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Community-Based Adaptation to Climate Change: A Case of Soc Trang, Vietnam

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Abstract Cu Lao Dung, a coastal district in the Soc Trang Province, is surrounded by Hau River and the East Sea. With that characteristic location, the district is deemed to be instantly susceptible to natural processes and calamities, including saline intrusion, alluvial, sedimentation, storm surges, inundation, soil degradation and especially coastal erosion. Those impacts have remarkably affected the society and economy of Cu Lao Dung. According to climate change scenarios for Vietnam released in 2012, more than 95% of Cu Lao Dung area will be inundated due to the rising sea level by 2050. Climate change modeling and assessment with past conditions indicate that climate change might significantly result in loss of agricultural land and increase of saline intrusion, inundated land, and soil degradation, etc. The purpose of this article is to analyze and assess thoroughly the vulnerability of Cu Lao Dung communities, in perspective of climate change impacts along with representing vulnerability commune-detailed levels through setting up a vulnerability map. Vulnerability and Capacity Assessment (VCA) and Rapid Integrated & Ecosystem-Based Assessment of Climate Change Vulnerability & Adaptation (RIVAA) are two principal methods of the study. The proposed solutions to enhance adaptive capacities to climate change based on existing sources of this area are also well discussed. The only remainder of this study is that information gathered lack synchronizing; therefore, vulnerability indexes of interference areas between communes are not appropriately demonstrated.

Keywords Cu Lao Dung, Soc Trang, Climate Change, Vulnerability, Adaptation

1. Introduction

Of Vietnam's regions, the Mekong Delta is generally regarded as the most severe influenced by climate change [1]. This is a quite low-elevation region, situating at the lower basin of Mekong River and confronting a significant number of hazards while the sea level is rising with consequences of the disappearance of lowland, the loss of cultivation land, the decline in biodiversity and the fall in freshwater availability.

Cu Lao Dung, a coastal district of the Soc Trang Province, is a territory located in a quite remarkable area, facing East Sea and Hau River to the West. In Soc Trang, this southeast district is well believed as the most vulnerable to climate change impacts like droughts, sea level rise, typhoons, tropical depressions, saline intrusion and other extreme events. Besides, main livelihoods of local community are sugarcane, produce and fruit tree cultivation as well as shrimp farming and fishery. Notwithstanding, such activities are highly depended on geomorphology, climate conditions and extant water resources [2-8]. Meanwhile, coastal areas in Vietnam are prone to be vulnerable under climate change impacts and extreme events [9]; thus, Cu Lao Dung's community can be affected considerably by these.

This article is established to assess thoroughly the vulnerability of typical ecosystems in Cu Lao Dung and main livelihoods of locals under climate change impacts. Simultaneously, adaptive capacity to climate change of local communities are examined to enhance resilience to climate change in accordance with community-based approach.

2. Study Location and Methods

Cu Lao Dung is geographically located from latitude 9°29' to 9°45' and from longitude 106°04' to 106°17', with Hau River across and formed by many cays (Figure 1). This is the largest island of Hau River, nearby East Sea, water-surrounded and having a vitally important position in terms of economy, society and national security of the Soc Trang Province. The district has 8 separate administrative units, namely An Thanh Nhat, An Thanh Tay, An Thanh Dong, Dai An 1, An Thanh Nhi, An Thanh 3, An Thanh Nam communes and Cu Lao Dung town.

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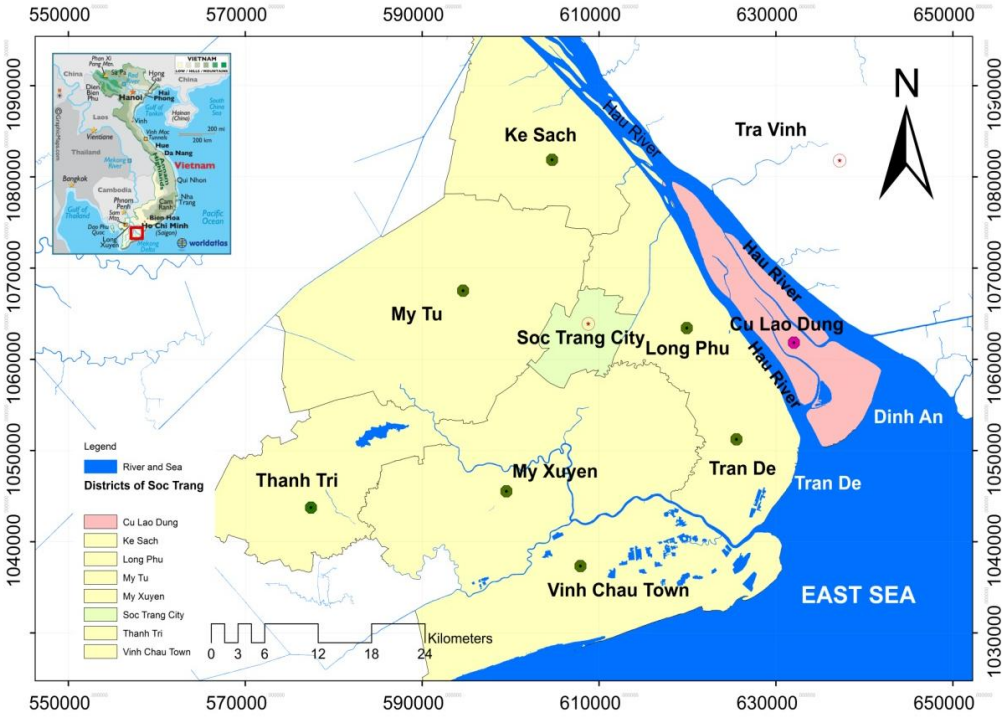

