Support to Local Governments in Vietnam to Improve Climate Change Responses Using CBMS Data and Mapping

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The Economy and Environment Program for Southeast Asia (EEPSEA) was established in May 1993 to support research and training in environmental and resource economics. Its objective is to enhance local capacity to undertake the economic analysis of environmental problems and policies. It uses a networking approach, involving courses, meetings, technical support, access to literature and opportunities for comparative research. Member countries are Thailand, Malaysia, Indonesia, the Philippines, Vietnam, Cambodia, Lao PDR, China, and Papua New Guinea.

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TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

LIST OF ABBREVIATIONS

CBMS	Community-Based Monitoring System
CCV	Climate change vulnerability
CCVI	Climate change vulnerability index
EEPSEA	Economy and Environment Program of Southeast Asia
MONRE	Ministry of Natural Resources and Environment
NTPCC	National Target Program for Climate Change Responses
NCCS	National Climate Change Strategy
VND	Vietnam Dong (Vietnam currency unit)

SUPPORT TO LOCAL GOVERNMENTS IN VIETNAM TO IMPROVE CLIMATE CHANGE RESPONSES USING CBMS DATA AND MAPPING

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EXECUTIVE SUMMARY

This study aims to develop and pilot test the methodology and indicators for mapping climate change vulnerability at the local level using data collected by community-based surveys. Climate change vulnerability is geographically presented and assessed by overlaying climate change risk (exposure), sensibility and adaptive capacity maps following the climate change vulnerability assessment framework of the United Nations' Intergovernmental Panel on Climate Change (IPCC). Based on this spacial assessment, the climatically most vulnerable areas could be identified for targeting the further responding actions.

Using EEPSEA methodology of mapping climate change vulnerability and data of Community-Based Monitoring System (CBMS), the research team selected appropriate indicators for Vietnam's localities and developed indexes of climate change sensitibility, exposure, adaptive capacity and total climate change vulnerability. The set of indicators comprises 18 variables, of which 7 reflecting climate change exposures, 5 reflecting human and ecological sensitivity and 6 reflecting socio-economic, infrastructural and technological factors contributing to adaptive capacity to climate change response. Construction of climate change vulnerability sub-indices and overall index is based on method of simple equal variable weighting.

Measuring and mapping climate change vulnerability (CCV) were piloted at two local administrative levels (the commune and the district levels), and in three localities in different regions of Vietnam (Nghia Lo Town in the mountainous province Yen Bai, Kim Son District in the delta province Ninh Binh and Tam Ky City in the coastal province Quang Nam). An analysis of pilot results showed perspectives and constrains to application of this methodology for improving climate change responses of local governments in Vietnam's context.

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1.0 INTRODUCTION

Climate change, illustrated mainly by global warming and sea level rise, is one of the most serious challenges facing human being in the 21st century. Natural disasters and other extreme climate phenomena are more often observed all around the world, whereas average temperature and global sea level are increasing at unprecedented rate, becoming a major concern of all nations.

Climate change impacts to Vietnam are considered to be serious. Vietnam is among the five countries most affected by climate change and is the second in the world (after the Bahamas) to be most affected by sea level rise. The Mekong River Delta – main area producing rice and many other agricultural and fishery products of the country – is one of three mostly vulnerable deltas in the world (alongside the Ganges River Delta in Bangladesh and the Nile River Delta in Egypt). By the end of 21st century, the average temperature will rise annually by 2-3^{0} C, total rainfall and rainfall in the rainy season will increase, while there will be decrease in the dry season. Sea level will rise by 75 cm to 100 cm relative to the level of the 1980-1999 period. With the anticipated one meter of sea levels rise, about 40% of the Mekong River Delta area, 11% of the Red River Delta area, 3% of the other coastal provinces, and over 20% of Ho Chi Minh City will be flooded. More than 4% of railway system, 9% of national highways and 12% of provincial highways will be damaged. About 10-12 per cent of Vietnam's population will be directly affected and economic damages will cost about 10 per cent of GDP (Vietnam Government, 2012).

Climate change heavily influences many aspects of production and business, life and people's livelihoods, natural resources, social structure, infrastructure and the economy. It is an explicit threat to poverty alleviation and achieving the Millennium Development Goals, and sustainable development of the country.

The major phenomenons of climate change in Vietnam are typhoons and tropical cyclones, floods, inundations and saltwater intrusions caused by sea level rise, droughts, landslides, extreme weather risks (too cold or too hot temperatures) which lead to increase of human, animal and crop diseases.

The Government of Vietnam, with a clear vision on climate change impacts, has promulgated the National Target Program to Respond to Climate Change (NTPCC) in December 2008 and the National Climate Change Strategy in March 2012 (NCCS). The NCCS outlines overall objectives, prioritized projects to be implemented in 2011-2015, and plans for 2016-2025 as well as objectives for 2050, with a vision to 2100. It also identifies strategic tasks to cope with global climate change.

The NTPCC and NCCS require industries and localities to integrate climate change issues into their development strategies and plan, and to prepare action plans for adaptation and mitigation of climate change impacts. There are two main objectives of the action plan: (i) To identify climate change phenomenons and vulnerability, to assess climate change impacts (including climate variability, sea level rise and climatic extremes) on every sector and locality; (ii) To identify measures to respond to climate change impacts. In order to achieve these main objectives, it's necessary to build management capacity of local governments and social organizations, and increase public awareness on climate change.

A geographically disaggregated picture of vulnerability to climate change is helpful for planning adaptation strategies in the same manner that a poverty map is helpful for designing anti-poverty policies and programs. This study aims to develop and pilot test the methodology and indicators for mapping climate change vulnerability at the local level using data collected by community-based monitoring surveys (CBMS) and the methodology of measuring and mapping climate change vulnerability developed by the Economy and Environment Program for Southeast Asia (EEPSEA). Here, climate change vulnerability is geographically presented and assessed by overlaying climate change risk (exposure) maps, economic, social and environmental sensibility maps and adaptive capacity maps following the climate change vulnerability assessment framework of the United Nations' Intergovernmental Panel on Climate Change (IPCC). Based on this spatial assessment, the climatically most vulnerable areas could be identified for targeting the further responding planning and mobilizing financial, human and technical resources to implement the NCCS and NTPCC in localities. This methodology may prove a useful tool for local governments and social organizations to respond to climate change in a better manner.

In particular, this research project has covered the following activities:

- Monitor the impacts of climate change at the local level through CBMS;

- Enhance the CBMS-Vietnam data collection instrument to monitor impacts of climate change;

- Process and analyze existing CBMS data and other available related data on vulnerability and hazard risks mapping;

- Customize the EEPSEA tools and instruments for vulnerability mapping and risk assessment in the pilot sites;

- Produce vulnerability maps showing impacts of climate change at the local level;

- Build capacities of communities on vulnerability mapping and risk assessment;

- Recommend adaptation strategies based on the results of vulnerability assessment and mapping that can be integrated in disaster and other environment management plans of local government in the pilot areas.

2. LITERATURE REVIEW

Vulnerability may be defined as the extent to which a natural or social system is susceptible to sustaining damage from climate change. It has two aspects, an external risk (shock to which an individual or community is subject) and internal risk (lack of means to cope). The net impact may be positive for resilience or negative to become vulnerable. As per Inter-governmental Panel on Climate Change (IPCC), vulnerability is degree to which a system will respond to a given change in climate including beneficial and harmful effects. It is also a degree to which a system is susceptible to or unable to cope with adverse effects of climate change including climate variability and extremes.

There are several efforts made by international organizations and individual researchers for measuring and mapping climate change vulnerability.

An Vulnerability Index for the natural environment (EVI), the basis of all human welfare, has been initially developed by the South Pacific Applied Geoscience Commission (SOPAC), the United Nations Environment Programme (UNEP) and their partners. This index is to be used together with economic and social vulnerability indices to provide insights into the processes that can negatively influence the sustainable development of countries. The are 50 indicators been selected to measure EVI. Each indicator is classified into a range of sub-indices including the three aspects of hazards, resistance and damage, and into policy-relevant sub-indices including (SOPAC, 2011).

The global risks advisory firm Maplecroft has released a new Climate Change Vulnerability Index (CCVI), which enables organizations to identify areas of risk within their operations, supply chains and investments. It evaluates 42 social, economic and environmental factors to assess national vulnerabilities across three core areas. These include: exposure to climate-related natural disasters and sea-level rise; human sensitivity, in terms of population patterns, development, natural resources, agricultural dependency and conflicts; thirdly, the index assesses future vulnerability by considering the adaptive capacity of a country’s government and infrastructure to combat climate change. The CCVI forms a central part of Maplecroft’s Climate Change and Environmental Risk Atlas 2012. The Atlas provides analysis of the key risks to business in the areas of climate change vulnerability and adaption; emissions and energy use; environmental regulation; and ecosystem services. It also includes interactive maps and indices to enable the identification, evaluation and comparison of climate change and environmental risks, whilst subnational indices focusing on exposure, sensitivity, forests, top soil degradation and water stress pinpoint risk vulnerability down to 25km^2 worldwide (Maplecroft, 2011).

Wheeler D. from the Center for Global Development quantified the vulnerability of 233 countries to three major effects of climate change, namely weather-related disasters, sea-level rise, and reduced agricultural productivity, and formed maps of overall climate change vulnerability (Wheeler D., 2011).

