

Assessing impacts of climate change to landuse sector in Vinh Long province

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(Received on 29th December 2016, accepted on 17th January 2017)

ASBTRACT

This work aimed at assessing impacts of climate change (CC) on landuse sector in Vinh Long province to 2020. Flood, saltwater intrusion (SI), drought, landslide, storm, temperature, rainfall were taken into consideration and assessed by data collection, matrix, expert, SWOT, and GIS methods, etc. Results showed that flood and SI were the main factors impacting landuse

Key words: *land use, climate change, saltwater intrusion, flood*

sector in VinhLong province, especially agricultural land. In all 8 considered districts, in the context of CC, landuse sectors in VungLiem, TraOn, and MangThit districts were of the consideration. Besides, this research indicated strengths, weaknesses, opportunities, and threats of land use sector in the relationship to CC in the local which are important basis for planning suitable adaption measures.

INTRODUCTION

Climate change (CC) is one of the top concerns of nations and territories all over the world. In this context, Vietnam is one of the 5 countries the most affected [1], especially the delta and coastal areas such as the MeKong Delta with the risks of about 39 % acreage flooded in case of 1m sea level rise [2]. Therefore, impacts of CC (both positive and negative) need assessing to provide the necessary information to perform plans, projects, monitors, etc. contributing to the improvement of the adaptability of the system.

CC with manifestations such as temperature increase, precipitation changes, sea level rise, the extreme weather phenomena, etc. heavily impact people and socio-economic sectors where land use is one of sensitive subjects to CC [3, 4], especially to flood and saltwater intrusion (SI). Many different methods have been used to study the relationship between CC and landuse sector, such as: methods based on historical climate data to assess impacts on landuse sector [5]; linked

diagram among CC, disaster management, and landuse planning to propose suitable adaption measures [6]; CLUE model (*Conversion of Land Use and Effect*) to assess impacts of CC on landuse planning [7-9], Stochastic Climate model to assess impacts of temperature, wind speed, and precipitation on landuse planning [10]; GIS and remote sensing to assess impacts of rainfall, temperature in particular and CC in general on landuse [11, 12]; place-based model (integrating social, environment, and natural systems) to assess vulnerability [13, 14], etc. Beatley [15] indicated that sustainability, decreasing risks, and the adaptation of community are important factors to balance the relationship between CC and landuse planning.

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 sea level, consequently, the north of the QL1 (Highway 1) is

usually inundated by flood; area between the QL1 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, natural 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 [16].

Therefore, this research aimed at assessing impacts of CC on landuse sector in Vinh Long province to 2020, indicating landuse types needing taking into account according to main impacts of CC, providing basis for planning adaptive measures, contributing to the sustainable development goals of the local.

METHODS

Impacts of CC were assessed by related factors such as flood, SI, drought, storm, precipitation, and temperature on landuse sector of Vinh Long province (including Vinh Long city, VungLiem, MangThit, TraOn, TamBinh, BinhTan, BinhMinh, and LongHo districts). Agricultural and non-agricultural land groups were taken into consideration due to a very small acreage of unused land group (about 0.09 %) [17].

Data collection and processing method

Data and documents related to landuse, the local CC factors, damages, CC coping plans of the landuse sector, etc. were collected, then processed by Excel software. Besides, research aimed at assessing impacts of CC so simulation results of CC scenarios (by SIMCLIM software, according to AR4 record of IPCC [18]), risks of SI and flood due to sea level rise 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).

Geographic Information System (GIS) method

The work used Mapinfo 11.5 and ArGIS software to establish maps and calculate impact scope of flood, SI, temperature, and rainfall, etc. on landuse in Vinh Long province to 2020.

CC risk assessment matrix

This method was used to assess risks due to CC factors to landuse sector serving determination of concerned areas with respective causes (i.e. the concerned areas and affecting subjects). Depending on occurrence possibility and related damages, risk level due to each CC factor in each local was assessed and classified according to the following scale as presented in Table 1.

Table 1. Risk level scale due to CC

0 < RR ≤ 1	1 < RR ≤ 2	2 < RR ≤ 3	3 < RR ≤ 4	4 < RR ≤ 5
Very low	Low	Average	High	Very high

Expert method

This method was used to determine weights of CC factors in the relationship to landuse sector

based on 20 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): $m_i = \text{Total score of factor } i / \text{Number of questionnaires}$; (iii) Calculating 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): $w_i = \frac{w_i'}{\sum_1^n w_i'}$

SWOT method (S-Strengths; W-Weaknesses; O-Opportunities; T-Threats)

SWOT was used to determine causes and to propose adaption measures to CC of landuse sector in Vinh Long province: (i) Determine S and W of landuse sector in Vinh Long province; (ii) Determine O and T of external factors impacting landuse sector in relation to CC; (iii) Analyse and combine logic pairs (S-O, S-T, W-O, W-T), then determine defective chains and propose compatible adaptive measures.

