Vulnerability assessment due to the climate change in Vinh Long province

Le Ngoc Tuan[1,*], Nguyen Van Bang[2]

Abstract—**This work aimed to assess the vulnerability to the climate change (CC) in Vinh Long province till 2020. Inundation, saltwater intrusion (SI), drought, riverbank landslide, storm, temperature and precipitation were taken into consideration. In addition to the sociological investigation, risk assessment matrix, adaptive capacity assessment methods, etc. the vulnerability to CC was evaluated via index method. Results showed that among 8 districts in the province, Long Ho, Vung Liem, Vinh Long city, and Tam Binh were the most vulnerable. Besides, sectors interested in the relationship to CC include agriculture, infrastructure, and landuse. Indicated vulnerable sectors and areas in the province were important factor for planning suitable coping measures, especially in the context of CC seriously increasing.**

Keywords—**climate change, adaptive capacity, risk, vulnerability**

1. INTRODUCTION

Global climate change (CC) heavily impacts people life [1]. In VietNam, within 50 recent years, the increase in average temperature (by 0.7 °C), sea level rise (20 cm), and severe weather phenomena are impacting increasingly serious. By the end of the 21st century, the average temperature and sea level will increase from 2.5 to 3.7 °C and 78–95 cm, respectively [2].

Vulnerability to climate change is the degree to which geophysical, biological and socio-economic systems are susceptible to, and unable to cope with, adverse impacts of climate change. Vulnerability assessment is very important to

determine defective links of a system, and then to establish respective response measures [1, 3]. There were many researches on assessing vulnerability due to CC to social and economic sectors by many different methods. A method of NOAA – USA mainly focussed on assessing disaster risks impacting infrastructure, economy, society, and environment, etc. MASSCOTE method of *FAO* was used to assess the vulnerability of irrigation sector [4]. Besides, vulnerability is aslo assessed by index method, such as Flood Vulnerability Index (FVI) – including adaptive module, social vulnerable module, and damage module [5]; Social and Infrastructure Flood Vulnerability Index (SIFVI) [6]; Vulnerability Index due to flood -calculated via flood frequency, exposure and serious level (not including social impacts due to flood) [7]; Vulnerability index to CC of poor coastal communities [8]; or Vulnerability index - calculated via exposure and resistance [9], etc. In VietNam, many studies on vulnerability of social economic sectors have also been performed with different approaches [10,11]. In general, vulnerability has been assessed via three main aspects: exposure, sensitivity (or risk level), and adaptive capacity of a system.

Vinh Long province is located in the MeKong Delta where could be the most flooded in the context of sea level rise [2]. The terrain is relatively low as compared to the sea level, consequently, the north of this area is usually inundated by flood; the area between the the National Rout 1 and Mang Thit river is often inundated by both flood and tide; the south of Mang Thit district is mostly flooded by tide. Flooding time is about 2 to 4 months. Besides, SI is also the concern when maximum salinities in main rivers of Vinh Long province have increased over the years (2007–2016) and increasingly enter

the inland (1‰ salinity boundary). In 2016, higher salinities were recorded in Hau River, Vung Liem, Mang Thit, and Tra On districts (2‰ salinity boundary); moreover, salinity boundary of 8‰ was appeared in Vung Liem district. In addition, natuaral disasters such as riverbank landslide, storm, drought, etc. have also happened quite frequently, thus seriously impacted lives and production of the local, especially in the context of CC [12].

Therefore, this research aimed at assessing vulnerability due to CC in Vinh Long province to 2020, indicating the areas and sectors needing taking into account according to main impacts of CC, providing basis for planning adaptive measures, contributing to reduce damages by CC, ensuring the sustainable development goals of the local.

2. METHODS

Vulnerability to CC of the main sectors were assessed (land use -SDD, mineral resources -TNKS, agriculture -NN, aquaculture -TS, industry -CN, transportation -GT, construction -XD, services – travel -DV-DL, society -XH) in all 8 districts/city in Vinh Long province (Vinh Long city, Vung Liem, Mang Thit, Tra On, Tam Binh, Binh Tan, Binh Minh, and Long Ho districts).