Yusuf A. and Fransisco H. from EEPSEA compiled CCVI of the Southeast Asian countries and mapped CCV with three component indices: climate change hazards, sensitivity and adaptive capacity (Yusuf A. and Fransisco H., 2009). The climate change vulnerability assessment considers 530 sub-national areas in 7 Southeast Asian countries, namely 341 districts (*kabupaten/kota*) in Indonesia, 19 provinces (*khet*) in Cambodia, 17 provinces (*khoueng*) in Lao PDR, 14 states (*negeri*) in Malaysia, 14 provinces in the Philippines, 72 provinces (*changwat*) in Thailand, and 53 provinces (*tinh/thanh pho*) in Vietnam). The methodology of this study will be detailly described in the next section.

A similar work was done by Heltberg R. and Bonch-Osmolovskiy M.. The CCVI with its component indices was calculated and mapped for Tajikistan as an example. The country was divided into 10 agro-ecological zones and assessed by 6 variables measuring exposure; 5 variables measuring agricultural, demographic, health, poverty, and disaster-related sensitivity to climate change; and 4 four variables measuring adaptive capacity (consumption, education, income diversification, and institutional development) (Heltberg R. and Bonch-Osmolovski M., 2010).

Using the same approach, the Nepal's National Adaptation Program of Action (Ministry of Environment) has constructed CCVI and maps in order to identify key climatic vulnerabilities at the district level and with a scope of total 75 districts in Nepal. The CCVI comprises 19 variables measuring exposure, 5 variables measuring sensitivity and 10 variables measuring adaptive capacity (Government of Nepal, 2011).

The number of works measuring and mapping climate change vulnerability for different regions, countries and zones in the world is increasing since this is useful information serving adaptation and mitigation of climate change.

In Vietnam, basing on historical data collected by climate observatories and world's estimated scenarios of green house gas emission, Vietnam Ministry of Natural Resources and Environment (MONRE) has studied scenarios of sea level rise for the whole country and some most affected big regions. A map set of inundated areas in several coastal provinces has been constructed in accordance with four scenarios of sea level rise by 50cm, 75cm, 1m and 2m. These maps are highly appreciated by the local administrations and other organizations, because they can be helpful for planning and conducting anti-disaster and climate change responding activities in localities. Detail scenarios for small-scaled regions are still not available yet.

In May 2011 MONRE with UNDP technical support has published "Guideline for Impact Assessment of Climate Change and Generation of Response Solutions", which includes steps and methods of CC assessment applied for local governments (Vietnam Institute of Meteorology, Hydrology and Environment, 2011). This Guidance provides some sets of criteria for assessing climate change phenomenon and proposes complexes of possible responding measures. The method of vulnerability mapping is also mentioned as one of the tools for assessing climate change risks, but there are no any further explanations and guidelines.

Several projects sponsored by the World Bank, UNDP, ADB and other international donors have focus on response to climate change in different provinces in Vietnam. Some international non-governmental organizations operating in Vietnam (CARE International, Oxfam, etc.) are also intensively working together with selected communities for mainstreaming climate change factors into socio-economic development plans. Almost all mentioned projects do not use mapping methods yet due to lack of data of spatial distribution of climate impacts.

Statistical data of climate change (such as number of storms, typhoons, extreme temperature changes, etc.) and human and material loss are collected by some central and local agencies in Vietnam, such as the Agency of Meteorology, Hydrology and Climate Change, the Agency for Emergency and Disaster Management. Maps of rainfall, flood, storms, landslides, etc. have been built and used at national and provincial levels. The Agency of Meteorology, Hydrology and Climate Change regularly issues maps and charts of climate monitoring, and supplies these maps to related governmental organisations.

However, at the local levels (district and commune) mapping of climate change exposure, sensitivity, response capacity and vulnerability is still not implemented yet. This study is the first effort in Vietnam to build and test the methodology of measuring and mapping climate change vulnerability at the lowest administrative levels (commune and district). It's considered as an initial exercise in the process of further implementation of such new methodologies for climate change assessment and for improving responding capacity of local government to climate change hazards.

3.0 METHODOLOGY

3.1. The Methodology of the EEPSEA Study on Mapping Climate Change Vulnerability

The general methodology adopted for this study is that of the Yusuf A. and Francisco H. from EEPSEA applied for mapping climate change vulnerability in Southeast Asia (Yusuf A. and Francisco H., 2009). This methodology was generated following the framework of the United Nations' Inter-governmental Panel on Climate Change (IPCC). According to this framework, the climate change vulnerability including exposure, sensitivity and adaptive capacity can be mapped using the statistical and survey data.

Vulnerability is defined by IPCC as: "The degree to which a system is susceptible to, or unable to cope with the adverse effects of climate change, including climate variability and extremes. Vulnerability is a function of the character, magnitude, and rate of climate variation to which a system is exposed, its sensitivity, and its adaptive capacity" (IPCC 2001, p.995). Vulnerability can thus be defined as a function of exposure, sensitivity, and adaptive capacity.

Vulnerability = f(exposure, sensitivity, adaptive capacity)

Exposure is defined as "the nature and degree to which a system is exposed to significant climatic variations".

Sensitivity is defined as "the degree to which a system is affected, either adversely or beneficially, by climate-related stimuli".

Adaptive capacity is defined as "the ability of a system to adjust to climate change including climate variability and extremes), to moderate the potential damage from it, to take advantage of its opportunities, or to cope with its consequences".

In their study on "Climate Change Vulnerability Mapping for Southeast Asia", Yusuf and Francisco derived the climate change vulnerability index through the following steps:

- Assessing exposure using information from historical records of climate-related hazards. Data of five climate-related risks: frequency of tropical cyclones; floods; landslides; droughts for about 20 years (1980-2000); physical exposure to landslides; and inundation zones of a five-meter sea level rise, were collected for drawing climate hazard maps and calculating exposure index.

- The population density was used as a proxy for human sensitivity to climate-hazard exposure. The assumption here is that regions that are relatively less inhabited will be less vulnerable compared to regions with high population densities, given the same degree of exposure to climate hazards.

- In addition to the human aspect of vulnerability, the ecological sensitivity of the region was calculated using biodiversity information as a proxy variable. A biodiversity-rich region, measured by the percentage of protected areas, is considered here as more vulnerable than other areas to climate hazards, other things being equal.

- An index of adaptive capacity was constructed as a function of socio-economic factors, technology, and infrastructure:

Adaptive capacity = f(socio-economic factors, technology, infrastructure)

The socio-economic factors include three indicators: human development index, poverty incidence and income inequality (Gini coefficient). The technology is reflected by two indicators: electricity coverage (the percentage of household with access to electricity) and irrigation extent (percentage of irrigated agricultural land).

The infrastructure includes road density (the length of road per square kilometer) and communication (the number of fixed phone lines per person).

- Based on the above, an index of the overall climate change vulnerability of the region was constructed. Weights of indicators in the indices were defined by simple distribution or by using "expert opinion polling" method.

- Maps of hazard exposure, sensibility, adaptive capacity and overall climate change vulnerability were constructed using the calculated indices and collected statistical data from different sources. (Table 1 and Figure 1).

Table 1. Indicators used for mapping climate change vulnerability by the EEPSEA study

	Index	**Index element**	**Indicator**	**Weight**
	Hazard		1. Cyclones	0.2
			2. Floods	0.2

Vulnerability	Exposure [1/3]		3. Droughts 4. Landslides 5. Sea level rise	0.2 0.2 0.2
	Sensitivity [1/3]	Human sensitivity	6. Population density	0.7
		Ecological sensitivity	7. Protected area	0.3
	Adaptive capacity [1/3]	Socio-economic capacity	8. Human development index 9. Poverty incidence 10. Income inequality	0.5 0.28 0.22
		Technology	11. Electricity coverage 12. Extent of irrigation	0.53 0.47
		Infrastructure	13. Road density 14. Communication	0.5 0.5

Source: Arief Anshory Yusuf and Herminia A. Francisco, 2009

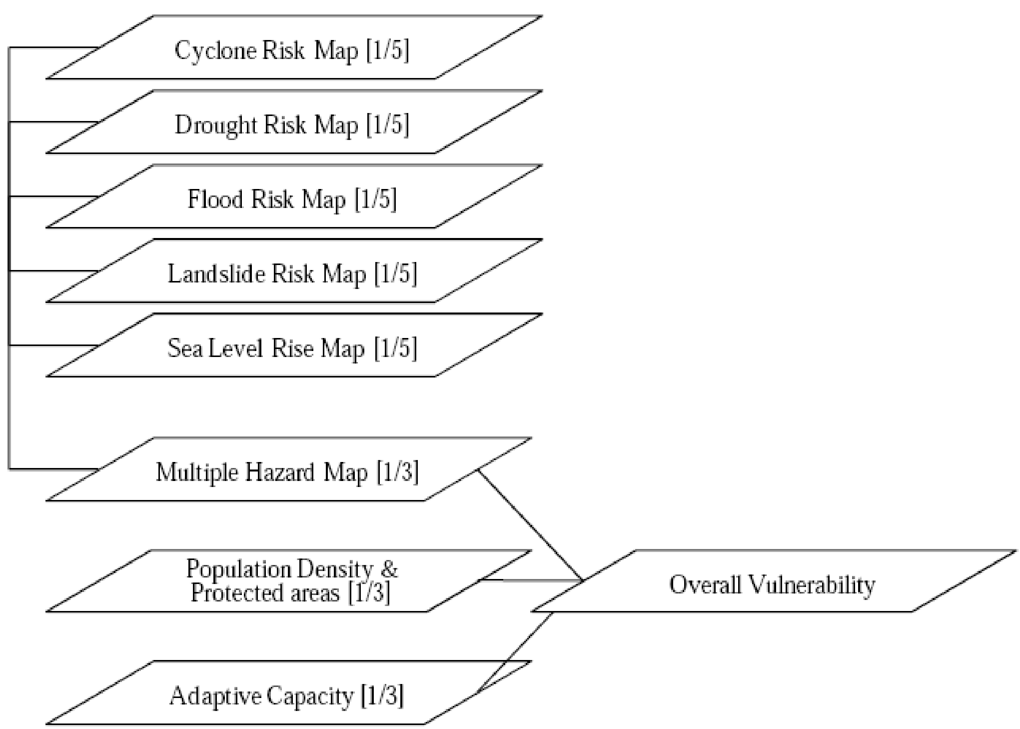


Figure 1. Method used in deriving the climate change vulnerability index in the EEPSEA study.