RESULTS AND DISCUSSION

Current status and landuse planning in Vinh Long province to 2020

Agriculture is a main economic activity, accounting for over 78 % of the natural area [17], contributing more than 33 % of the total economic value of sectors in Vinh Long province [19]. Rice planting activities (LUC) dominates agricultural area mainly distributed in Tam Binh, Vung Liem, and Tra On districts; followed by *perennial land* (CLN), about 19,200 ha, mostly in Tra On, Long Ho, and Vung Liem districts. For *non-agricultural land group*, (i) countryside and urban living lands are mainly distributed in Tam Binh and Tra On districts; (ii) dedicated land for other purposes (offices, security, defense, business, public, etc.) are mostly in Long Ho, Mang Thit districts and Vinh Long city, etc. *Unused land*, about 110ha, accounting for 0.09 % of the natural area of Vinh Long province. By

2020, in Vinh Long province, there will be 74.08 % of natural area used for agricultural activities and the rest (25.92%) for non-agricultural ones [17].

Impact assessment of CC to land use sector in Vinh Long Province *Agricultural land group*

Inundation by tide: Inundation is the factor that most strongly influenced agricultural land types in Vinh Long Province.

Regarding rice, calculations showed about 20.000 ha of rice area (LUC) to be affected by flood, accounting for nearly 28 % of total rice land area in the province. Districts were heavily affected as Vung Liem (6,680.15 ha, 45.16 %), Long Ho (2,909.09 ha, 42.91 %), and Tam Binh (2,886.87 ha, 17.23 %). By 2020, flooded area could decrease (about 19,850 ha) but flooded rate could increase (accounting for 30.8% of the rice land area in the province) (Table 2, Fig. 1A). This can be explained by the change in rice landuse planning in 2020.

Besides, perennial land group (CLN) was also impacted by flood. Calculation showed about 4,543 ha of perennial plant area to be flooded (accounting for 23.64 %), distributed in Long Ho, Binh Minh, and Tra On districts (Fig. 1B). By 2020, flooded perennial plant area could be about 3,544 ha. Similar to rice, because of adjusting landuse planning, flooded perennial plant area could decrease while flooded rate tends to increase (Table 2).

The province has 1,750 ha of annual crop land (HNK) but 323 ha was flooded (accounting for 18.44%). Binh Minh district had the largest flooded area. Calculations for 2020 showed flooded annual crop area to be about 378.7 ha, increasing about 56 ha as compared to that in the current status. Binh Minh district needs taking into concern due to about 93 % of annual crop area likely affected by flood (Table 2).

Regarding aquacultural activities (NTS), the province has 1,109 ha for this purpose but 43 % of which was in risk of flood, especially in Long Ho and

Tam Binh districts. By 2020, following the increase in aquaculture area in the province (2,052 ha), the area sensitive to flood could expand, including Tra

On, Long Ho, Vung Liem, and Mang Thit districts (Table 2).