Figure 1. The position of the Cu Lao Dung District, Soc Trang Province

Table 1. Vulnerability Iindexes Built for Communities in Cu Lao Dung

Exposure (E)	Sensitivity (S)	Adaptive Capacity (AC)
1. Temperature increase 2. Sea level rise 3. Tropical depression 4. Saline intrusion 5. Precipitation growth	1. Community perception 2. Percentage of citizens over 65 years old[(q)] 3. Percentage of citizens under 4 years old[(q)] 4. Approach to sanitary water sources[(q)] 5. Livelihood[(q)] 6. Percentage of temporary households 7. Percentage of poverty-stricken households	1. Supportive policies of local government 2. Methods to update disasters' information[(q)] 3. Methods to cope with emergencies[(q)] 4. Percentage of knowledgable citizens about climate change impacts[(q)] 5. Methods to alter crops to adapt to weather conditions 6. Household income 7. Medical advances 8. Education establishment 9. Irrigation system

[(q)]: Data received from questionnaires. The others are collected from local governmental documents.

Assessing the vulnerability of a system, both natural and social (including climate change impacts), factors are analyzed and estimated: (i) exposure to climatic changes (high or low); (ii) sensitivity to changes (advantageous or disadvantageous); and (iii) adaptive capacity of that system to changes [10]. Hence, the vulnerability of a system under impacts of climate change can be represented as follows:

Vulnerability = f (exposure, sensitivity, adaptive capacity)

To assess vulnerability and adaptive capacity to climate change of Cu Lao Dung's communities, indirect assessments are conducted through susceptibility and levels of impacts of climate change to alternative ecosystems and livelihoods of communities. Two following main measures were carried out to assess vulnerability to climate change in Cu Lao Dung:

- Vulnerability and Capacity Assessment (VCA) [11]. This method is to assess climatic and natural disaster risks and how local communities employ resources.
- Rapid Integrated & Ecosystem-Based Assessment of Climate Change Vulnerability & Adaptation (RIVAA) [12]. This method is taken to examine information from two flows: authorities to communities (top-down) and communities to authorities (bottom-up).

To construct a vulnerability map, this study built up a set of vulnerability indicators, including: (i) exposure; (ii) sensitivity; (iii) adaptive capacity. Each indicator is an integration of vulnerability indexes [13, 14], based on statistics gained from questionnaires and local governmental documents as shown in Table 1.

According to World Bank's instruction [15], calculation parameters are as follows:

∗ Exposure to Climate Change is determined by:

$$E = [(SDT1+ ... + SDT12)/ 12 + (SDP1+ .. +SDP12)/ 12 + (SDH1+ .. +SDH12)/ 12 + (SDSal1+ .. +SDSal12)/ 12 + N_{th}] / 6 \quad (1)$$

With,

SDT_i: standard deviation of average temperature measured at Soc Trang station in month i

SDP_i: standard deviation of total precipitation measured at Dai Ngai station in month i

SDH_i: standard deviation of tidal level measured at Dai Ngai station in month i

$SDSal_i$: standard deviation of salinity level measured at Dai Ngai station in month i

N_{th}: frequency of storm surges/tropical depressions annually in the study area.

∗ Sensitivity of communities is estimated by:

$$S= [(s_1 + s_2)/2+ (s_3 + s_4)/2 + s_5 + s_6]/4 \quad (2)$$

With,

s_1: Ratio of over 65- years population

s_2: Ratio of under 4- years population

s_3: Ratio of households which yet do not know to diversify livelihoods

s_4: Ratio of destitute households

s_5: Ratio of makeshift households

s_6: Ratio of citizens who yet do not approach sanitary water resources

∗ Adaptive Capacity is addressed by:

$$A= [(a_1 + a_2 + a_3)/3 + a_4 + a_5 + a_6 + (a_7 + a_8)/2]/5 \quad (3)$$

With,

a_1: Ratio of citizens who have at least 3 methods to update adversities' information

a_2: Ratio of citizens who have at least 3 methods to deal with emergencies

a_3: Ratio of citizens who have participated in Climate Change lessons

a_4: Average personal income

a_5: Ratio of students who have not attended high school

a_6: Ratio of governmental officials who have met criteria

a_7: Ratio of irrigation channels which have met production and society requirements

a_8: Ratio of households which have frequent and safe approach to electricity

∗ Vulnerability is ciphered by:

$$\text{Vulnerability (V) = [Exposure (E)+ Sensitivity (S) + (1-Adaptive Capacity (AC))]/3} \quad (4)$$

Researches lasted from March 21st to April 19th, 2013 along with interviewing local government and community to gather informations such as weather data, climate-related risks, current adaptive means and action plans, communities' livelihoods and their perception regarding exploiting and guarding existing natural resources in the area.