Source: Arief Anshory Yusuf and Herminia A. Francisco, 2009

3.2. The CBMS Methodology of Data Collection

CBMS as a tool for monitoring socio-economic development in general and poverty in particular. It is an organized way of collecting ongoing or recurring information at the local level to be used by local governments, national government agencies, NGOs, and civil society for planning, budgeting, and implementing local development programs, as well as for monitoring and evaluating their performance. Easy to collect and process, the system is flexible and accommodates community-specific indicators. The data is collected and analyzed by trained community members, in partnership with local government officials, for use by local development planners. The method can be applied quickly, inexpensively, and frequently. It is easy to sustain and is easily conducted by trained local fieldworkers.

CBMS has been piloted in Vietnam during some last years in a series of communes of 5 provinces. CBMS methodology includes a household census procedure, survey tools (commune and household questionnaires) for gathering a set of socio-economic indicators and respective data at household and village level, involvement of local staff and people in data collection, processing and validation. The set of indicators reflects multi-dimensional poverty and should meet the immediate demands of local people on community and household data and information.

The design of survey tools has to take into count the knowledge levels of the local people as well as the availability of data processing equipment and software in the localities. Thus, the questionnaires, software and output indicators have to be simple and easy for local people to understand and use.

Household data used to include information on age, sex, education level, occupation of household members, major economic resources of household (land, labor, machine, animals), living conditions (availability of electricity and safe water, type of dwelling, sanitary facilities), sources and quantity of income, education and health services.

Using GIS, CBMS data could be mapped and present spatial distribution of socio-economic phenomenon of households and villages.

3.3. Methodology of this Study

a) Improving the CBMS data set

Adopting the EEPSEA methodology of mapping climate change vulnerability, we have improved CBMS tools with aims to reflect the climate change impacts to households and communities. There are some changes of CBMS questionnaire and indicators:

- Adding indicators reflecting impacts of climate hazard (droughts, floods, cyclones and typhoons, saltwater intrusion, landslides, severe cold, pests, etc.) to household. Retrospective questions cover 3 last years[1].

- Adding indicators reflecting adaptive capacity of local communities (infrastructure, technology, human and financial capacity) to commune questionnaire.

b) Selection of indicators

We have consulted with local experts and defined the indicators to be added to the CBMS indicator set. Three criteria were used for selection of indicators: (i) Availability of data at community and household levels; (ii) Reflecting the climate change impacts and responses of local communities; (iii) Understandable for local people.

The following variables were selected by the local experts for measuring and mapping climate change vulnerability.

(i) Exposure sub-index:

In the EEPSEA study, the overall climate hazard index comprised five different climate hazards: the frequency of droughts, floods and cyclones for about 20 years, physical exposure to landslides, and inundation zones of a five-meter sea level rise. These variables may be different in different provinces. In a smaller area, like in Vietnam's districts or towns, these variables are almost the same in different communes and villages. In this case, it's meaningless to compare values of hazard index.

However, the number of households/persons exposed to the climate hazard used to be different in different communes and villages. Therefore, we use the percentage of households which are negatively impacted by climate hazards as variables reflecting climate change exposure. There are 7 major types of climate hazards in Vietnam:

(1) Typhoons and cyclones;

(2) Floods;

(3) Droughts;

(4) Landslides;

(5) Saltwater intrusion caused by sea level rise;

(6) Cold surge caused by severe weather/extreme temperature change

(7) Animal and crop pests and diseases caused by climate change.

We collect data of human, property, agricultural and aquacultural damages and loss caused to households by climate hazards during the last 3 years and calculated average

[1] Theoretically, retrospective period used for important events like typhoons, floods may be longer, but for more detailed issues like lost values or damages in kind the retrospective period in household questionnaire should be not too long.

annual frequency of exposure of each type of hazards. The climate change exposure index is combination of 7 such variables with equal weight (1/7).

(ii) Sensitivity sub-index:

Changes in temperature and hydrological systems due to climate change affect the functioning of human and ecological systems in both positive and negative manner. The basic element of the human system is people themselves. Larger the population number in the geographical area experiencing climate change, the greater will be the effect of climate change. Similarly, larger the number of vulnerable people (the poor, children and old-aged, orphans, invalids, etc.), the greater will be negative impacts of climate change on the human system. In our CBMS database, the population density, as well as percentage of people of vulnerable groups can be counted.

Concerning ecological system, it seems easier to measure sensitivity in a broader scope through such variables as percentage of protected area, forest area, water space in total territorial area. At the district and commune level, it's difficult or impossible to use these variables because data is not available. To reflect ecological sensitivity, we use the percentage of agricultural, forestry and aquacultural area in total area (at district level), and the percentage of income, which households obtained from agricultural, forestry and fishery in total household income (at commune and village level).

Thus, the sensitivity sub-index comprises 5 variables:

(8) Population density;

(9) Percentage of oldaged (older 65) and children (15 and younger) in total population;

(10) Percentage of the poor in total population;

(11) Percentage of people in vulnerable groups in total population;

(12) Percentage of agricultural, forestry and aquacultural area in total area (at district level), and the percentage of income, which households obtained from agricultural, forestry and fishery in total household income (at commune level).

(iii) Adaptive capacity sub-index:

As the ability of a system to adapt, adjust or to cope with climate change, adaptive capacity is considered as the function of socio-economic, technology and infrastructural factors. Based on the three mentioned criteria of indicator selection and on local expert opinion polling, we decide to select 6 variables, of which 2 variables presenting socio-economic factors, 2 variables presenting infrastructural factors and 2 variables presenting technological factors. They are the following:

- Socio-economic factors:

(13) Percentage of adult population trained on anti-disasters or climate change response (*at district level*), or Percentage of households trained on anti-disasters or climate change response (*at commune level*);

(14) The community anti-disaster fund compared to total production value of the commune (*at district level*) or Percentage of households which have got financial,

technical, material, labor supports from community for climate change response (*at commune level*).

- Infrastructural factors:

(15) Percentage of households having a permanent dwelling.

- Technological (communication) factors:

(16) Number of transportation vehicles (cars, trucks, buses, ships, boats) per household;

(17) Percentage of households having a telephone;

(18) Percentage of households having a tv set.

So, total number of variables/indicators used for measuring sub-indices of CCVI is 18. (Table 2 and Figure 2).

c) Selection of weighting method and measuring CCV:

Vulnerability is a multidimensional concept associated with high uncertainty in measurement and classification. Generating a vulnerability index from the diverse and incommensurate data is a challenge and still discussible.

Every index is a conventional combination of different variables. The convention used to be established in accordance with the objectives of the desired outcome. There are various methods for aggregating variables into sub-indices and sub-indices into composite index: (i) Simple averages assume all variables carry equal weight; (ii) Weighted averages can be used to depart from the assumption of equal weights but introduce the need for "expert judgment" to determine the weights, thereby introducing another element of arbitrary choice; (iii) Regression-based weights are only feasible when an objective measure of the outcome (in this case vulnerability) exists; this is not the case here since then there wouldn't be the need to compute the index.

Eakin and Bojorquez-Tapia (2008) note that equal weighting makes an implicit judgment about the degree of influence of each indicator. Beside the simple technique of calculation and easily understandable to all people, the application of equal weighting avoids subjective and arbitrary judgment. The most popular global indices such as the Human Development Index, the Millenium Development Goals Index, the Poverty Index, the Gender Development Index, etc., are constructed with simply equal weighting.

Thus, we elect to use simple unweighted averages as the simplest and least arbitrary method available. We use simple unweighted averages of normalized variables to form sub-indices and simple averages of sub-indices to form the overall vulnerability index.

d) Measuring sub-indices and CCVI:

We have to normalize all variables by a linear transformation into the 0-1 interval. In particular, variable x is transformed to x', where $x' = (x - \min x)/(\max x - \min x)$, where minimum and maximum is taken over the value of x across the regions. In our methodology, almost variables are formed as percentage, so there's no need to normalize, except only one indicator of population density. In this case, with aims to make indices comparable in the national scope, we adopted the assumption that the highest population density is equal as the highest density of a urban district in Hanoi, i.e. aproximatelly 10.000 persons per square kilometer. The lowest density is equal 0. Thus, the variable x' will be equal x/10.000.