Table 2. Agricultural area (ha) having the risk of flood

Code	Times		Binh Minh	Binh Tan	Long Ho	Mang Thit	Tam Binh	Vinh Long city	Tra On	Vung Liem	Total
LUC	Current	ha	1,465.6	2,050.4	2,909.1	1,713.1	2,886.9	107.8	2,141.2	6,680.2	19,954.3
		%	37.1	21.3	42.9	24.6	17.2	23.2	17.7	45.2	28.0
	2020 – B2	ha	1,084.1	1,733.4	2,607.3	1,839.1	2,650.6	26.6	2,327.1	7,581.9	19,850.1
		%	36.3	20.7	44.9	29.8	16.7	9.1	20.3	56.0	30.8
CLN	Current	ha	879.6	115.4	957.6	404.2	288.0	577.5	674.4	646.4	4,543.0
		%	55.6	11.4	26.8	19.8	13.4	46.7	15.2	20.2	23.6
	2020 – B2	ha	579.3	76.5	970.0	457.2	245.7	4.8	532.2	678.0	3,543.7
		%	58.6	11.0	33.1	28.4	13.8	12.8	15.4	25.8	25.1
NTS	Current	ha	19.3	6.5	168.2	63.7	102.3	22.7	39.1	56.2	477.9
		%	59.8	4.6	51.4	49.0	56.4	67.9	41.3	32.9	43.1
	2020 – B2	ha	56.5	-	198.4	139.1	35.2	-	417.7	174.2	1,021.2
		%	82.3	-	71.4	72.0	34.9	-	76.1	30.9	49.8
HNK	Current	ha	156.5	23.5	34.0	20.0	30.0	6.9	23.1	28.9	322.8
		%	65.1	5.1	36.0	30.8	11.1	22.8	8.4	9.0	18.4
	2020 – B2	ha	203.2	34.6	46.6	85.9	8.3	-	-	-	378.7
		%	93.0	9.5	36.7	80.1	18.5	-	-	-	40.4
Total	Current	ha	2,521.0	2,195.8	4,068.9	2,200.9	3,307.2	714.9	2,877.8	7,411.6	25,298.0
		%	43.5	19.6	37.8	23.9	17.1	40.5	17.0	40.1	27.1
	2020 – B2	ha	1,923.2	1,844.5	3,822.4	2,521.2	2,939.8	31.4	3,277.0	8,434.2	24,793.7
		%	45.1	18.9	41.8	31.2	16.5	9.5	21.1	50.4	30.4

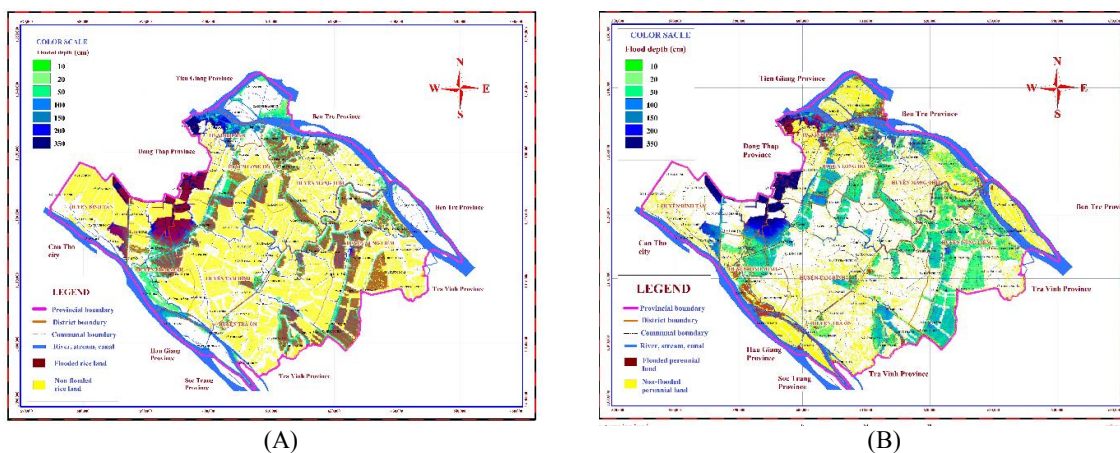


Fig. 1. Maps of current status of inundation in Vinh Long province: (A) rice land; (B) perennial plant land
 - SI and drought

Table 3. Agricultural area (ha) having the risk of SI in Vinh Long province

Code	Times		Mang Thit		Tra On		Vung Liem		Total	
			1‰	4‰	1‰	4‰	1‰	4‰	1‰	4‰
LUC	Current	ha	582.64	0	1,036.15	0	13,016.78	767.28	14,635.57	767.28
		%	8.38		8.56		88.01	5.19	20.50	1.07
	2020 – B2	ha	991.33	0	2,475.29	0	12,915.94	2,032.32	16,382.56	2,032.32
		%	16.09		21.61		95.48	15.02	25.41	3.15
CLN	Current	ha	625.74	0	144.99	0	2,873.62	257.42	3,644.35	257.42
		%	30.59		3.28		89.78	8.04	18.96	1.34
	2020 – B2	ha	827.71	0	403.29	0	2,508.01	834.37	3,739.01	834.37
		%	51.39		11.64		95.53	31.78	26.44	5.90
NTS	Current	ha	35.74	0	0.90	0	171.42	21.86	208.06	21.86
		%	27.51		0.94		95.7	12.21	18.76	1.97
	2020 – B2	ha	112.34	0	15.06	0	571.42	258.84	698.81	258.84
		%	58.13		2.74		98.88	44.79	34.05	12.61
HNK	Current	ha	6.02	0	3.89	0	275.69	83.74	285.60	83.74
		%	9.29		1.43		86.03	26.13	16.31	4.78
	2020 – B2	ha	0	0	0	0	0	0	0	0
		%								
Total	Current	ha	1,250.15	0	1,185.92	0	16,337.50	1,130.9	18,773.57	1,130.29
		%	13.60		7.02		88.39	6.12	20.08	1.21
	2020 – B2	ha	1,931.37	0	2,893.64	0	15,995.37	3,125.54	20,820.38	3,125.54
		%	23.93		18.64		95.60	18.68	25.52	3.83