3. Levels of Damage by Impacts of Climate Change in Cu Lao Dung

3.1. Characteristic Ecosystems and Contingent Livelihoods

Interview and survey consequences in Cu Lao Dung District indicates that main livelihoods in local area comprise: (i) *Sugarcane cultivation*; (ii) *Fruit trees production* (mango, coconut, longan, jack fruit, langsat, guava); (iii) *Vegetable and upland crops* (pumpkin, watermelon, indian taro); (iv) *Aquaculture* (extensive shrimp farming, extensive shrimp farming, extensive elongated goby, intensive elongated goby, Pseudapocryptes elongates breed and several other aquatic products at industrial scale); (v) *Service*: hired clam harvesting (or being a member of clam cooperative); hired sugarcane collecting; fishery; gathering shrimp, grab, fish and small-sized commerce (Figure 2).

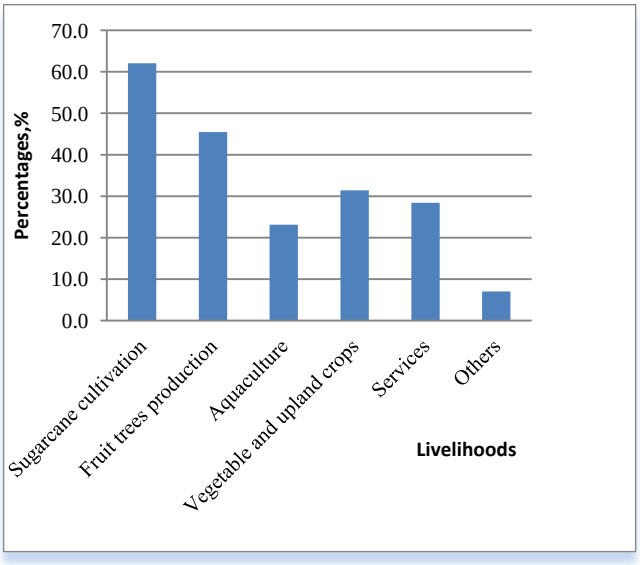

Figure 2. The main livelihoods of Cu Lao Dung's communities

Table 2. Ecosystems and Dependent Livelihoods

Ecosystems	Dependent livelihood
1. Estuaries	- Fishery, water transport (ferry, boat, etc.) - Exploiting shrimp, fishery services - Tapping the forest products along the coast line.
2. Mangroves	- Natural shrimp, fish, clam and shellfish catching - Exploiting mangroves
3. Alluvium	- Extensive shrimp and grab farming, clam and shellfish rearing - Shrimp catching
4. Sand dunes	- Sugarcane, produce and fruit tree production - Stock raising - Extensive shrimp farming - Logging and collecting forest products

Roughly 58.6% of households depend on sugarcane, which is the local principal product with the area of 8403.97 ha (occupying 32.15% of district's area and 52.1% of

agricultural area) [16], [17]. Other livelihoods such as shrimp rearing, fishery and services (clam and sugarcane harvesting), etc. similarly benefit from local existing natural resources. Mangrove and coastal alluvia ecosystems bring about the diversity of aquatic resources, yielding local fishermen various advantages. Estuarine brackish water renders the area with potentials to develop aquaculture. Accordingly, relevant services like sugarcane and clam gathering, etc are gradually rising. Overall, Cu Lao Dung's inhabitants dwell principally on agricultural practices. Economic activities are still depended drastically on natural surroundings and related ecosystems (estuaries, mangroves, alluvium, sand dunes). The relationship and dependency between local livelihoods and characteristic ecosystems in Cu Lao Dung are briefly demonstrated in Table 2.

3.2. Impacts of Climate Change on characteristic Ecosystems and main Livelihoods

Climatic factors contribute to changes upon characteristic ecosystems and main livelihoods of locals, including:

1) Erratic rains: counter-seasonal rain in dry seasons and heavy precipitation in rainy seasons;
2) Long-lasting heat waves;
3) Inundation associated with sea level rise;
4) Landslide due to the combination of waves, counterwinds and inundation;
5) Tropical depressions and typhoons.

Climate-related events and risks, which have resulted in both positive and negative effects on characteristic ecosystems, are represented in Table 3 and main livelihoods in Cu Lao Dung District are abstracted in Table 4.