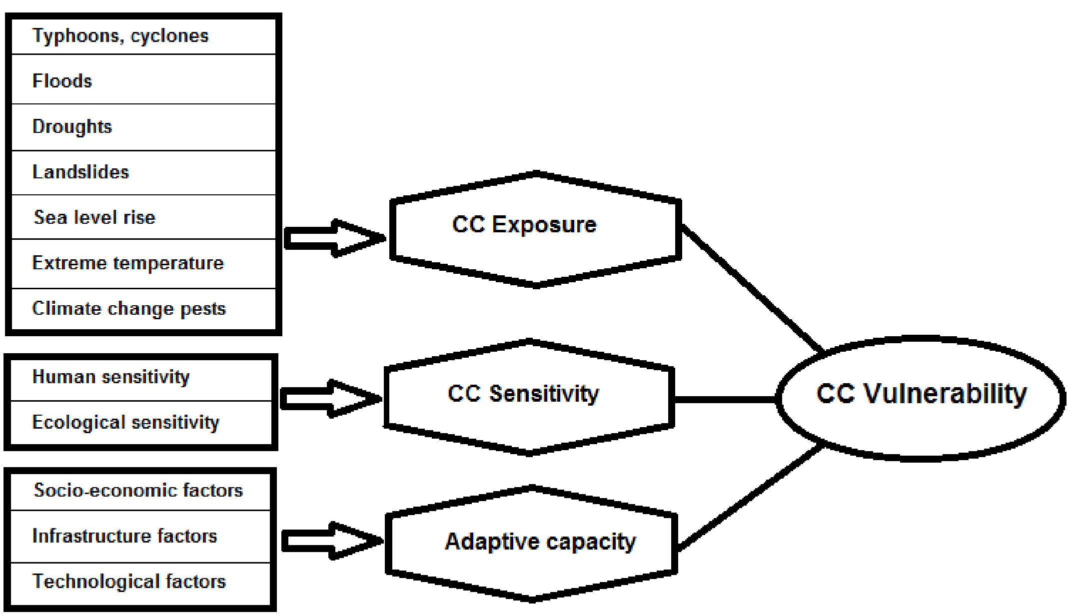
We define variables in the most intuitive manner so that for the exposure and sensitivity sub-indices, the highest value always corresponds to the greatest vulnerability while for adaptive capacity, the highest value corresponds to the lowest vulnerability. We therefore calculate vulnerability as:

Vulnerability = 1/3(Exposure) + 1/3(Sensitivity) + 1/3(1-Adaptive Capacity).

Table 2. Indicators used for mapping climate change vulnerability in this study

Sub-index	**Index element**	**Variable**	**Weight**
Climate Change Exposure [1/3]	Typhoons and cyclones [1/7]	(1) Percentage of households affected by typhoons and cyclones.	[1/7]
	Floods [1/7]	(2) Percentage of households affected by floods.	[1/7]
	Droughts [1/7]	(3) Percentage of households affected by droughts.	[1/7]
	Landslides [1/7]	(4) Percentage of households affected by landslides	[1/7]
	Sea level rise [1/7]	(5) Percentage of households affected by saltwater intrusion.	[1/7]
	Extreme temperature change [1/7]	(6) Percentage of households affected by cold surge.	[1/7]
	Climate change [1/7]	(7) Percentage of households affected by crop and animal pests and diseases.	[1/7]
Sensitivity [1/3]	Human sensitivity [4/5]	(8) Population density compared to highest density.	[1/5]
		(9) Percentage of oldaged (older 65) and children (15 and younger) in total population.	[1/5]
		(10) Percentage of the poor in total population.	[1/5]
		(11) Percentage of people in vulnerable groups in total population.	[1/5]
	Ecological sensitivity [1/5]	(12a) Percentage of agricultural, forestry and aquacultural area in total area (at district level)	[1/5]

		(12b) Percentage of income from agricultural, forestry and fishery in total household income (at commune level).	
Adaptive capacity [1/3]	Socio-economic factors [1/3]	(13a) Percentage of adult population trainings on anti-disasters or climate change response (*at district level*). (13b) Percentage of households which have got trainings on anti-disasters or climate change response (at commune level).	[1/6]
		(14a) The community anti-disaster fund compared to total production value of the commune (*at district level*) (14b) Percentage of households which have got financial, technical, material, labor supports from community for climate change response *(at commune level).*	[1/6]
	Infrastructural factors [1/3]	(15) Percentage of households having a permanent dwelling.	[1/6]
	Technological factors [1/3]	(16) Number of transportation vehicles per household.	[1/6]
		(17) Percentage of households having a telephone	[1/6]
		(18) Percentage of households having a tiviset	[1/6]



e) Mapping climate change vulnerability

For the preparation of various GIS maps, the indicators, the sub-indices and the total climate change vulnerability index were imported in the shape file of pilot districts and communes by using MapInfo software.

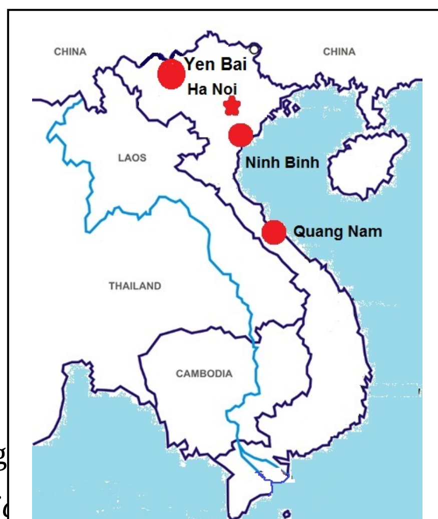
These maps can be used as tools to provide a snapshot of the present situation of climate change vulnerability and its different component aspects at the district, commune and village levels.

4.0 MEASURING AND MAPPING CLIMATE CHANGE VULNERABILITY IN THREE PILOT LOCALITIES

4.1. Description of the Pilot Localities

The administrative hierachy in Vietnam consists of 4 levels: central (national) government, province, district (or town) and commune (ward). There are 698 districts/towns and more than 11,000 communes/wards. Commune *(xa)* is the basic administrative unit in rural areas. A commune consists of several villages or hamlet *(lang, thon, xom, ap, ban, buon*). Ward (*phuong*) is the basic administrative unit in urban area. A ward consists of several popupation quarters (*to dan pho*).

This study focuses on the coastal and mountainous areas where the dominant climate hazards affected heavily**.** Three administrative units of district level and commune level are selected for the CBMS survey, measuring and mapping CCV. These localities represent different geographical conditions, economic structures, human livings and climate change phenomenons in diferent provinces and regions, particularly, in the mountainous region (Yen Bai province), the coastal delta (Ninh Binh province) and the coastal area in the Central region (Quang Nam province). (Figure 3).



Fig… nces

(a) Kim Son Distri… River Delta

Ninh Binh is one province in the Red River Delta in the North Vietnam. Ninh Binh has experience in CBMS. During 2006-2008, 25 communes in Nho Quan - a mountainous and poorest district of the province - have implemented CBMS and used for development planning, poverty reduction and women advancement.

In this study, Kim Son – a coastal district is selected for testing CCV mapping at district level. This district has a population of 172 thousands persons. The district covers an area of 214 km2 with population of 178 thousands persons. There are 25 communes and two townships in the district. Agriculture, fishing on the sea and aquaculture of shrimp, crabs, shell, fish are main occupations of population. Seven coastal communes of this district belongs to the Red River Delta biosphere reserve – one of world wetland biosphere reserves. The district is often affected by typhoons and cyclones, extreme sea waves, saltwater intrusion, floods, droughts and animal and crop pests.

Kim Trung - a coastal commune in the Kim Son district is also selected for CCV mapping at commune level. It's located 50 km from Ninh Binh town and 150 km from Hanoi. Kim Trung commune has area of 4.5 km2 and 2800 inhabitants. There are 6 villages in this commune. Fishing, cultivation of rice, raising shrimp, crabs, shell, fish are main occupations of population. 58% of laborers are working in agriculture, aqua-culture and fishery.

(b) Nghia Lo Town, Yen Bai Province in the North Mountainous Region

Yen Bai is one province in the Mountainous Region in the North of Vietnam. Yen Bai has experience in CBMS. During 2006-2008, CBMS has been implemented in 6 communes and used for development planning and poverty reduction.

Nghia Lo town is the centre of the western part of the province. This town has area of 30 km2, population of 28 thousands persons, and divided into 4 urban wards and 3 rural communes. Agriculture, trade, sevices and handicrafts are main occupations of the population. The typical impacts of climate change here are affects of typhoons, droughts, floods, landslides, extreme temperature and animal pests caused by climate change.

Cau Thia - one of the 4 urban wards in the Nghia Lo town is selected for CCV mapping at commune level. It has area of 1.14 km2, 2500 inhabitants, and divided into 9 population quarters (In order to make encoding easier, below we will call "population quarter" as "village"). About 26.5% of laborers in this ward working as farmers. Even in 3 villages, this share of farmers reached 60-70%. This ward is affected by floods, landslides, severe temperature and pests.