In all landuse types in Vinh Long province, agricultural landuse is the most sensitive to SI, especially in Vung Liem (0.5–4 ‰), Mang Thit (0.5–1 ‰), and Tra On districts (0.5–1 ‰). Calculated results showed about 18,700 ha (20.08 % of total agricultural area in the province) and about 1,130 ha of agricultural area (1.21 %) to be in 1 ‰ and 4 ‰ salty areas, respectively (Table 3). According to medium emission scenario (B2 scenario), SI tends to expand in southern area of Tra On district and northern area of Mang Thit district, nearby Hau river and Co Chien river.

Vung Liem district could be mostly affected because most agricultural area was in 1 ‰ salty area (Table 3), in which, a part of Trung Nghia, Trung Ngai, Trung Thanh Dong, and Quoi Thien communes were affected by salinity of 4 ‰ (Fig. 2 and 3).

In all landuse types, rice and perennial plant land areas were significantly affected by SI, especially Vung Liem, Mang Thit, and Tra On districts. Notably, by 2020, the area affected by SI could expand larger than that in the current status.

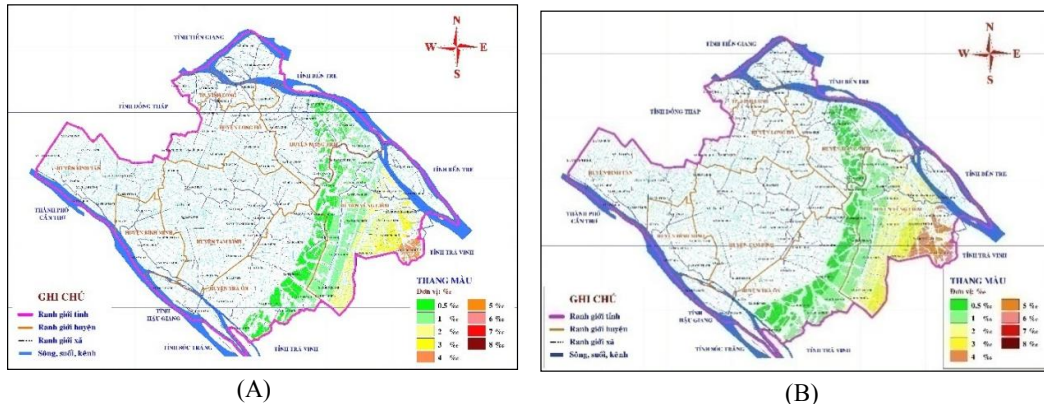


Fig. 2. Rice land having risk of SI in Vinh Long province: (A) Current status, (B) 2020 – B2 Scenario

Beside SI, drought is also the factor exacerbating impacts of SI. Drought often occurs in high areas not taking advantages of gravity irrigation and semi-gravity irrigation, leading to the propagation of salinity to inland, and then

affect the growth of rice as well as domestic water supply. In 2016, drought harmed 1,884 ha of crop in Vung Liem district, corresponding to 16 billion VND [19].

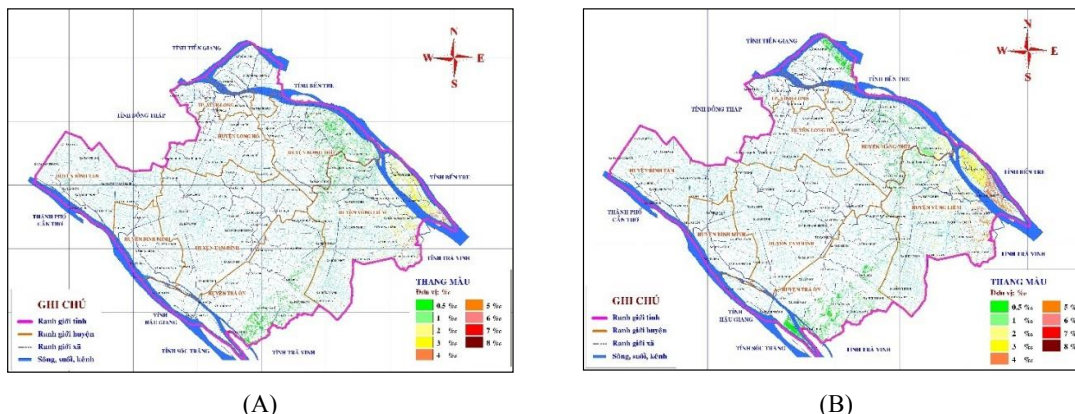


Fig. 3. Perennial plant land having risk of SI: (A) Current status, (B) 2020 – B2 Scenario