Data collection and processing method

Related data and documents were collected at the agencies and departments in Vinh Long province to assess impacts, risk level, adaptive capacity, and vulnerability to CC, and then processed by Microsoft Excel software. Besides, this research aimed at assessing the vulnerability to CC, so simulation results of CC scenarios (by SIMCLIM software, according to AR4 record of IPCC [1]), risks of SI and inundation by tide in the context of CC were inherited. Our previous research showed that in 2020, according to the average emission scenario (B2), temperature and precipitation in Vinh Long province would be 27.64 °C and 1,491.80 mm, respectively. For water level, it would increase about 9cm as compared to that in the reference period (1980–1999).

Sociological survey method

This method was used to assess the awareness about CC, adaptive capacity to CC of local managers, management agencies, and communities.

Communities: A representative survey was conducted in urban (Vinh Long city) and rural areas (Tam Binh, Tra On, and Vung Liem districts) which are also significantly affected by saltwater intrusion and inundation. 600 questionnaires were collected (150 questionaires/area with a reliablity of 92%).

Managers and management agencies: The surveys were conducted in 22 agencies, including: The People's Committees of 08 districts/city in Vinh Long province (as mentioned), 12 departments (Department of Natural Resources and Environment -DONRE, Department of Agriculture and Rural Development -DOARD, Department of Industry and Trade -DOIT, Department of Transport -DOT, Department of Construction -DOC, Department of Health -DOH, Department of Science and Technology -DOST, Department of Planning and Investment -DOPI, Department of Culture, Sports and Tourism - DOCST, Department of Education and Training - DOET, The Steering committee for Flood and Storm Control -SCFSC, The Industrial zones authority -IZA) and 02 other related units (VinhLong Water Supply Company and VinhLong Power Company). 250 questionnaires were collected.

Vulnerability assessment method

According to the concept of vulnerability of IPCC [1], in this work, the vulnerability to CC (V) was calculated by formula: $V = \frac{1}{2}(R + 5 - AC)$; in which, evaluated scores were standardized by the scale of 0–5; R was risk level due to CC; AC was adaptive capacity. The vulnerability to CC in each local was assessed according to the following scale as presented in Table 1.

Assessing risks due to CC

This method was used to assess risks due to CC (RR) as a basis to evaluate the vulnerability to CC as mentioned, in which possibility that social and economic aspects would be damaged was considered [11]. Related CC factors taken into account were flood, SI, drought, temperature, precipiattion, landslide, and storm. Depending on the occurrence possibility and related damages, the risk level due to each CC factor in each local was assessed according to the scale in Table 1.

Table 1. Assessing sacle of the vulnerability (or risk) to CC

0 < V (or RR) ≤ 1	1 < V (or RR) ≤ 2	2 < V (or RR) ≤ 3	3 < V (or RR) ≤ 4	4 < V (or RR) ≤ 5
Very low	Low	Average	High	Very high

Risk level due to CC of each sector in each local was calculated as follows:

- Determining the risk level (of each sector) to each CC factor (*risk component*).
- Determining the weight of each CC factor in relation to the considered sector by *Expert method*.
- Calculating the integrated risk level to CC (based on values of risk component and corresponding weight)

Assessing adaptive capacity to CC

Adaptive capacity was the ability or potential of a system to respond successfully to climate variability and change, and included adjustments in both behaviour and in resources and technologies [11]. Adaptive capacity of each local (used to calculate V index as mentioned, and then indicate defective links of the system) was assessed by indicators as Table 2. Assessing scale of AC was showed in Table 3.

Table 2. Assessing indicators of adaptive capacity to CC

Object	Group	Component	Code
(1) Community	People [13, 14]	Awareness of CC [15]	CN1
		The percentage of people participating in activities responding to CC [16]	CN2
		The percentage of people living in places affected by CC and haing adaptation experience [17]	CN3
	Finance [13, 14]	Per capita income [14]	TC1
		Support of governments in recovery from natural disasters [18]	TC2
	Facilities (CSVC) [13, 14]	Transportation [19]	VC1
		Irrigation system [19]	VC2
		Existing facilities: housing structure; percentage of people using national electricity and clean water supply network; ability of accessing information, etc. [20]	VC3
	Society [13, 14]	Percentage of teacher-to-pupil [13]	XH1
		Percentage of medical staff-to-population [13]	XH2
		Percentage of employee [16]	XH3
		Percentage of people being communicated about CC [15]	XH4
(2) Management agencies (The departments managing economic sectors)	Organization [13, 14]	Organizational structure, number of managers working on CC management (or related tasks) [16]	TC1
		Awareness of CC of local managers [13]	TC2
		The policies related to CC responses [21]	TC3
	Coordination mechanism	Cooperative relationship in CC response missions [22]	CCPH
	Facilities [13, 14]	Serving CC responses in general and coping with incidents due to CC and natural disaster in particular [22]	CSVC
	Finance	Active and/or fixed finance sources for CC response activities as well as finance invested through programs and projects related to CC [16, 23]	NS
(3) Management agencies	*(The People's Committees of districts)* Similar to group (2)		