(c) Tam Ky Town, Quang Nam Province in the Central Region

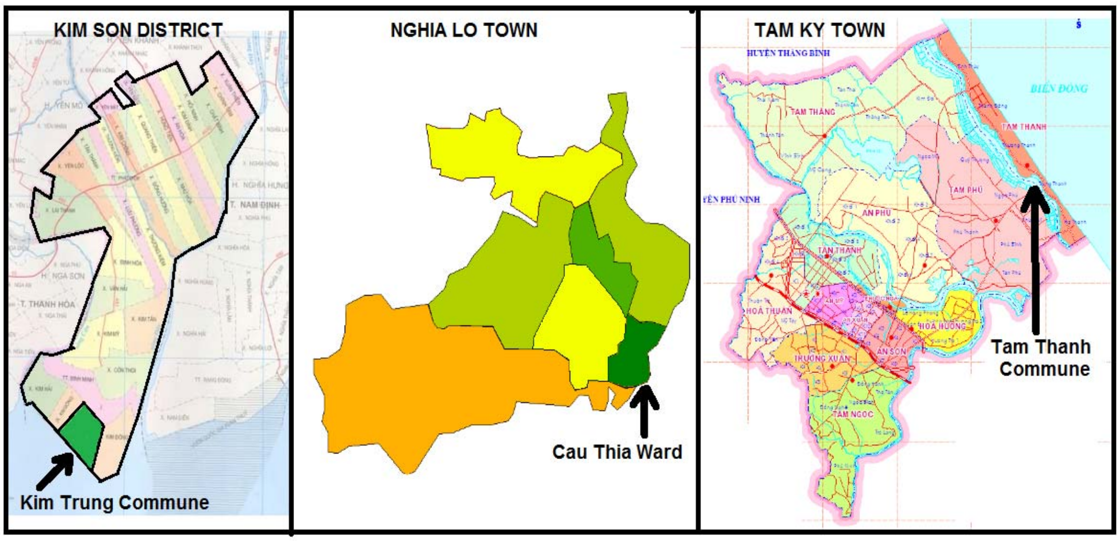
Quang Nam province is in the middle of Vietnam and approximately 800 km far from Hanoi, 80 km far from Da Nang, the third big city of Vietnam.

Tam Ky town is the administrative centre of Quang Nam province. It has area of 100.2 km2, population of 125 thousands persons. The town includes 9 urban wards and 4 rural communes. Agriculture and fishing are main occupation of the rural population, while trade and services are main occupation of the urban population.

The CBMS survey we have conducted in Tam Thanh commune supplied data for constructing CCVI at commune level. Tam Thanh commune is located along the sea coast on one side and the river bank on the other side. This commune consists of 7 villages. It's affected by typhoons, flood, drought, landslides. This commune is one of 160 poor coastal communes getting special support from the Government.

Table 3. The selected pilot localities

Province	*Name of the selected district*	*Number of communes in the selected district*	*Name of the selected commune*	*Number of village in the commune*	*Number of households in the commune*
Ninh Binh	Kim Son	27	Kim Trung	6	646
Yen Bai	Nghia Lo	7	Cau Thia	9	707
Quang Nam	Tam Ky	13	Tam Thanh	7	1592



4.2. Mapping Climate Change Vulnerability at Commune Level

4.2.1. Measuring and mapping exposure to climate change

Using household data collected from CBMS survey in three communes, we calculated the component indicators and the sub-index of climate change exposure as following.

Table 4. Climate change exposure sub-index of three pilot communes

Indicator	**(1) TYP**	**(2) FLD**	**(3) DRG**	**(4) LSL**	**(5) SLT**	**(6) CLD**	**(7) PST**	**EXP**
KIM TRUNG COMMUNE								
Commune	**0.0108**	**0.0010**	**0.0031**	**0.0000**	**0.3220**	**0.0000**	**0.2399**	**0.0824**
Village 1	0.0000	0.0000	0.0299	0.0000	0.0348	0.0000	0.4478	**0.0732**

Village 2	0.1148	0.0000	0.0000	0.0000	0.0546	0.0000	0.0656	**0.0336**
Village 3	0.0000	0.0000	0.0000	0.0000	0.4399	0.0000	0.0601	**0.0714**
Village 4	0.0000	0.0000	0.0000	0.0000	0.5030	0.0000	0.0335	**0.0766**
Village 5	0.0000	0.0000	0.0000	0.0000	0.0939	0.0000	0.9126	**0.1438**
Village 6	0.0000	0.0054	0.0000	0.0000	0.4355	0.0000	0.1129	**0.0791**
CAU THIA WARD								
Ward	**0.0019**	**0.0259**	**0.0104**	**0.0165**	**0.0000**	**0.0236**	**0.2933**	**0.0531**
Village 1	0.0000	0.0513	0.0154	0.0564	0.0000	0.0236	0.4769	**0.1099**
Village 2	0.0169	0.0928	0.0633	0.0169	0.0000	0.1692	0.6414	**0.1224**
Village 3	0.0000	0.0104	0.0000	0.0052	0.0000	0.0253	0.1563	**0.0246**
Village 4	0.0000	0.0000	0.0044	0.0044	0.0000	0.0000	0.1467	**0.0222**
Village 5	0.0000	0.0095	0.0048	0.0238	0.0000	0.0000	0.1429	**0.0279**
Village 6	0.0000	0.0082	0.0000	0.0041	0.0000	0.0143	0.1276	**0.0206**
Village 7	0.0000	0.0268	0.0000	0.0230	0.0000	0.0041	0.2107	**0.0372**
Village 8	0.0000	0.0148	0.0000	0.0000	0.0000	0.0000	0.3667	**0.0545**
Village 9	0.0000	0.0208	0.0069	0.0208	0.0000	0.0000	0.3438	**0.0595**
TAM THANH COMMUNE								
Commune	**0.0779**	**0.0015**	**0.0000**	**0.0000**	**0.0008**	**0.0000**	**0.0042**	**0.0121**
Village 1	0.1510	0.0036	0.0000	0.0000	0.0027	0.0000	0.0027	**0.0229**
Village 2	0.0242	0.0027	0.0000	0.0000	0.0000	0.0000	0.0040	**0.0044**
Village 3	0.0300	0.0000	0.0000	0.0000	0.0000	0.0000	0.0037	**0.0048**
Village 4	0.0078	0.0026	0.0000	0.0000	0.0026	0.0000	0.0026	**0.0022**
Village 5	0.0823	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	**0.0118**
Village 6	0.1876	0.0000	0.0000	0.0000	0.0000	0.0000	0.0155	**0.0290**

Village 7	0.0047	0.0000	0.0000	0.0000	0.0000	0.0000	0.0012	**0.0008**

Note:

TYP =	Typhoons	FLD =	Floods	DRG =	Droughts	LSD = Landslides
SLT=	Saltwater	CLD =	Cold	PST =	Pests	EXP = Exposure

