
	Total	*0*	*270.35*	*201.22*	*444.31*	*38.78*	*954.66*
Quang Ninh	Duy Ninh	0	74.78	38.97	420.29	241.14	775.18
	Hai Ninh	30.37	547.12	1430.69	985.97	798.79	3792.93
	Hien Ninh	90.01	339.91	307.08	444.81	1.66	1183.48
	Total	*120.38*	*961.81*	*1776.74*	*1851.07*	*1041.59*	*5751.59*
Le Thuy	Hung Thuy	0	397.53	1164.7	37.45	473.41	2073.09
	Hong Thuy	0	120.53	1122.59	1426.14	182.75	2852.01
	Total	*0*	*518.07*	*2287.29*	*1463.59*	*656.16*	*4925.1*
Vinh Linh	Vinh Giang	1.04	265.29	183.52	205.98	221.98	877.81
	Vinh Thai	0	152.53	893.09	86.84	219.72	1352.18
	Total	*1.04*	*417.83*	*1076.61*	*292.83*	*441.69*	*2229.99*
Gio Linh	Gio Hai	4.51	96.62	507.00	640.51	269.07	1517.7
	Gio Mai	0	3.66	260.63	1257.5	193.12	1714.92
	Gio Viet	0	1.01	44.1	353.77	116.29	515.17
	Trung Giang	21.35	206.02	398.36	382.15	131.41	1139.3
	Total	*25.86*	*307.31*	*1210.1*	*2633.94*	*709.89*	*4887.09*
Trieu Phong	Trieu An	0	83.23	63.43	730.8	509.1	1386.57
	Trieu Lang	0	75.69	550.66	365.76	108.42	1100.53
	Trieu Do	0	0	0	356.69	587.44	944.12
	Trieu Van	0	7.2	195.56	755.77	248.44	1206.97
	Total	*0*	*166.11*	*809.65*	*2209.02*	*1453.4*	*4638.18*
Hai Lang	Hai An	90.43	221.65	428.6	375.59	27.92	1144.19
	Hai Khe	75.54	347.05	153.64	145.68	78.98	800.89
	Total	*165.97*	*568.69*	*582.24*	*521.28*	*106.9*	*1945.09*
Phong Dien	Dien Huong	0	0	1.77	845.25	867.62	1714.63
	Dien Hoa	0	0	0	819.13	603.3	1422.43
	Dien Mon	0	0	0	783.14	989.72	1772.87
	Phong Binh	0	0	419.8	885.2	390.79	1695.79
	Phong Chuong	0	0	1054.55	1983.31	569.02	3606.88
	Total	*0*	*0*	*1476.11*	*5316.05*	*3420.45*	*10212.6*

Table 10. Continued from the previous page
Tabela 10. Ciąg dalszy ze strony poprzedniej

District	Commune	Very low	Low	Medium	High	Very high	Total
Quang Dien	Quang An	0	0	523.72	323.42	598.43	1445.57
	Quang Cong	0	0	0	91.48	1278.9	1370.39
	Quang Loi	0	0	187.47	1684.48	1325.27	3197.23
	Quang Ngan	0	0	12.05	461.14	699.32	1172.52
	Quang Thai	0	0	237.27	1322.08	319.82	1879.17
	Quang Thanh	0	0	7.42	647.38	406.95	1061.75
	Quang Phuoc	0	0	0	775.31	233.74	1009.05
	Total	*0*	*0*	*967.94*	*5305.3*	*4862.45*	*11135.68*
Phu Loc	Trung May	0	0	240.7	9.58	2657.29	2907.57
	Loc Tri	348.85	1598.02	1775.58	197.54	2344.73	6264.73
	Loc Vinh	0	0	1973.41	777.95	547.11	3298.47
	Vinh Giang	0	0	0	0	1840.7	1840.7
	Vinh Hai	0	0	0	618.5	60.81	679.31
	Vinh Hien	0	0	34.92	0	2211.95	2246.87
	Vinh My	0	0	0	650.07	201.09	851.15
	Total	*348.85*	*1598.02*	*4024.61*	*2253.64*	*9863.68*	*18088.8*
Phu Vang	Phu An	0	0	299.25	11.44	796.56	1107.25
	Phu Dien	0	0	50.97	0	1584.63	1635.6
	Phu Xuan	0	0	6.6	561.57	2374.52	2942.69
	Vinh An	0	0	38.29	855.03	761.36	1654.68
	Vinh Ha	0	0	644.51	0	2339.19	2983.7
	Vinh Phu	0	0	0	32.93	745.53	778.46
	Vinh Thai	0	0	917.46	1004.36	763.49	2685.3
	Vinh Xuan	0	0	18.57	1005.18	954.21	1977.97
	Total	*0*	*0*	*1975.65*	*3470.51*	*10319.5*	*15765.66*
Total		**2654.57**	**8755.83**	**17884.07**	**27755.02**	**34004.11**	**91053.6**
Rate (%)		**2.92**	**9.62**	**19.64**	**30.48**	**37.35**	**100**

Source: Data from Map of Vulnerability Indicator (V).
Źródło: Dane z mapy wskaźnika podatności (V).

with large areas are Dien Mon 989.72 ha, Dien Huong 867.62 ha, Dien Hoa 603.3 ha. Trieu Phong district has 1453.4 ha, equivalent to 4.27% of the area of high vulnerability. Quang Ninh District, with an area of 1041.59 ha, equivalent to 3.06% of the area, is highly vulnerable. Ba Don town with 995.58 ha, accounting for 2.93%; Gio Linh with 709.89 ha (accounting for 2.09%); Le Thuy with 656.16 ha (accounting for 1.93%). The remaining districts all occupy a small area of less than 500 ha (Vinh Linh with 441.69 ha, Hai Lang with 106.9 ha, Quang Trach with 94.03 ha, Bo Trach with 38.78 ha).

CONCLUSION

We assess the level of vulnerability due to climate change impacts on natural resources, environment, and socio-economy in extremely difficult coastal communes in Quang Binh, Quang Tri, and

Thua Thien Hue province of Vietnam, using the use of the IPCC vulnerability assessment research method. The vulnerability assessment includes three Sensitive indicators:

- Indicator (S) (including four sub-indicators: Indicator access to traffic; Impact of residential areas; Impact of industrial zones; Dependency level of community).
- Exposure Indicator (E) (including 3 sub-indicators sea level rise up to 2100, Change in temperature to 2100, Change in rainfall to 2100).
- Adaptability Indicator (AC) (including 2 sub-indicators slope and morphology).

The analysis, assessment and combination with GIS has shown the extent of vulnerability caused by the impacts of climate change in extremely disadvantaged communes in the coastal area of Quang Binh, Quang Tri and Thua Thien Hue provinces of Vietnam shows the need to pay special attention to this area. Because over 67% of the study area has high and very high vulnerability. This is an alarming problem. While the life of the people here is still very difficult. The percentage of poor and near-poor households is high. It is necessary to have solutions to improve the quality of life of the people here. At the same time, it is necessary to provide short-term and long-term solutions to prevent and adapt to the impacts of climate change.

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