Table 3. Assessing scale of adaptive capacity to CC

Scale	Description
0 < AC ≤ 1.5	*Poor* AC, many shortcomings, affecting many factors
1.5 < AC ≤ 2.5	*Medium* AC, many shortcomings but could be overcome
2.5 < AC ≤ 3.5	*Enough* AC, might have some shortcomings but harmless
3.5 < AC ≤ 4.5	*Good* AC, might have few shortcomings but harmless
4.5 < AC ≤ 5	*Very good* AC, no shortcomings

Weights among indicators (components or groups) were equal, thereby, AC_{group} index was calculated by average of $AC_{component}$ index; AC_{object} index was calculated by average of AC_{group}.

AC index of each sector (AC_{sector}) in each local was integrating calculated by AC_{object} indices, including communities, local management agencies, and departments managing related sectors*, with respectively weights of 0.3:0.3:0.4. *Land use and mineral resource sectors were assessed in relationship with DONRE; agricultura and aquaculture -DOARD; industry -DOIT; service and travel -DOCST; transportation -DOT; construction -DOC; other sectors -DOH, DOST, DOPI, DOET, SCFSC.

AC of each local (AC_{local}) was calculated by average of AC_{sector} indices of that local.

Expert method

This method was used to determine weights of CC factors in relationship to each economic - social sector based on 30 experts' opinions: (i) Ranking importances of CC factors to landuse sector (The more important the factor is, the higher the ranking score will be); (ii) Determining ranking score of each factor (m_i): *m_i = Total score of factor i / Number of questionaires*; (iii) Calculating the intermediate weight of each factor (w_i'):

+ Accepting that minimum m_i has $w_i' = 1.0$

+ Calculating w_i' of other factors by formula:

$$w_i' = \frac{m_{i(min)}}{m_i}$$

+ Calculating final weight of each factor (w_i):

$$w_i = \frac{w_i'}{\sum_1^n w_i'}$$

3. RESULTS AND DISCUSSION

Adapative Capacity to CC

Management agency group

AC index of the management agency group was presented in Table 4.

Regarding *district management agencies:* the average AC index was *enough* (2.9 point), ranging from 2.0 to 3.4 among investigated areas, in which, VinhLong city and TraOn district had the highest AC. Conversely, TamBinh had the lowest AC index in the province (2.0 point) because of limitations in organizational structure and financial capacity leading to the reduction in AC to CC. The former reason was also the limitation of all areas, so it needed overcoming in order to consolidate the system, contributing to improving the AC of the local.

For *departments managing sectors:* average AC index was 3.0, ranging from 2.4 to 3.6. DOARD had the highest AC index (3.6 point, *good* level) due to highlights of organizational structure, finance, coordination mechanisms to cope with CC. Regarding departments managing sectors less sensitive to CC (DOCST, DOH, DOET, etc), AC índices ranged from 2.4 to 3.5 (*medium* to *enough* level). The weaknesses of AC to CC mostly come from organizational structure and coordination mechanisms in CC responses, thereby needed concerning and improving.

Table 4. Assessment results of adaptive capacity of management agencies group in Vinh Long province

	Organization	TC1	TC2	TC3	CCPH	CSVC	NS	Average
Departments and agencies	DONRE [(*)]	2	3	4	4	Qualified	3	3.3
	DOARD [(*)]	4	4	3.5	4	Qualified	3	3.6
	DOT [(*)]	1	2	2	4	Qualified	4	3.2
	DOC [(*)]	1	2	3.5	3	Qualified	3	2.7
	DOCST	3	4	3	2	Qualified	2	2.4
	DOIT	3	3	3	3	Qualified	2	2.7
	DOST	1	4	2.5	4	Qualified	4	3.5
	DOPI	1	4	2	4	Qualified	4	3.4
	DOET	1	3	2	3	Qualified	3	2.7
	DOH	1	3	2	3	Qualified	3	2.7
	IZA	3	4	3.5	3	Qualified	3	3.2
	Average	1,9	3,3	2.8	3.4		3.1	3.0
The People's Committees of	VinhLong city	3	3	4	4	Qualified	3	3.4
	BinhMinh	3	2	3	2	Qualified	3	2.6