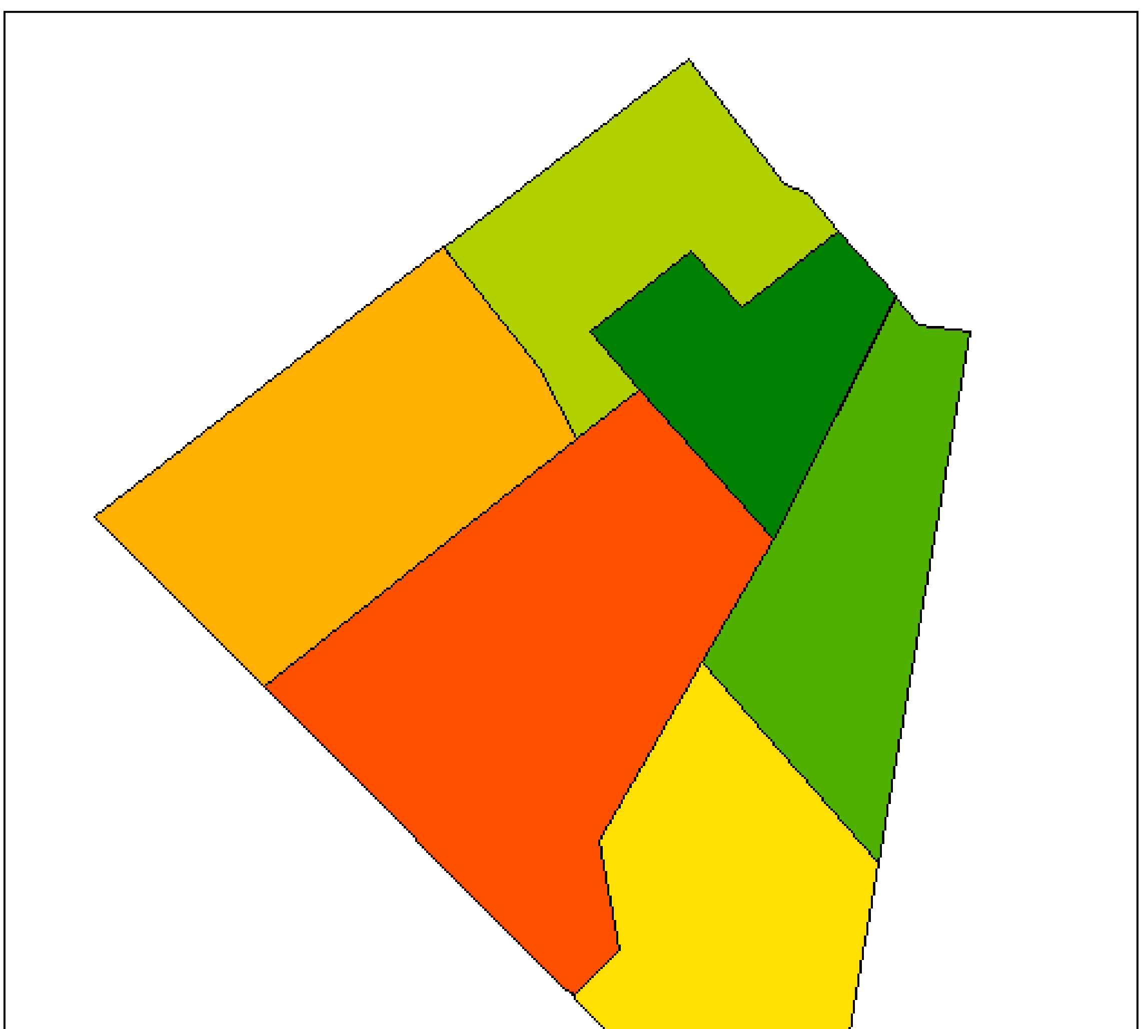
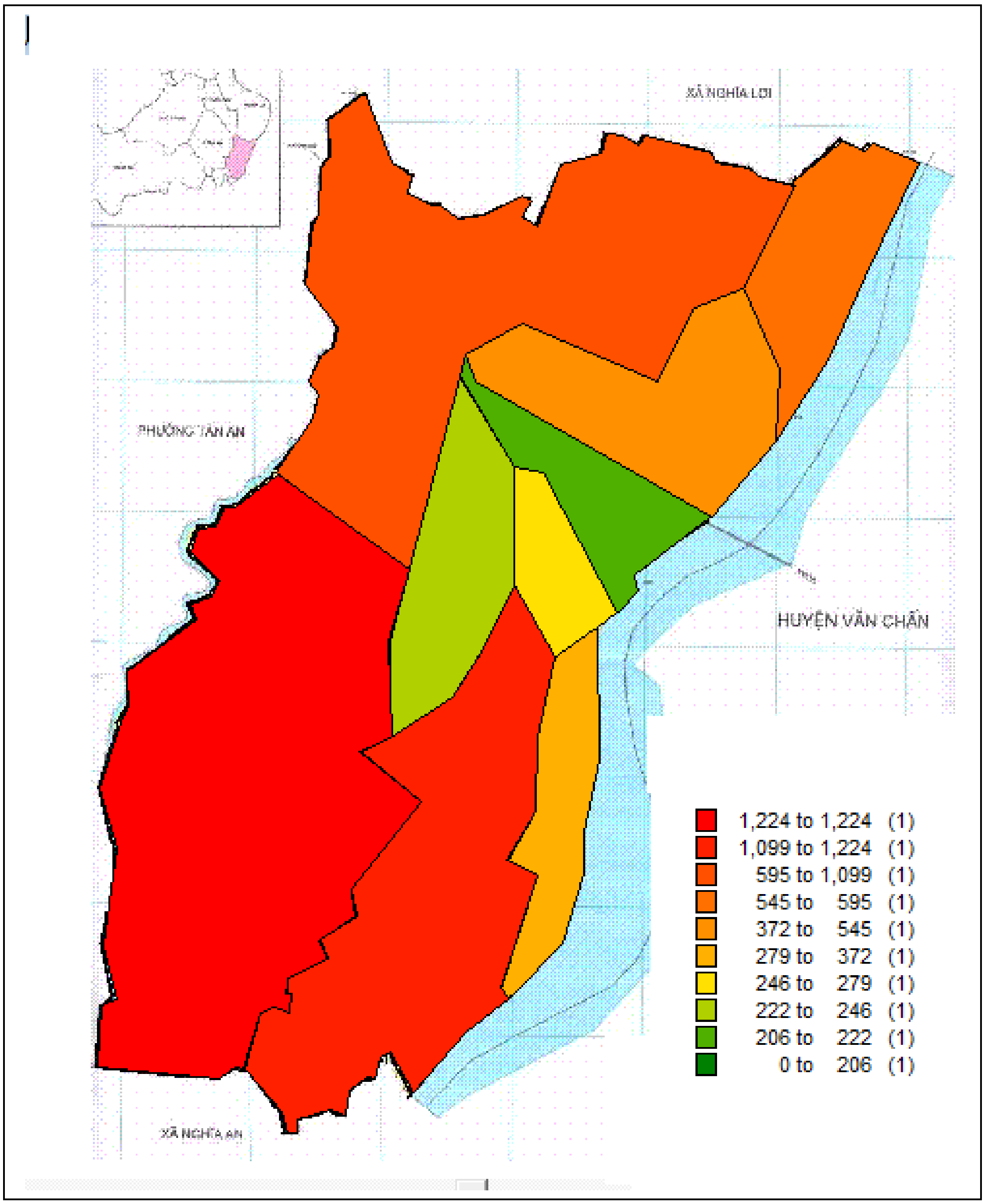
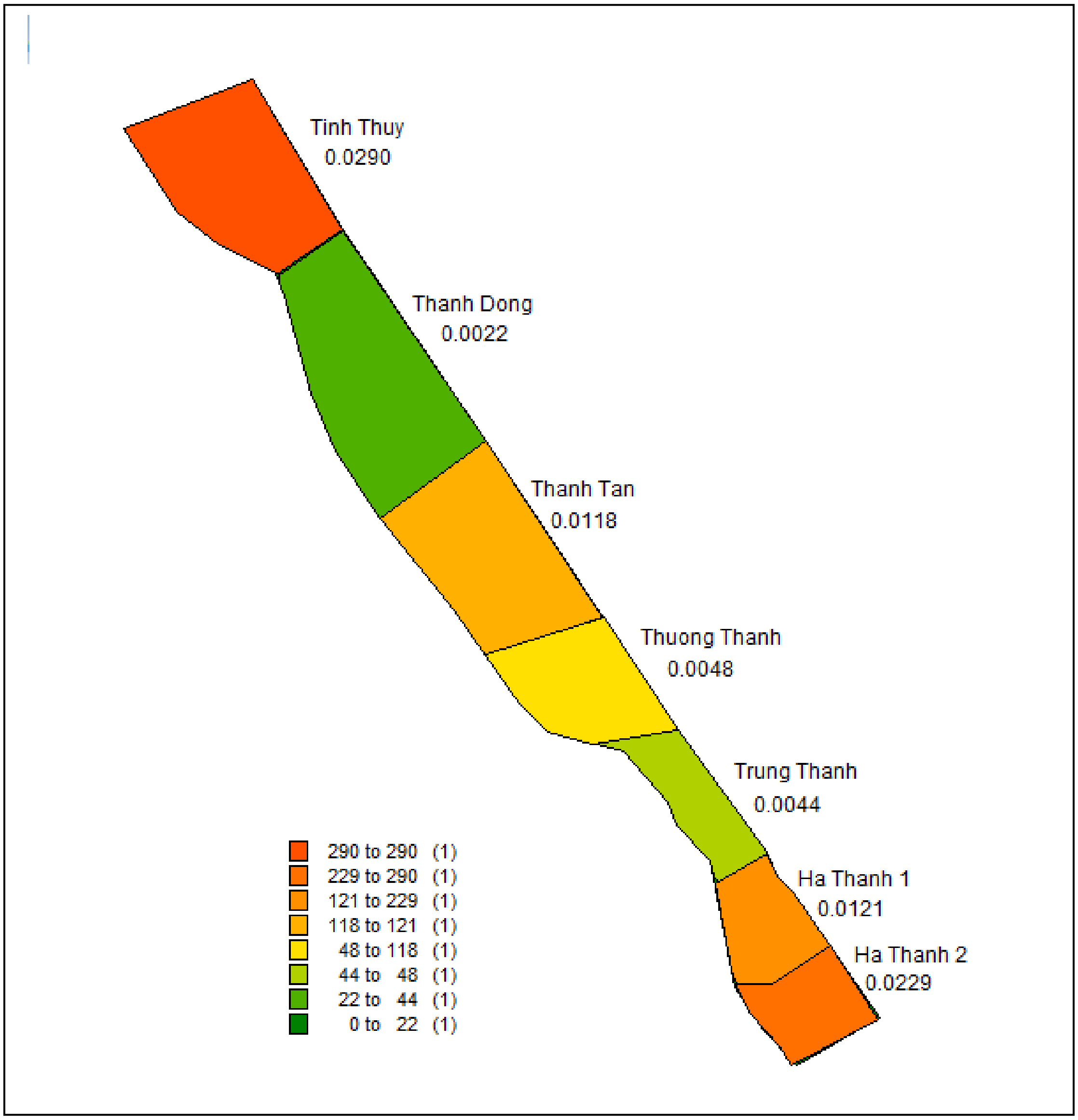


Figure 5a. Maps of the climate change exposure sub-index of Kim Trung commune




Tinh Thuy
0.0290
Thanh Dong
0.0022
Thanh Tan
0.0118
Thuong Thanh
0.0048
Trung Thanh
0.0044
Ha Thanh 1
0.0121
Ha Thanh 2
0.0229
290 to 290 (1)
229 to 290 (1)
121 to 229 (1)
118 to 121 (1)
48 to 118 (1)
44 to 48 (1)
22 to 44 (1)
0 to 22 (1)

Indices and maps show that the diferent types and degrees of climate change exposure in three communes and their villages, in particular:

- All pilot communes and villages are affected negatively by some among 7 major climate change phenomenons. The high percentage of households affected by climate change reaches 30%.

- The Northern coastal commune (Kim Trung) faces the sea level rise at the most, with the salwater intrusion as strong impacts on agricultural production. In the same time, the mountainous commune (Cau Thia) is affected by landslides due to extreme rainfal and river floods. The Central coastal commune (Tam Thanh) is affected by typhoons and cyclones, which cause damages of infrastucture, agricultural and fishery production, public and private property.

- Agriculture, fishery and aqua-culture are the economic branches affected strongly by various phenomenons of climate change. There are losses and damages of crops, animals due to windstorms, floods, droughts, pests and diseases. The mostly obvious impact is the loss due to annually extending animal and crop pests and diseases, and due to extreme cold temperature in the Northern area. The villages with higher share of farming households have higher degrees of climate change impacts.