Table 3. Impacts of Climate Change on Habitat and Ecosystems

Climate risks	Mani-festation	Negative impact	Positive influence
Counter-seasonal rain in dry season	In dry season, local great rains come suddenly, sometimes at nights.	▪ Sudden rains can conduce to the appearance of alum at cultivation floor and poison farmed trees. ▪ Some types of insect (mosquitoes, flies, etc.) may prosper after such rains.	▪ Some sorts of water-lacked and salty farmed trees can avoid withering. ▪ Decline forest fire risks. ▪ Saltiness could reduce. ▪ Dipping heat waves in dry seasons.
Irregular rain: long-lasting and intense rain and at the end of the rainy season	▪ At the onset of the rainy season, there appear sudden intense thundershowers. ▪ At the end of the rainy season, there occur irregular highly intensive long-lasting rains.	▪ Great rains might inundate, affecting farms. ▪ Biologic progress could be affected.	▪ Great rains at the onset of seasons bring about positive effects for farms, which are about to be prepared. ▪ Long-lasted great rains condition positively extensive shrimp farming, enhance metabolism inside aquatic farms and stimulate shrimp to grow stronger. ▪ Great rains mean more supply for fresh water
Long-lasting heat wave	▪ Unpredictable weather conditions in dry seasons. ▪ Higher frequency of days with temperature above 350C than 10 years ago.	▪ Heat waves cause dramatic diseases. ▪ Bivalves and mollusks growing on alluvium may die simultaneously owing to heat waves or heat-waves-related diseases. ▪ Maladies such as bird flu have a tendency to boom, affecting negatively birds in general.	▪ Flora may blossom thanks to increasing photosynthesis.
Inundation alongside sea level rise	▪ The rise of sea level alongside remarkable inundations within a year (October and November) cause the accelerating seriousness of saline intrusion.	▪ The area of mangroves might descend because of deep sinking. ▪ Salinity-tolerant species can be extinguished.	▪ Sedimentation advances may lead to constitution of new alluvium. ▪ Sand-exploitation areas are enriched by the amount of sand from eroded ones or from deposited alluvium.
Erosion due to the combination of waves, winds and inundation	▪ Inundation along with counterwind (especially in January and February) may cause erosion (as happened in An Thanh 3, An Thanh Dong and Dai An 1).	▪ Erosion can cause the loss of soil and areas of forest and therefore, the loss of natural nourishment for species (Figure 3a). ▪ Erosion may destroy the wave-protection-hedge (Figure 3b). ▪ Exploitation of sand along rivers could heighten the risk of land-sliding.	
Tropical depressions, typhoons and cyclones	▪ Tropical depression and typhoon are likely to climb compared to 10 years ago and defy formed regulations.	▪ Damage mangroves and living environs of many species. ▪ Speed up shoreline erosion…	l

Table 4. Impacts of Climate Change on Community' Main Livelihoods

Climate Risks	Mani-festation	Negative consequences	Positive consequences
Counter-seasonal rain in dry season	▪ In dry season, severe local rains come suddenly, sometimes at nights.	▪ Intensive farming is affected due to the diminishing salt concentration. ▪ Affect the quality and productivity of sugarcane (owing to the reduction in sweetness and devalue sugarcanes, irregular rains may inflict diseases on the elderly and children and make their family spend time to take care of them).	▪ Make the lack of household water less intense. ▪ Nourish some kinds of produce. ▪ Decline amounts of heat waves so citizens can be able to feel fresher.
Tropical depressions, typhoons and cyclones	▪ Tropical depression and typhoon are likely to climb compared to 10 years ago and defy formed regulations.	▪ Damage infrastructure, construction sites, housing and produce. ▪ Impose limits to the operation of fishing means. ▪ Some social events have to be detained. ▪ Repairing and relieving costs might be in the rise.	
Inundation alongside sea level rise	▪ The rise of sea level alongside remarkable inundations within a year (October and November) cause the accelerating seriousness of saline intrusion.	▪ Inundate produce ▪ Affect intensive shrimp farming ▪ Goods delivery may be tough due to inundations. ▪ Thunders thread farming activities and cause harm to housing.	▪ Be beneficial for pre-farming actions. ▪ Accelerate metabolism inside shrimp farms, thus improve shrimp development.
Long-lasting heat wave	▪ Unpredictable weather conditions in dry seasons. ▪ Higher frequency of days with temperature above 35^0C than 10 years ago.	▪ Salt concentration rise might impact extensive farming. ▪ Create benign conditions for diseases on sugarcane and other types of produce. ▪ Along with diseases which cause death to clamp pools. ▪ Domestic fowls might be destructed.	▪ Be valuable for sugarcane farming. ▪ Advantageous for desiccating farm products.
Tropical depressions, typhoons and cyclones	▪ Tropical depression and typhoon are likely to climb compared to 10 years ago and defy formed regulations.	▪ Increase salt concentration and obstruct the flow of water towards the sea, hence affect shrimp farming negatively ▪ It causes inundation, therefore, it creates hindrances to produce and fruit trees' practice ▪ Decrease agriculture, aquaculture and housing areas.	▪ Be benignant to highland because of stabilizing the level of water supply, deterring fresh water amount from penetrating deeply the earth and maintaining efficient moisture for produce's development.
Erosion due to the combination of waves, winds and inundation	▪ Inundation along with counter wind (especially in January and February) may cause erosion (as happened in An Thanh 3, An Thanh Dong and Dai An 1).	▪ Cause harm to shrimp farming, ▪ Erosion leads to the loss of land and natural nutrients for shrimp. ▪ Erosion destructs the defensive wall from strong waves due to making the loss of Sonneratia caseolaris forest.	▪ Enhance sedimentation process in nearby territories.