districts	Long Ho	2	2	3	2	Qualified	4	2.8
	BinhTan	4	3	2	2	Qualified	4	3.0
	MangThit	2	2	4	2	Qualified	4	2.9
	TraOn	2	4	4	3	Qualified	3	3.1
	TamBinh	1	3	2	2	Qualified	2	2.0
	VungLiem	2	4	2	3	Qualified	3	2.9
	Average	2,4	2,9	3	2.5		3.3	2.9

(*) Managing sectors sensitive with impacts of CC

Community group

AC of community in Vinh Long Province was in *medium* level and not much different among local areas, ranging from 2.4 to 3.1 (highest in Vinh Long city) *(Table 5)*. The aspects reducing AC of comunity would be: low percentage of people participating in activities responding to CC (Tam Binh, Vung Liem, and Binh Tan districts),

less effective support of irrigation system in production (Tam Binh, Tra On, Vung Liem, Mang Thit, and Binh Minh districts), and some social issues such as education, employment, etc. Improving these weaknesses is important tasks to improve AC of community and then to reduce vulnerability to CC.

Table 5. Adaptive capacity of community in Vinh Long province

District	Human			Finances		Facilities			Society				Total
	CN1	CN2	CN3	TC1	TC2	VC1	VC2	VC3	XH1	XH2	XH3	XH4	
Vinh Long city	3	2	3	4	4	3,5	3	1,5	2	4	3	3	3.1
Tam Binh	3	1	2	2.75	4	3.5	2	4	1	2	1	1	2.4
Tra On	4	2	2	3	3	3.25	2	4.5	3	2	1	1	2.7
Vung Liem	3	1	2	3	3	3.25	2	4.5	3	2	1	1	2.5
Mang Thit	3	2	2	3	4	3.75	2	3.5	2	2	1	3	2.7
Binh Minh	3	2	3	3.25	2	3.25	2	3	2	2	3	3	2.6
Long Ho	3	2	2	2.75	3	3.25	3	3.5	2	1	4	3	2.7
Binh Tan	4	1	2	3.75	3	3.75	3	4	1	1	4	1	2.8

Table 6 presented AC index in each local area of Vinh Long province. In general, sectors and areas having *enough* adaptive capacity (according

to AC assessment scale) would be agriculture, aquaculture, environmental resources, land use, Binh Tan district, and Vinh Long city.

Table 6. The AC index to CC in VinhLong province

District	SDD	TN - KS	NN	TS	CN	DV - DL	XH	GT	XD	Average
Binh Minh	3.03	3.03	3.14	3.14	2.76	2.67	2.93	2.98	2.78	2.94
Binh Tan	3.29	3.29	3.41	3.41	3.03	2.94	3.20	3.25	3.05	3.21
Long Ho	3.00	3.00	3.11	3.11	2.73	2.64	2.90	2.95	2.75	2.91
Mang Thit	3.02	3.02	3.13	3.13	2.76	2.67	2.93	2.98	2.78	2.94
Tam Binh	2.67	2.67	2.78	2.78	2.40	2.31	2.58	2.62	2.42	2.58
Tra On	3.06	3.06	3.18	3.18	2.80	2.71	2.97	3.02	2.82	2.98
Vinh Long city	3.29	3.29	3.40	3.40	3.02	2.94	3.20	3.25	3.05	3.20
Vung Liem	2.95	2.95	3.06	3.06	2.69	2.60	2.86	2.91	2.71	2.87
Average	3.04	3.04	3.15	3.15	2.77	2.68	2.95	2.99	2.79	

Risk level caused by CC

Table 7 presented risk level due to CC of sectors in Vinh Long province. Accordingly, agriculture had the highest risk, especially in Vung Liem and Long Ho districts. In which, flood

and SI were 2 main reasons. Besides, infrastructure, land use, environmental resource also had high risk with CC factors. The results also showed that Long Ho, Vung Liem, Tra On districts, and Vinh Long city need concerning with the specific sectors as follows: Long Ho –

agriculture, industry, construction, and aquaculture; Vung Liem – agriculture, land use, and infrastructure; Tra On – infrastructure, environmental resource, and agriculture; VinhLong city – land use, transportation, and

construction. These results are an important basis to consider and establish suitable solutions to cope with CC for each sector in each area in the local.