- Other phenomena

Riverbank landslide often occurs in soft ground areas nearby riverbank and mostly affects irrigation works, houses, traffic, etc. For agricultural land use sector, landslide insignificantly affects. Temperature, rainfall, and storm in Vinh Long province also resulted in similar statements.

To sum up, flood and SI are 2 main factors affecting agricultural land group of Vinh Long province, especially the rice land. This work also indicated agricultural land use sector in Vung Liem (due to flood, SI), Long Ho (due to flood), Tam Binh (due to flood), and Tra On (due to SI) districts need taking into the consideration. By 2020, in the context of CC increasingly serious, agricultural land use sector in Vinh Long province also face to more risks.

Non-agricultural land groups

- Inundation by tide

Calculated results showed about 9,146.65 ha of non-agricultural land area to be inundated (25% of total non-agricultural land area). Long Ho, Vung Liem, Tam Binh districts, and Vinh Long city need taking into the consideration due to more than 1,000 ha of non-agricultural land area inundated in each local. By 2020, the risk of flood could be 2 times as many as that in the current (up to 17,411.67 ha) due to impacts of sea level rise as well as the increase in total area of non-agricultural land (over 50,000 ha) according to land use planning. Long Ho, Vung Liem districts and Vinh Long city could be still sensitive areas to flood and CC (Table 4).

Table 4. Area (ha) of non-agricultural having the risk of flood in Vinh Long Province

Code			Binh Minh	Binh Tan	Long Ho	Mang Thit	Tam Binh	Vinh Long	Tra On	Vung Liem	Total
OTC	Current	ha	774.1	423.6	1,412.8	724.8	1,045.6	785.9	938.4	1,668.8	7,774
		%	41.0	18.6	29.3	21.5	16.4	53.4	15.3	23.7	23.3
	2020 – 2nd	ha	1,296.3	640.4	2,415.8	1,211.2	1,381.7	1,405.8	1,479.0	2,927.5	12,757.7

CDG	Current	%	50.5	20.8	41.6	29.2	18.8	61.2	20.6	35.4	31.4
		ha	143.0	118.0	389.1	131.0	99.7	282.8	16.5	41.1	1,221.2
	2020 – 2nd	ha	522.5	545.1	1,001.6	470	359.3	867.4	333.2	365.4	4,464.5
		%	43.1	45.9	57.6	45.2	32.5	68.2	32.0	42.3	47.2
NTD	Current	ha	7.0	1.7	23.6	17.8	9.3	27.5	14.2	50.4	151.4
		%	34.2	9.6	32.3	19.7	20.0	64	11.5	29.1	25.8
	2020 – 2nd	ha	7.8	1.3	30.6	25.1	17.6	22.9	20	64.1	189.4
		%	39.2	7.4	41.1	31.2	29.6	53.5	17.1	36.4	32.2
Total	Current	ha	924.2	543.4	1,825.4	873.6	1,154.6	1,096.2	969.0	1,760.2	9,146.6
		%	43.3	21.9	33.0	22.2	17.4	60.2	15.2	24	25.2
	2020 – 2nd	ha	1,826.6	1,186.7	3,448.1	1,706.3	1,758.6	2,296.1	1,832.2	3,357.1	17,411.7
		%	48.1	27.7	45.3	32.4	20.7	63.6	22.0	36.0	34.3