3.3. Levels of Vulnerability of Characteristic Ecosystems and Main Livelihoods

Vulnerability is estimated through a three-step process: (i) rate risks of ecosystems and livelihoods; (ii) rate adaptive capacity of communities regarding climate change; (iii) rate synthetically vulnerability identified from vulnerability matrixes compiled between risks and adaptive capacity of ecosystems and communities. Synthetic estimation results from vulnerability of communities are abstracted in Table 5.

- *Mangroves and Sand dunes* in Cu Lao Dung have *Moderate* level of vulnerability under climate change impacts and economic pressure. Therefore, it can be concluded: the authorities have had certain concern about conservation, protection and enhancement of resilience to climate change of local characteristic ecosystems.
- *Estuaries and Alluvia* are under *Moderate – High* level of vulnerability. These ecosystems are widely seen as being considerably sensitive to changes of weather and affected by communal activities. Solutions to adapt to climate change suggested by communities are not apparent and still passive. Water resource is contaminated by manufacturing and domestic activities. Water utilities like sewerage, dam, dock, ferry, hydroelectric dams on the upstream part of the Mekong River, water-adjusted facilities have caused cross-boundary impacts, diminishing water resources, alluvium and nutrients inside water. Shoreline erosion caused by typhoons, counterwinds and sea level rise are frequently and intensive. Locals often complain about alluvium being exploited by different communities,

comprising ones in Cu Lao Dung (locals) and ones from Long Phu District and Tra Vinh Province. This proves that alluvium management remains troubles.

- Two main livelihoods of communities in Cu Lao Dung, *sugarcane cultivating and shrimp farming*, are assessed as *High* level of vulnerability. Within these years, the cost is sliding upward from 87 to about 100 USD/ha, consisting of preparing oil, hiring labor, fertilizer and product-transport from farm to channel. Sugarcane productivity is from 115 to 130 ton/ha. Profit from sugarcane may be up to around 100 USD/ha (2005) [18]. Nonetheless, surveyed output represents that current profit is declining to 43 or 65 USD/ha; some households, especially, have not benefited from this plant. Other livelihoods, *produce, fruit tree and near-shore fishing*, are concerned to be vulnerable at *Moderate-High* level.

3.4. Vulnerability Map

The result of calculating vulnerability indexes for each commune based on the abovementioned equations indicate differences between each commune's figure. The correlation between 3 factors [19]: (i) exposure to natural impacts; (ii) sensitivity of community; (iii) adaptive capacity of community at each commune and correlation in regard to levels of vulnerability of alternative communes is presented in Figure 3. In accordance with this calculation, communes which have higher levels of vulnerability will be more likely to be vulnerable.

Results of calculation represent levels of vulnerability in Cu Lao Dung. With the assistance of ARCGIS, vulnerability map is constructed as shown in Figure 4.

From the vulnerability map, it can be pointed out that:

- Dai An 1 is the most vulnerable

Table 5. Levels of Vulnerability of Ecosystems and Livelihoods because of Impacts of Climate Change

Ecosystem/ Livelihood	Ranks of risk		Adaptive capacity		Level of vulnerability
	Livelihood	Ecosystem	Community	Institution	
Estuaries		*High*		*Mode-rate*	*Moderate - High*
Mangroves		*Moderate - High*		*High*	*Moderate - Low*
Alluvium		*Moderate - High*		*Mode-rate*	*Moderate - High*
Sand dunes		*Moderate - Low*		*Mode-rate*	*Moderate - Low*
Sugarcane cultivation	*Moderate -High*		Low		*High*
Intensive/ extensive shrimp farming	*High*		Low		*High*
Produce cultivation	*Moderate -High*		*Mode-rate*		*Moderate - High*
Near-shore fishing	*High*		*Mode-rate*		*Moderate - High*
Fruit tree production	*Moderate*		Low		*Moderate - High*

EVALUATION OF RISKS

Moderate: In accordance with local community, ongoing impacts and climatic and non-climatic risks have and ***are likely to cause some damage*** to the integrity and connectivity of ecosystems and their ability to supply livelihoods with principal eco-services.

High: According to local community, ongoing impacts and climatic and non-climatic risks have and are supposed to ***conduce toward severe loss*** to the integrity and connectivity of ecosystems, to their resilience, recovery and eco-services-supply ability.

Low: Based on communal opinions, ongoing impacts and climatic and non-climatic risks have and ***are going to result in harm*** to the integrity and connectivity of ecosystems, to their resilience, recovery and eco-services-supply ability.

* If risks on ecosystems are between Moderate and High, the suggested estimation will be Moderate – High

* If risks on ecosystems are between Moderate and Low, the suggested estimation will be Moderate – Low

EVALUATION OF ADAPTIVE CAPACITY

High: Communities are dealing *considerably well* with climatic and non-climatic impacts. They are capable of adjusting livelihood activities effectively when changes and accelerating climatic and non-climatic evens are taking place. They *are rendered with sufficient information regarding climate change scenarios and local development plans*. Solutions to cope with Climate Change at current *are appraised as highly feasible in the future*.