Table 7. Average risk level due to CC of sectors in Vinh Long province

		SDĐ	TNMT	NN	TS	CN	DVDL	XH	GT	XD
Binh Minh	Current	1.2	0.9	0.86	0.77	1.12	0.8	1.01	1.21	1.38
	2020	1.2	0.9	1.27	0.96	1.12	0.8	1.01	1.46	1.61
Binh Tan	Current	0.67	1.01	1.14	0.59	0.43	0.8	0.81	0.95	0.7
	2020	0.67	1.01	1.55	0.59	0.43	0.8	0.81	0.95	0.93
Long Ho	Current	1.08	1.31	1.89	1.71	1.81	1.38	1	1.6	1.73
	2020	1.27	1.31	1.89	1.94	1.81	1.57	1	1.6	1.96
Mang Thit	Current	1.05	1.1	1.52	1.41	1.16	0.71	0.86	1.17	1.14
	2020	1.24	1.2	1.7	1.86	1.26	0.71	0.91	1.21	1.38
Tam Binh	Current	0.75	1.21	1.21	1.14	1.14	0.85	0.95	1.39	1.49
	2020	0.75	1.21	1.62	1.14	1.37	0.85	0.95	1.39	1.72
Tra On	Current	1.18	1.52	1.52	1	1.14	0.85	1.3	1.56	1.76
	2020	1.37	1.62	1.7	1.41	1.47	0.85	1.4	1.63	2.08
Vinh Long city	Current	1.68	1	1.21	0.77	0.68	1.18	1.19	1.48	1.39
	2020	1.68	1	1.62	0.77	1.14	2.02	1.19	1.73	1.63
Vung Liem	Current	1.78	1.51	1.96	1.64	0.7	0.71	1.46	1.7	1.21
	2020	1.78	1.51	1.96	1.86	0.8	0.77	1.51	1.73	1.61

To calculate, assess, and also warn about the vulnerability to CC for sectors in Vinh Long province, this work used maximum risk level (*detailed data was not showed*). Accordingly, the maximum risk level of sectors of (i) land use, (ii) environmental resource, (iii) agriculture, (iv) aquaculture, (v) industry, (vi) service and travel, (vii) society, (viii) transportation, and (ix)

construction were ranged in 1-4, 2-4, 2-4, 1-4, 1-3, 1-3, 1-3, 2-4, and 1-4, respectively.

Vulnerability assessment caused by CC

Based on the calculation of AC index and risk level due to CC factors, V the index was calculated and presented in Table 8.

Table 8. Vulnerability index to CC of sectors in Vinh Long province

		SDD	TNMT	NN	TS	CN	DVDL	XH	GT	XD
Binh Minh	Current	2.49	1.99	1.93	1.43	2.62	1.67	2.04	2.01	2.61
	2020	2.49	1.99	2.43	1.93	2.62	1.67	2.04	2.51	3.11
Binh Tan	Current	1.86	1.86	1.80	1.30	1.49	1.53	1.40	1.88	1.48
	2020	1.86	1.86	2.30	1.30	1.49	1.53	1.40	1.88	1.98
Long Ho	Current	2.50	2.00	2.95	2.95	2.64	2.18	1.55	2.53	2.63
	2020	2.50	2.00	2.95	2.95	2.64	2.68	1.55	2.53	2.63
Mang Thit	Current	1.99	1.99	2,44	1.94	2.12	1.67	1.54	2.01	2.11
	2020	2.49	2.49	2.44	2.94	2.12	1.67	2.04	2.01	2.11
Tam Binh	Current	1.67	2.17	2.61	2.61	2.30	1.85	1.71	2.19	2.79
	2020	1.67	2.17	2.61	2.61	2.80	1.85	1.71	2.19	2.79
Tra On	Current	1.97	1.97	2.41	1.41	2.10	1.65	2.02	2.49	2.59
	2020	2.47	2.47	2.41	1.91	2.60	1.65	2.02	2.49	2.59
Vinh Long city	Current	2.86	1.86	2.30	1.30	1.99	2.03	1.90	2.38	2.48
	2020	2.86	1.86	2.30	1.30	1.99	2.53	1.90	2.88	2.98
Vung Liem	Current	3.03	3.03	2.97	2.47	1.66	1.70	2.07	2.55	2.15
	2020	3.03	3.03	2.97	2.97	2.16	1.70	2.57	2.55	2.65