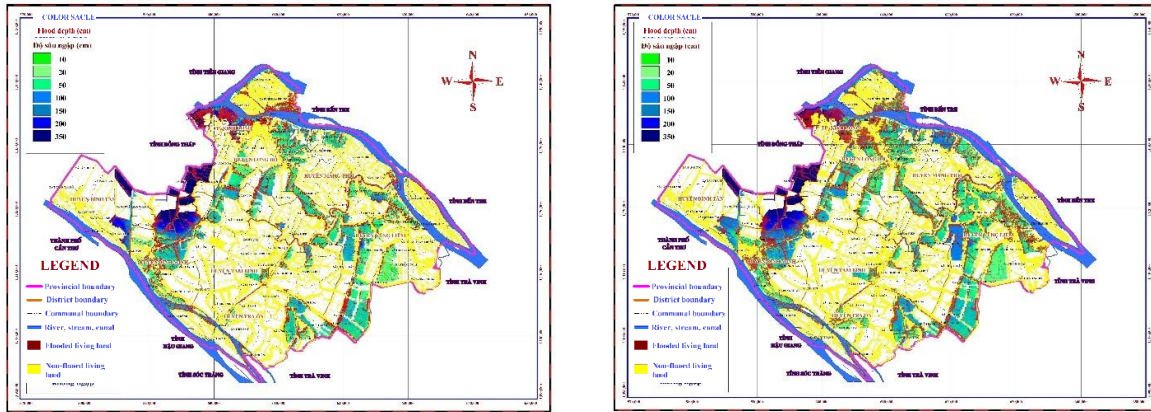


Fig. 4. Land having risk of flood in Vinh Long province: (A) Current status, (B) 2020 – Scenario

According to Table 4, while graveyard land is only 587 ha (1.6 %) and insignificantly changes to 2020, living land and dedicated land are 2 main types of non-agricultural land with 33,419.97 ha (92 %) and 2,261.2 ha (6 %), respectively, therefore, the latter two types were taken into the consideration in this work.

Living land: total flooded area was about 7,774 ha (23 % of province area). By 2020, flooded rate tends to increase. With specific characteristics of urban area, Vinh Long city and Binh Minh town had the highest rate of flooded area corresponding to 41 % and 53.4 %. These figures could be 50.5 % and 61.2 %, respectively in 2020 (Table 4 – Fig. 4).

Dedicated land: calculated results showed more than 1,200 ha (54 %) of dedicated land could

be flooded currently; distributed in Vinh Long city (282 ha, accounting for 92 %), the highest flooded rate of dedicated land, followed by Binh Tan, Binh Minh, and Long Ho districts corresponding 118 ha (65.7 %), 143 ha (64.25 %), and 389 ha (61.4 %), respectively (Table 4). By 2020, the flooded dedicated land area in the whole province could increase as 4 times many as that in the current status, about 4,464 ha, noted in Long Ho, Vinh Long city, and Binh Tan. It could be explained by impacts of sea level rise in the context of CC as well as the expansion of dedicated land area in the future (9,461.77 ha, as 4 times more than as that in the current status).

- *Riverbank landslide*

Riverbank landslide often occurs in the province, especially in Tra On, Vinh Long City,

Vung Liem, and Long Ho districts. In 2014, there were 6 landslide positions in the inland and along main rivers in Mang Thit, Long Ho districts and Vinh Long city, destroyed about 250m of riverbank, dikes, and roads, etc. In 2015, there were 39 landslide positions extraordinarily occurring (excepting the landslide positions at construction sites), resulting in damages to property, houses, crops as well as the human's life [21]. In general, landslide affects infrastructures in Vung Liem, Long Ho, Tra On, and Mang Thit districts, especially in Vinh Long city.

- *Other phenomena*

Drought: in recent years, droughts have widely occurred at the end of April. Vung Liem, Binh Tan, Tam Binh, and a part of Binh Minh districts (Dong Thanh commune) are needed to be

yaken into the consideration. However, *drought* as well as *SI* insignificantly affect non-agricultural landuse in the province while *rainfall and storm* mostly affect infrastructures and people.

Similar to agricultural land group, *flood* is the top concern of non-agricultural land group in Vinh Long province. Besides, riverbank landslide also causes certain impacts. Accordingly, non-agricultural landuse sector in Long Ho, Vung Liem, Tam Binh districts and Vinh Long city need concerning in the context of CC.

Determination of concerned CC factors and hotspot areas

Based on the impact level and possibility of appearance of CC factors, the CC risk assessment matrix for landuse sector in Vinh Long province was presented in Table 5.