Moderate: Communities are *coping on average with* climatic and non-climatic impacts. They can adapt gradually from livelihoods while occurring climatic and non-climatic events. They are furnished with data about climate change scenarios and local development plans. Nonetheless, *contemporary adaptation solutions are assumed to be less effective in the future*.

Low: Communities are *passively arranging to conform* to climatic and non-climatic events. They are incapable of modifying and recuperating from mounting extreme climatic and non-climatic events. *They may not grasp any news about climate change scenarios and local development plans. Furthermore, their modern-day solutions to climate change are modestly regarded as being effective in the future*.

* If the adaptive capacity of communities between Moderate and High, the proposed assessment will be Moderate – High* If adaptive capacity of community is between Moderate and Low, the proposed assessment will be Moderate – Low

Cu Lao Dung town is the least vulnerable

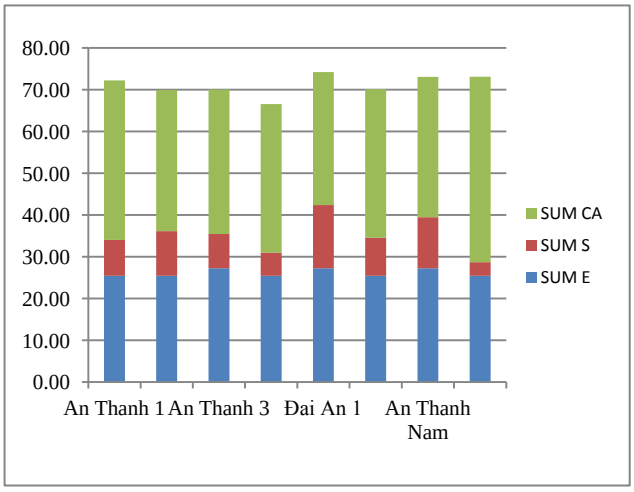

Figure 3. Factors of vulnerability indexes

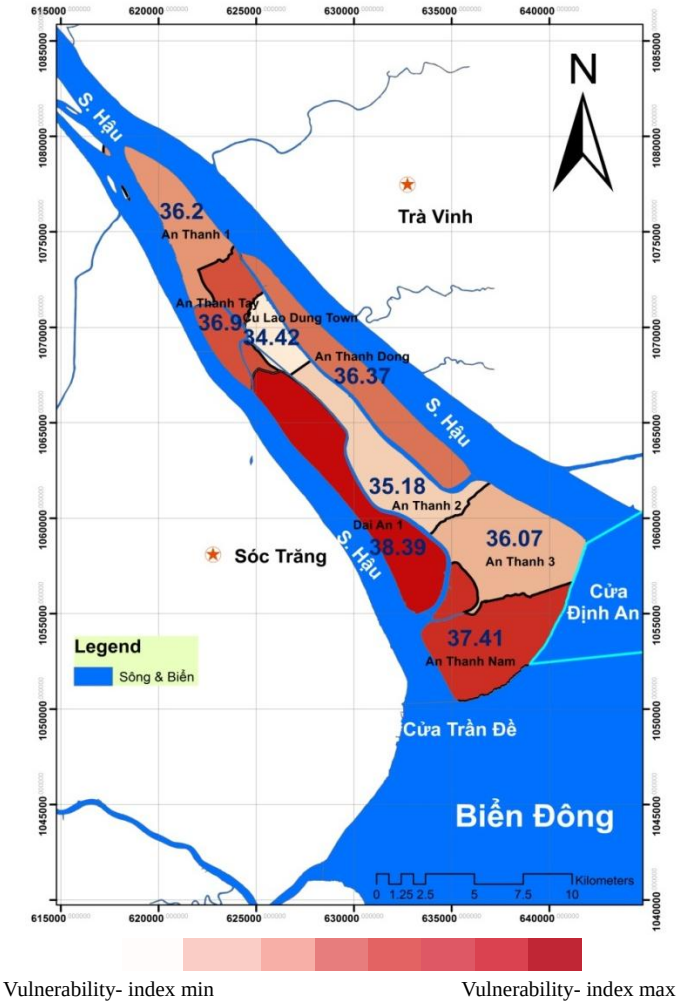

Figure 4. Vulnerability map for Cu Lao Dung

4. Community-Based Adaptive Solutions

From the assessment of the climate change impacts and risks to ecosystems and livelihoods in Cu Lao Dung due to weather, several groups decent community-based measures are proposed to adapt to climate change [20-25] as follows:

Group 1: Community-based adaptation to inundation and seal level rise such as enhancing forestry and improving irrigation works

Annually, particularly in July, August and September, under impacts of inundation and sea level rise, almost farm land is degraded severely, consequently affecting local livelihoods. The break of the ditch and the overflow of seawater contribute to landslide and therefore, interrupting agricultural activities beyond this range of ditch. Several measures listed hereafter can be applied to work the situation out:

(i) Local authorities may try to exert local capacities, especially in areas where impacts are most intense, to fortify the ditch. Community contributes their workforce to reinforcement dyke while local government looks for and supplies capital to civilians with what they need.