Vulnerable areas to CC in Vinh Long province

Table 8 and Fig. 1 showed Long Ho, Vung Liem, Vinh Long, and Tam Binh were the most vulnerable areas in Vinh Long province. Vulnerability index to CC of the local areas was detailed in Fig. 1b by the scale 1.5–2.5.
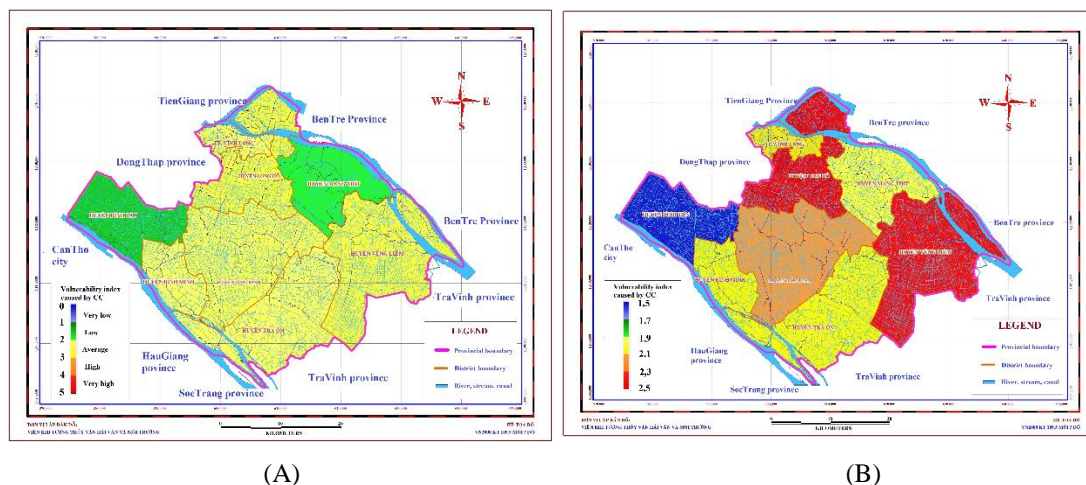

(A)   (B)

Fig. 1. Vulnerability to CC in VinhLong province: (A) Current status; (B) Detailed from current status

With specific characteristics of nature, economy, and society, each local area had different weaknesses in the relation to V to CC. In Long Ho, agriculture, aquaculture, industry, and infrastructure sectors needed concerning under CC impacts; land use, agricultura, and infrastructure for Vung Liem; land use and infrastructure for Vinh Long city; agriculture, aquaculture, and infrastructure for *TamBinh*. This was an important basis for proposing suitable solutions for corresponding sectors and areas to improve the effectiveness of activities coping to CC in the local.

Vulnerable sectors to CC in Vinh Long province

Agriculture, infrastructure (transportation and construction), and land use were the most vulnerable sectors to CC in Vinh Long province.

- *Agriculture:* was the decisive economic sector in Vinh Long province but the most vulnerable (Table 8). Average AC indices were higher than those of other sectors (Table 6), but just able to reduce partly the risk level. Therefore, the agriculture would be still the most concerned sector in the process of economic development in the local, especially in Vung Liem, Long Ho and Tam Binh districts.

Flood, temperature rise, and SI led to the increase in vulnerability of agriculture sector in the province.

+ The rate of flooded agricultural area and the related damages need concerning in Long Ho, Binh Minh, Binh Tan, and Vung Liem districts.

+ *SI* would impact agricultural sector in Vung Liem, Tra On, and Mang Thit districts, especially rice and a small part of crops.

+ *Temperature* had not yet significantly affected agricultural production but high temperature in dry season, many days per year with temperature higher than 35 °C (71 days in 2015), etc. would affect agricultural production areas, especially in Binh Tan, Binh Minh, and Long Ho districts.