- Analysing the indicators and index of climate change exposure, we recognised that some kinds of climate change impacts were still not included in consideration yet. In Tam Thanh commune, for example, more than 22% of adult population are fishfolk, even in one among 7 villages this share is over 60%. We have counted only real losses caused by climate change (human death and injury, value of house and property damages, value of production loss), but we could not estimate opportunity losses in fishing business yet (reduction of catched quantity and value due to unfavourable weather or sea waves). The similar situation is happened with aqua-cultural production in Kim Trung commune and with agricultural production in Cau Thia ward: the decrease of productivity compared to that in usual climate condition is still not counted and included in real losses yet. Therefore, the degree of climate change exposure is underestimated in this case.

4.2.2. Measuring and mapping climate change sensitivity

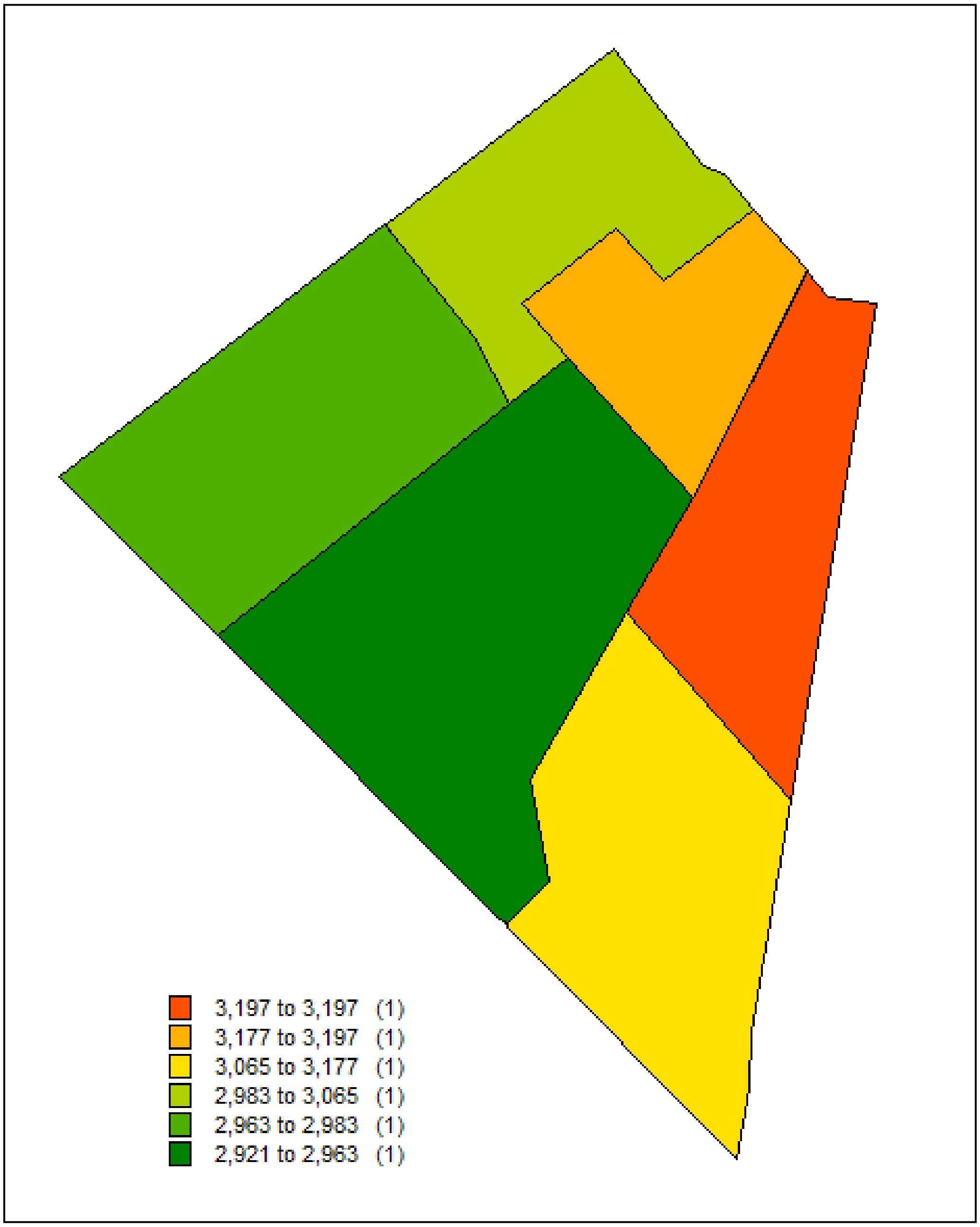
Table 5. Climate change sensitivity sub-index of three pilot communes

Indicator	**Human sensitivity**				**Ecolog. Sensit.**	**SEN**
	(8) POP	**(9) CHD**	**(10) POV**	**(11) VUL**	**(12) AGR**	
KIM TRUNG COMMUNE						
Commune	0.2951	**0.3391**	**0.2191**	**0.0166**	**0.3489**	**0.2438**
Village 1	0.3471	0.3062	0.1822	0.0155	0.2933	**0.2289**
Village 2	0.4349	0.3676	0.2530	0.0040	0.0945	**0.2308**

Village 3	0.3065	0.3831	0.1326	0.0110	0.4586	**0.2584**
Village 4	0.3197	0.3066	0.2447	0.0281	0.3139	**0.2426**
Village 5	0.2323	0.3349	0.3002	0.0139	0.3472	**0.2457**
Village 6	0.2600	0.3432	0.2097	0.0156	0.3930	**0.2443**
CAU THIA WARD						
Ward	**0.1862**	**0.2972**	**0.0819**	**0.0202**	**0.0145**	**0.1200**
Village 1	0.0914	0.3130	0.1179	0.0008	0.0331	**0.1112**
Village 2	0.1016	0.3032	0.1742	0.0004	0.0535	**0.1266**
Village 3	0.5987	0.3039	0.0196	0.0013	0.0193	**0.1886**
Village 4	0.6107	0.3103	0.0129	0.0025	0.0041	**0.1881**
Village 5	0.4589	0.3460	0.0569	0.0046	0.0062	**0.1745**
Village 6	0.9014	0.2782	0.0387	0.0034	0.0070	**0.2457**
Village 7	0.5641	0.2351	0.0757	0.0050	0.0016	**0.1763**
Village 8	0.2728	0.3210	0.0480	0.0013	0.0082	**0.1303**
Village 9	0.0907	0.2815	0.1340	0.0008	0.0281	**0.1070**
TAM THANH COMMUNE						
Commune	**0.3899**	**0.2746**	**0.0787**	**0.0944**	**0.2820**	**0.2239**
Village 1	0.6158	0.2572	0.0953	0.0486	0.2378	**0.2509**
Village 2	0.7033	0.2993	0.0986	0.0657	0.2614	**0.2857**
Village 3	0.8612	0.2916	0.0297	0.0659	0.2153	**0.2927**
Village 4	0.3989	0.4622	0.0041	0.1513	0.1900	**0.2413**
Village 5	0.1239	0.2341	0.0688	0.1756	0.3126	**0.1830**
Village 6	0.3096	0.3417	0.1367	0.0854	0.3232	**0.2393**
Village 7	0.4854	0.1461	0.0584	0.1363	0.4035	**0.2459**

Note:

POP =	Population density	CLD =	Children, oldaged	POV = Poverty
VUL=	Vulnerables	AGR =	Agric. income	SEN = Sentivity