(ii) Planting forest on soil-sand interface. There may be some pilot projects on 1-ha area alongside the dyke, surrounding farm land. The most appropriate suggested species is nipa-palm.

(iii) Local government improves propagandistic campaigns to raise people's awareness of: role and value of mangroves, better irrigation, seasonal calendar adjustment and applying water-saving flora…Workshops can be organized involving raising environment-protection awareness conducted by local Women Union.

(iv) Effectively strengthen forest-management model being carried on by Deutsche Gesellschaft für Internationale Zusammenarbeit organization (GIZ). If people involve themselves in forestry, this activity will benefit them currently as well as their descendants in the foreseeable future.

Group 2: Approaching sustainable fishery in order to preserve aquatic lineage

Near-shore aquatic resources are becoming scarcer than previous times due to over-exploitive methods. One of the reasons is the blossoming number of fishermen and the employment of exploratory gadgets. Ordinary fishing means are nets, fishing rods, frames, rakes, rear-open nets, electric sticks, fish traps. Fishing by "frames" leads to vast death of fish because the size of the mesh is very small. This tool is used along with taking advantage of the flow and even small-sized fish can never avoid. The increasing usage of the tool is minimizing aquatic resources and not recommended by the government. Accordingly, to preserve natural beneficial aquatic products, suggestions are made as follows:

(i) Alter from destructive fishing appliances to more sustainable ones.

(ii) Conduct cooperative fishery model by establishing

fishing team to enhance the effectiveness of balancing between exploitation and preservation of typical aquatic species.

Group 3: Improve adaptive capacity to climate change for vulnerable targets through livelihood support and constituting freshwater, hygienic and environmental programme

The most vulnerable ones are the poverty-stricken and minority ethnic groups, who are less-educated and earn indecent income, as well as the unemployed, women and young children. Cu Lao Dung's people live primarily on existing resources, hardly find other alternatives. In this situation, local communities exploit natural resources all the way (involving destructive fishing and deforestation, etc.), thus making these resources exhausted. Furthermore, freshwater resource for daily activities is going to be rare as saline intrusion is booming. Aiming to tackle those issues, several adaptive actions are concerned:

(i) The government should support training courses for women to resolve occupation problems.
(ii) They should also constitute hygienic freshwater –supplying stations and provide indigent households with water tanks used in dry seasons.
(iii) The government needs to take care of building toilets for locals associated with propagandizing to raise awareness of protecting the environment so as to reduce contamination in rivers.
(iv) Improving livelihoods of the destitute by experimenting highly productive and well adaptable plant species in the mangrove, for example high-yield sugarcane.
(v) Learning lessons of climate change adaptive livelihood models and those yielding highly effective benefits in South East Asia.

Group 4: Raising local awareness in terms of impacts and adaptation to climate change

At shown in the survey results on the education, the amount of local inhabitants, who did not attend primary school, were over 35% and those were a mere 5% for people graduating from high school. Owing to the low level of people's literacy, environment-related skills and knowledge are still restrained. In daily livelihood activities, they are still lacking perception of protecting natural resources. More specifically, local inhabitants are still employing over-exploitation fishing apparatuses, demonstrating low awareness of conserving the environment and lacking teamwork ability to do so. Thence, following measures are proposed:

(i) Disseminating and encouraging to applying widely skills, knowledge in regard to environmental protection, climate change adaptation.
(ii) Setting up a core-force in propagandist actions, stimulating the participation of Women Union, Farmer Group, Young Communist Party, etc.

5. Conclusions

Cu Lao Dung is a sharply sensitive area to impacts of climate change due to geographic features and coastal location. Analysis and assessment illustrate that: (i) primary livelihoods are hugely contingent upon natural and climatic factors (husbandry with mainly sugarcane, fishing and shrimp farming); (ii) estuarial and alluvial ecosystems are damaged at *Moderate-High* level under economic pressure and probable climatic impacts. Sand-dune and mangrove one are at *Moderate-low* level of vulnerability; (iii) Two dominant livelihoods, sugarcane cultivation and shrimp farming, possess a *High* level of vulnerability to climatic risks; (iv) Vulnerability map suggests that for levels of vulnerability caused by climate change in different areas are different. From vulnerability map, each area may have the chance to employ congruous measures under current circumstances, aiming at developing livelihoods along with improving the resilience of endemic ecosystems.

Proposed adaptive solutions to climate change in Cu Lao Dung are chiefly community-based, which are generally estimated as 'soft' measures (or unconstructive), concentrating on livelihoods relating to the most likely vulnerable ecosystems.

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REFERENCES

[1] Carew-Reid, J (2007). *Rapid Assessment of the Extent and Impact of Sea Level Rise in Viet Nam*, Climate Change Discussion Paper 1, ICEM –International Centre for Environmental Management, Brisbane, Australia.

[2] Adger, W.N (1998). *Indicators of Social and Economic Vulnerability to Climate Change in Vietnam*, CSERGE working paper, Centre for Social and Economic Research on the Global Environment, 39 pages.