- *Infrastructure:* (including 2 main sectors of transportation and construction) had concerned V index in Vinh Long province. Apart from relative high risk to CC impacts, AC of this sector was low, as follows:

+ Construction sector was affected by 3 main phenomena: flood, riverbank landslide, and storm. Flood affects infrastructure, housing structures, and engineering system, leading to the highest risk level to CC of Vinh Long city and Binh Minh district. Statistics in the past 5 years showed most of local areas had

landslide, resulting in damages for dyke system, riverbank, canal, etc. Two most concerned areas were Tra On (15 landslide positions – about 1,367 m, 2015) and LongHo (5 landslide positions – about 550 m, 2015). Storm mostly affected housing structures (unroofed, collapse, breaking down, etc), especially in Tam Binh, Tra On, Long Ho, and Vung Liem districts.

+ AC of the local agencies managing transportation and construction sectors were still low. It could be explained that these agencies were not responsible for CC issues, so organizational structure, human resources, accessing programs as well as information of CC needed more concerning.

- *Land use:* in the context of complex and increasingly negative change of climate, *flood and SI* were 2 main factors leading to significant impacts. As mentioned, AC index of this sector was relatively high (AC=3.04), runner up (after that of agriculture), therefore, vulnerability could be resulted from risks due to CC.

+ SI impacted the most on land use in Vung Liem district, a part of Tra On and Mang Thit districts, accordingly impacted quality and function of land types, especially land for agricultural production.

+ Flood has impacted to a large area of Vinh Long province, especially in Vung Liem, Long Ho, Binh Minh districts, and Vinh Long city, etc.

+ Temperature, drought, precipitation, and landslide have caused insignificant vulnerability. However, unexpected evolutions and unpredictable impact intensity have posed requirements of monitoring changes of the weather, climate, and indicate timely warnings to effectively reduce related damages.

4. CONCLUSION

On the basis of assessment of AC and risk level, vulnerability to CC of the sectors and areas in Vinh Long province were assessed. The results showed that agriculture, infrastructure (transportation and construction), and land use were the most vulnerable sectors. Flood, SI, and increase in temperature would impact *agriculture* in Vinh Long province, especially in Vung Liem, Long Ho, and Tam Binh districts. *Infrastructure* in Vinh Long city and Binh Minh district had the highest V due to flood while Tam Binh, Tra On,

Long Ho and Vung Liem districts would have risks from storm. Regarding *land use sector*, SI would impact agricultural areas in Vung Liem, a part of Tra On and Mang Thit districts while flood would impact large area of Vinh Long province, especially in Vung Liem, Long Ho, Binh Minh districts, and Vinh Long city. The research also showed Long Ho, Vung Liem, Tam Binh districts, and Vinh Long city would be vulnerable areas due to CC, needed planning coping solutions in order to reduce damages from CC and to ensure sustainable development goals of the province.

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Đánh giá tính dễ bị tổn thương do biến đổi khí hậu tại tỉnh Vĩnh Long

Lê Ngọc Tuấn[1], Nguyễn Văn Bằng[2]

[1]Trường Đại học Khoa học Tự nhiên, ĐHQG-HCM,
[2]Viện Khoa học Khí Tượng Thủy Văn và Biến đổi khí hậu
Tác giả liên hệ: lntuan@hcmus.edu.vn

Tóm tắt—**Nghiên cứu nhằm mục tiêu đánh giá tính dễ bị tổn thương (TDBTT) do biến đổi khí hậu (BĐKH) trên địa bàn tỉnh Vĩnh Long đến năm 2020. Các yếu tố được xem xét bao gồm ngập lụt, xâm nhập mặn, hạn hán, sạt lở, giông lốc, nhiệt độ và lượng mưa. Bên cạnh phương pháp điều tra xã hội học, ma trận đánh giá rủi ro, đánh giá năng lực thích ứng…, TDBTT do BĐKH được đánh giá thông qua phương pháp chỉ số. Kết quả cho thấy trong số 8 huyện thị tại địa phương, huyện Long Hồ, Vũng Liêm, thành phố Vĩnh Long và huyện Tam Bình DBTT nhất do BĐKH. Bên cạnh đó, các lĩnh vực đáng quan tâm trong mối quan hệ với BĐKH bao gồm nông nghiệp, hạ tầng và sử dụng đất. Nghiên cứu chỉ ra các khu vực và lĩnh vực DBTT là cơ sở quan trọng cho việc hoạch định các giải pháp ứng phó với BĐKH tương thích tại địa phương.**

Từ khóa—**biến đổi khí hậu, khả năng thích ứng, rủi ro, tính dễ bị tổn thương.**