Table 5. The CC risk assessment for landuse sector in Vinh Long province (*: weight)

District/ city		SI	Flood	Land- slide	Drought	Temper- ature	Rain- fall	Storm	Total	
		0.19*	0.23	0.18	0.12	0.11	0.1	0.07	Average	Max
Binh Minh	Current	0	2	1	1	0	0	0	0.76	2
	2020	0	3	1	1	0	0	0	0.99	3
Binh Tan	Current	0	1	0	0	0	0	0	0.23	1
	2020	0	2	0	0	0	0	0	0.46	2
Long Ho	Current	0	4	0	0	0	0	0	0.92	4
	2020	1	4	1	0	0	0	0	1.29	4
Mang Thit	Current	3	2	1	0	0	0	0	1.21	3
	2020	4	3	0	0	0	0	0	1.45	4
Tam Binh	Current	0	4	0	1	0	0	0	1.04	4
	2020	1	4	0	1	0	0	0	1.23	4
Vinh Long city	Current	0	2	2	0	0	0	0	0.82	2
	2020	0	3	2	0	0	0	0	1.05	3
Tra On	Current	3	3	2	0	0	0	0	1.62	3
	2020	4	4	2	0	0	0	0	2.04	4
Vung Liem	Current	4	4	1	3	0	0	0	2.22	4
	2020	5	5	1	3	0	0	0	2.64	5
Total	Current	10	22	7	5	0	0	0		
	2020	15	28	7	5	0	0	0		

Table 5 indicated the flood and SI, main factors increasing risk for landuse sector of Vinh Long province, especially flood due to its wide scope and high level of impacts. The areas are needed to be taken into the consideration in the

relationship between landuse sector and CC factors include Vung Liem, Tra On, and Mang Thit districts (due to flood and SI), Vinh Long city and Binh Minh town (due to flood) (Fig. 5).

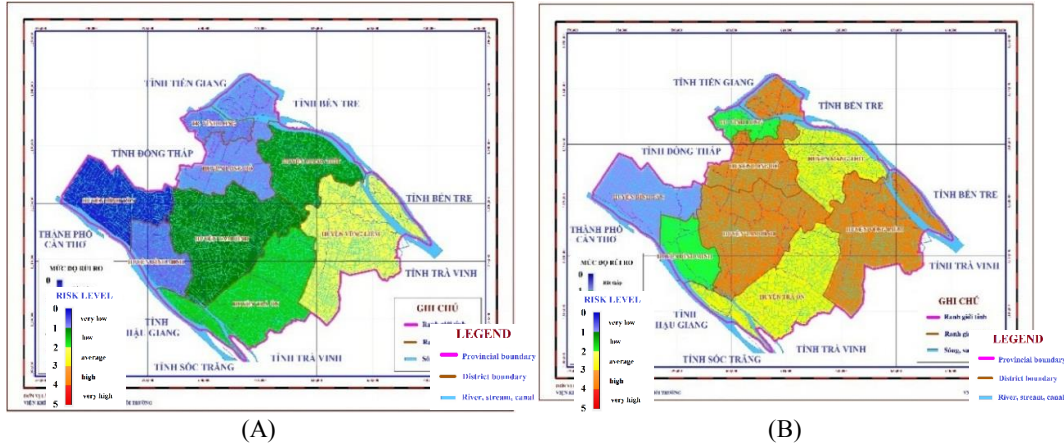


Fig. 5. Current status of risk index due to CC of landuse sector in Vinh Long Province: (A) Average; (B) Maximum
Opportunities and Threats of land use sector in Vinh Long province in the context of CC

Table 6 recapitulated of strenghts, weaknesses, opportunities, and threats of landuse sector in Vinh Long province in the context of CC.

Table 6. Strenghts, weaknesses, oppotunities, and threats of landuse sector in Vinh Long province in the context of CC

Strenght (S)	Weakness (W)
<ul style="list-style-type: none"> - S1: Relative flat terrain; innng from Tien river and Hau river; relative good soil quality (balances nutritional ingredients) [16]. - S2: Located in the center of Mekong delta; thriving agriculture sector; ensurement of local food security. - S3: Medium adaptive capability to CC of the community and local authorities [20]. - S4: Being particularly interested planning and orientation of exploiting and developing landuse sector to 2020, vision to 2030 [16]. - S5: Investment of irrigation system and dikes to prevent flood, riverbank landslide, etc [20]. 	<ul style="list-style-type: none"> - W1: Hollow terrain and relative low (high risk of tidal flooding). - W2: Limited experience of response to CC of community in some locals [20]. - W3: Limited capability of accessing CC information of community [20]. - W4: Lack of adequate attention of responding to climate change in a number of state authorities [20]. - W5: Low effectiveness in implementation of CC coping plan in some locals (i.e. discrete, not focus) [20]. - W6: Complex river system; Being affected by semi-diurnal tide (risk of SI)
Opportunities (O)	Threats (T)
<ul style="list-style-type: none"> - O1: Advantages for agricultural sector due to an increase in temperature and prolonged dry season (to dry agricultural products, etc) - O2: Opportunities to mobilize finance to cope with CC and disasters from government, local authorities, and international sources (AFD, New Zealand partnerships for International Development Fund, etc), [22] - O3: Ease of spreading CC information on different media (Tv, internet, newspaper, etc.) 	<ul style="list-style-type: none"> - T1: Occurrence of flooding almost over the province; tendency to increase to 2020. - T2: SI in Vung Liem, Tra On, and Mang Thit districts; tendency to increasingly propagate to the inland - T3: Risks of droughts combining to tides