[3] Ahammad, H. (2007). *Consumer Magazine*, Department of Resource Economics and Agriculture in Australia (ABARE), Vol.14, No.1, Canberra, Australia.

[4] Australian Government Department of Climate Change and

Energy Efficiency (2011). *Hunter & Central Coasts New South Wales* – Vulnerability to climate change impacts.

[5] IPCC, Working Group 2 (2001a). *Third Assessment Report,* Annex B: Glossary of Terms.

[6] IPCC, Working Group 1 (2007). *Fourth Assessment Report*, The Physical Science Basis.

[7] IPCC (2012). *Managing the Risks of Extreme Events and Disasters to Advance Climate Change Adaptation.* A Special Report of Working Groups I and II of the Intergovernmental Panel on Climate Change. Cambridge University Press, Cambridge, UK, 582 pp.

[8] Ministry of Environment and Tourism - MET, (2010). *Climate Change Vulnerability and Adaptation Assessment for Namibia's Biodiversity and Protected Area System.* Jane Turpie, Guy Midgley, Chris Brown, Jon Barnes, John Pallett, Phillip Desmet, Jacquie Tarr & Peter Tarr, Anchor Environment Consultants, Namibia Nature Foundation, Southern African Institute for Environment Assessment, 238 pages.

[9] Cu Lao Dung People's Committee (2012). *Cu Lao Dung People's Committee - Report on social and economic development in 2012 and prospect for 2013,* 24 pages.

[10] Dasgupta, S., Laplante, B., Meisner, C. Wheeler, D. Yan, J. (2007). *The Impact of Sea Level Rise on Developing Countries: A Comparative Analysis.* Policy Research Working Papers No. 4136, World Bank.

[11] McCarthy, J., Canziani, O., Leary, N., Dokken, D., and White, K. (eds.) (2001). Climate *Change 2001: Impacts, Adaptation, and Vulnerability.* Cambridge University Press. Cambridge.

[12] IPCC (2001b). *Climate Change 2001: Impacts, Adaptation and Vulnerability,* Cambridge University Press, Cambridge [11].

[13] International Union for Conservation of Nature (IUCN) (2012). *Vulnerability and Capacity Assessment (VCA),* Project "Building Coastal Resilience in VietNam, Cambodia and Thailand – BCR", Ben Tre.

[14] CARE International (2010). *Community-Based Adaptation Toolkit Digital Toolkit.* Version 1.0 - July.

[15] Malini Nair, N. H. Ravindranath, Nitasha Sharma, Ruth Kattumuri & Madhushree Munshi (2013). "Poverty index as a tool for adaptation intervention to climate change in northeast India", *Climate and Development Journal*, Volume 5, Issue 1, pages 14-32.

[16] Prime Minister of Vietnam (PM) (2011). *Decision number 2139/QD-TTg on the approval of National Climate Change Strategy,* dated December, 17 pages.

[17] Rasmus, H. and Bonch-Osmolovskiy, M. (2011). *"Mapping Vulnerability to Climate Change".* World Bank Policy Research Working Paper No. 5554.

[18] Olivier Joffre, O. and Truong, L.H. (2009). *A Baseline Survey in the Coastal Zone of Soc Trang Province: Livelihood Assessment and Stakeholder Analysis*, Deutsche Gesellschaft für Internationale Zusammenarbeit (GIZ) Vietnam, 110 pages.

[19] Tuan, L.A., Du, L.V. & Skinner, T. (ed) (2012). *Rapid Integrated & Ecosystem-Based Assessment of Climate Change Vulnerability & Adaptation for Ben Tre Province, Vietnam.* Completed under the 'Global Cooperation on Water Resource Management' (WWF and Coca-Cola) and the 'Capacity building and sustainable production' programme (WWF – DANIDA) by World Wildlife Fund for Nature (WWF).

[20] Preston, B.L., Smith, T.F., Brook, C., Gorddard, R., Mearsham, T.G., Withycambe, G., Mclnnes, K., Abbs, D., Beveridge, B. and Morrison, C. (2008). *Mapping Climate Change Vulnerability in Sydney Coastal Council Group.* Prepared for Sydney Coastal Council Group.

[21] Department for International Development - DFID, (2001). *Sustainable Livelihoods Guidance Sheets*.

[22] Reid, H. (Eds) (2009). *Community-based adaptation to climate change*, International Institute for Environment and Development, Russell Press, Nottingham, UK.

[23] Smit, B., Burton, B., Klein, R.J.T., and Wandel, J. (2000). *"An Anatomy of Adaptation to Climate Change and Variability".* Climatic Change, pages: 223 – 251.

[24] Siri E.H. Eriksen (2007). *Report for Cooperation and Development Norway (Norad),* Global Environmental Change and Human Security (GECHS), University of Oslo, Norway.

[25] Sherbinin, A., Schiller, A. and Pulsipher, A. (Eds.) (2007), "The vulnerability of global cities to climate hazards". *Environment & Urbanization*, Vol. 19, No. 1.