Accordingly, relationships among S, W, O, and T were as follows:

(i) S1 + O2: Increasing investment (both internal and external of the province) to improve

agricultural land quality and ensure the food security.

(ii) S2 + O1: Taking advantages of temperature increase to diversify ways of processing agricultural products and to save energy.

(iii) S3 + O3: Improving the respond capacity to CC of community and local authorities by assistant programs, finance sources from government and local authorities as well as international organizations.

(iv) O3 – W3: Increasing the response capability to CC by increasing communication programs.

(v) O2 – W1, W6: Taking advantages of funding and financial supports; studying and constructing suitable tidal dyke system as well as, minimize SI.

(vi) S3 - T1, T2, T3: Promoting the strengths of coping capacity of community in the context of increasingly serious CC.

(vii) S4 – T1, T2: Studying and suitable allocating land resource to ensure the socio-economic development as well as to minimize CC damages.

(viii) S5 – T1: Taking into account effects of flooding in designing and constructing irrigation system in the local.

(ix) T2 – W1: Setting up pump stations, irrigation dikes, etc. to minimize CC impacts on low terrain and hollow areas in the local.

(x) T1, T2 – W5: Planning the CC response programs, especially response to flooding and SI for landuse sector.

To sum up, solutions contributing to improve the respond capacity to CC of landuse sector in Vinh Long province including: adaptive measures (iii, v, vii, ix, x), mitigative measures (ii) and assistant measures (i, iv, vi, viii), matching the Support Programme to respond to climate change in Vietnam [23].

CONCLUSION

The research aimed at assessing impacts of CC on landuse sector in Vinh Long province to 2020. Regarding the *agricultural land group* (the most affected group), flooding and SI were 2 main factors impacting most seriously, especially in Vung Liem (flooding, SI), Tra On (flooding), and Mang Thit (flooding) districts. Droughts partly impacted Vung Liem district while rainfall, temperature, and storm insignificantly affected. Regarding *non-agricultural land group*, flooding and riverbank landslide need the attention, especially in Vinh Long city (flooding, landslide), Binh Minh town (flooding), and Tra On district (landslide). SI, temperature, rainfall, and storm, etc. had little impacts on this landuse type. Besides, this work analyzed strengths, weaknesses, opportunities, and threats of landuse sector in Vinh Long province. Measurementthe adaptive capacity to CC was then suggested, contributing to increase the CC response efficiency in the local.

Đánh giá tác động của biến đổi khí hậu đến lĩnh vực sử dụng đất tỉnh Vĩnh Long

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TÓM TẮT

Nghiên cứu nhằm mục tiêu đánh giá tác động của biến đổi khí hậu (BĐKH) đến lĩnh vực sử dụng đất (SDD) tỉnh Vĩnh Long đến năm 2020. Các yếu tố được xem xét, đánh giá bao gồm ngập, xâm nhập mặn (XNM), hạn hán, sạt lở, giông lốc, nhiệt độ và lượng mưa thông qua các phương pháp tổng hợp tài liệu, ma trận đánh giá, phương pháp chuyên gia, phân tích SWOT, GIS.... Kết quả cho thấy ngập và XNM tác động nhiều nhất đến lĩnh

vực SDD tỉnh Vĩnh Long, đặc biệt là loại hình đất nông nghiệp. Trong tất cả 8 huyện thị được xét, trước những diễn biến bất lợi của BĐKH, các địa phương có lĩnh vực SDD đáng quan tâm bao gồm huyện Vũng Liêm, Trà Ôn và Mang Thít. Bên cạnh đó, nghiên cứu cũng chỉ ra các thế mạnh, điểm yếu, cơ hội và thách thức của lĩnh vực SDD trong mối quan hệ với BĐKH tại địa phương làm cơ sở quan trọng để hoạch định các giải pháp thích ứng tương thích.

Từ khóa: sử dụng đất, biến đổi khí hậu, xâm nhập mặn, ngập lụt

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