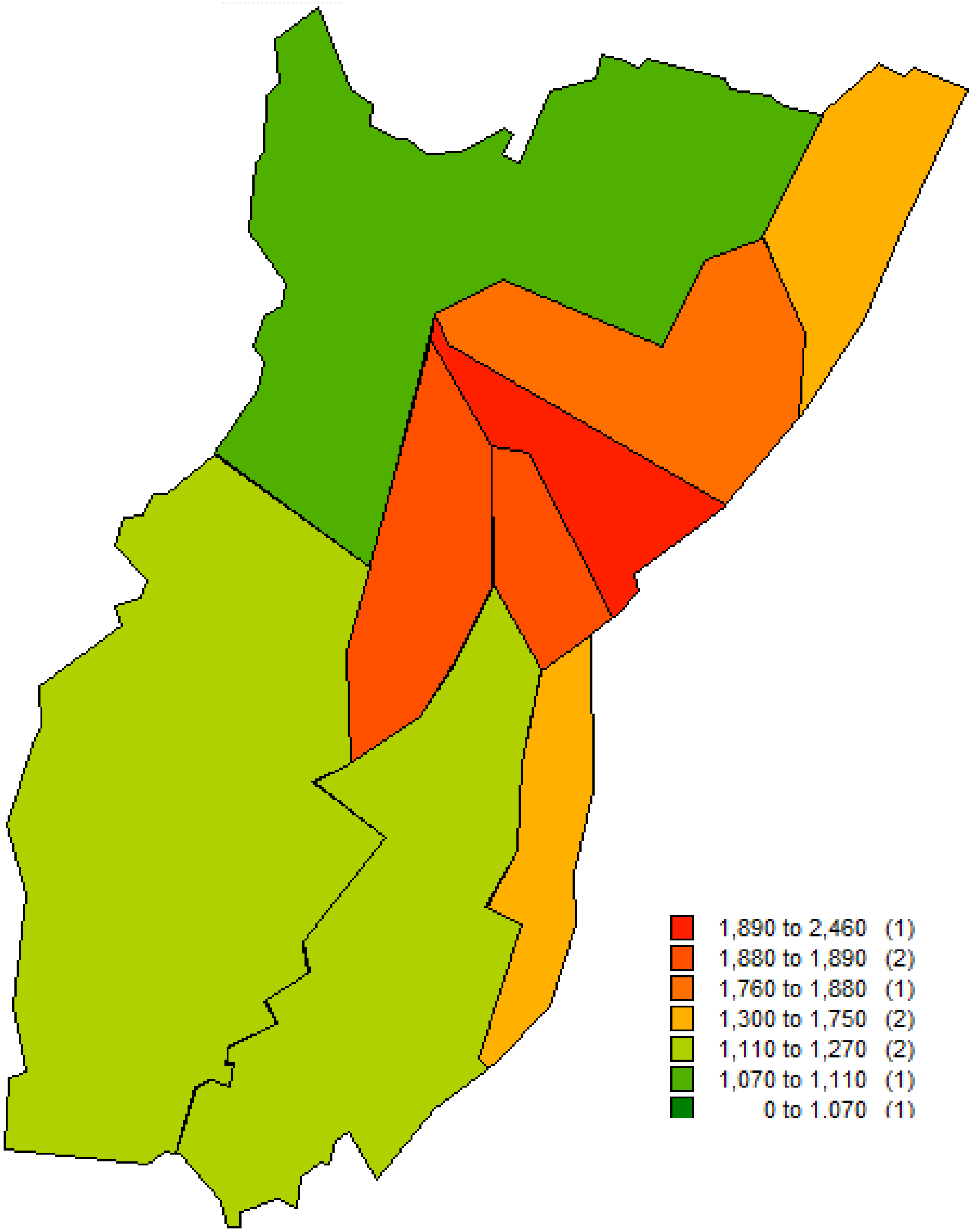


Figure 6b. Maps of climate change sensitivity of Cau Thia Ward

Figure 6c. Maps of climate change sensitivity of Tam Thanh Commune

Analysing results of measuring and mapping the climate change sensitivity, we have some following remarks:

- All 4 selected indicators reflecting human sensitivity, namely population density and percentage of the vulnerable groups, belong to those indicators used by local governments in their daily policy making and administration works. There are the same criteria defined by the Government for all locations in the country. Therefore, the sub-index of human sensitivity is comparable in the nation-wide scope. In contrary, ecological sensitivity could be reflected by various indicators, which present very diversified ecological conditions of localities. The huge diversification of local ecological conditions makes the choice of nationaly representative indicators complicated.

- In our indicator set that used for computing sensitivity sub-index, the human sensitivity has a dominant role in comparison to ecological sensitivity, because 4 of total 5 indicators relates to the human aspect. We do not under-appreciate ecological aspect; nevertheless in our current CBMS survey, there is few questions relating ecological sensitivity. It's to note that in the future, some more variables should be include in indicator set so that the weight of human and ecological sensitivities are more balanced.

- The selected indicator reflecting ecological sensitivity in our study, as well as the indicators of this sub-index in some other studies (like coverage of protected area, forest area, food insecurity, etc.) concern mostly problem in rural areas. Thus, the influence of ecological sensitivity indicators on the total sensitivity index is minor in urban locations (in our study, the case is some vilages in Cau Thia Ward, where the variable of agriculture share is unsignificant, almost zero). Mean-while, urban area containes many ecological problems and challenges caused by climate change. It seems that we had to pay more attention for improving indicator set of urban ecological sensitivity.

4.2.3. Measuring and mapping adaptive capacity to climate change

Table 6. Adaptive capacity sub-index of three pilot communes

	Socio-economic factors		**Infrast-ructure**	**Technology**			**ADT**
	(13) TRN	**(14) SUP**	**(15) DWL**	**(16) VHL**	**(17) TEL**	**(18) TVS**	
KIM TRUNG COMMUNE							
Commune	**0.1254**	**0.0000**	**0.8746**	**0.0279**	**0.9690**	**0.9675**	**0.4941**
Village 1	0.0000	0.0000	0.8806	0.0149	0.9104	0.9552	0.4602
Village 2	0.5574	0.0000	0.9180	0.0328	0.9672	0.9672	0.5738
Village 3	0.0328	0.0000	0.9754	0.0082	0.9672	0.9836	0.4945
Village 4	0.1953	0.0000	0.8284	0.0355	0.9822	0.9349	0.4961

Village 5	0.0000	0.0000	0.6796	0.0388	0.9806	0.9709	0.4450
Village 6	0.0806	0.0000	0.9758	0.0323	0.9758	1.0000	0.5108
CAU THIA WARD							
Ward	**0.9986**	**0.4272**	**0.8416**	**0.0537**	**0.8755**	**0.9547**	**0.6919**
Village 1	1.0000	0.7077	0.2000	0.0000	0.8000	0.8462	**0.5923**
Village 2	1.0000	0.9873	0.7089	0.0000	0.8987	0.9494	**0.7574**
Village 3	1.0000	0.2813	0.9219	0.0625	0.9219	0.9844	**0.6953**
Village 4	1.0000	0.1600	0.9733	0.0800	0.8533	0.9733	**0.6733**
Village 5	1.0000	0.4143	0.9143	0.1571	0.9000	0.9857	**0.7286**
Village 6	1.0000	0.3086	0.9506	0.0370	0.9506	1.0000	**0.7078**
Village 7	1.0000	0.0690	0.9310	0.0690	0.8966	0.9655	**0.6552**
Village 8	0.9889	0.1778	0.8889	0.0778	0.9000	0.9444	**0.6630**
Village 9	1.0000	0.7500	0.9583	0.0104	0.7708	0.9375	**0.7378**
TAM THANH COMMUNE							
Commune	**0.6351**	**0.4460**	**0.9805**	**0.2274**	**0.7827**	**0.8951**	**0.6611**
Village 1	0.9866	0.4477	0.9651	0.0402	0.8016	0.8767	**0.6863**
Village 2	0.9798	0.9637	0.9919	0.0927	0.5323	0.7984	**0.7265**
Village 3	0.1517	0.5112	0.9663	0.2528	0.8427	0.8539	**0.5964**
Village 4	0.0313	0.0391	0.9688	0.0703	0.8359	0.9375	**0.4805**
Village 5	0.9940	0.7410	1.0000	0.5783	0.8494	0.9398	**0.8504**
Village 6	0.9256	0.3767	0.9767	0.2326	0.8047	0.9395	**0.7093**
Village 7	0.0176	0.0141	0.9965	0.4366	0.8592	0.9507	**0.5458**

Note:

TRN = Training SUP = Support VHL = Vehicles DWL = Dwelling

TEL = Telephone TVS = Tiviset ADT = Adaptive capacity

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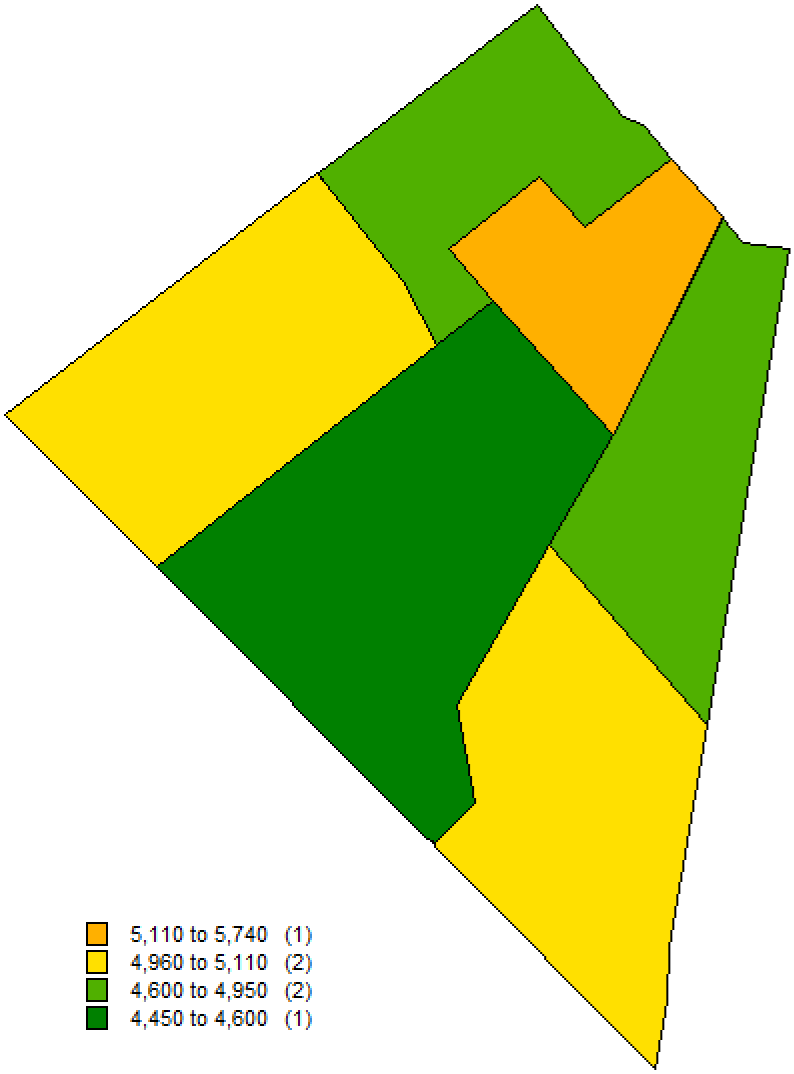


Figure 7. Maps of adaptive capacity to climate change of Kim Trung commune

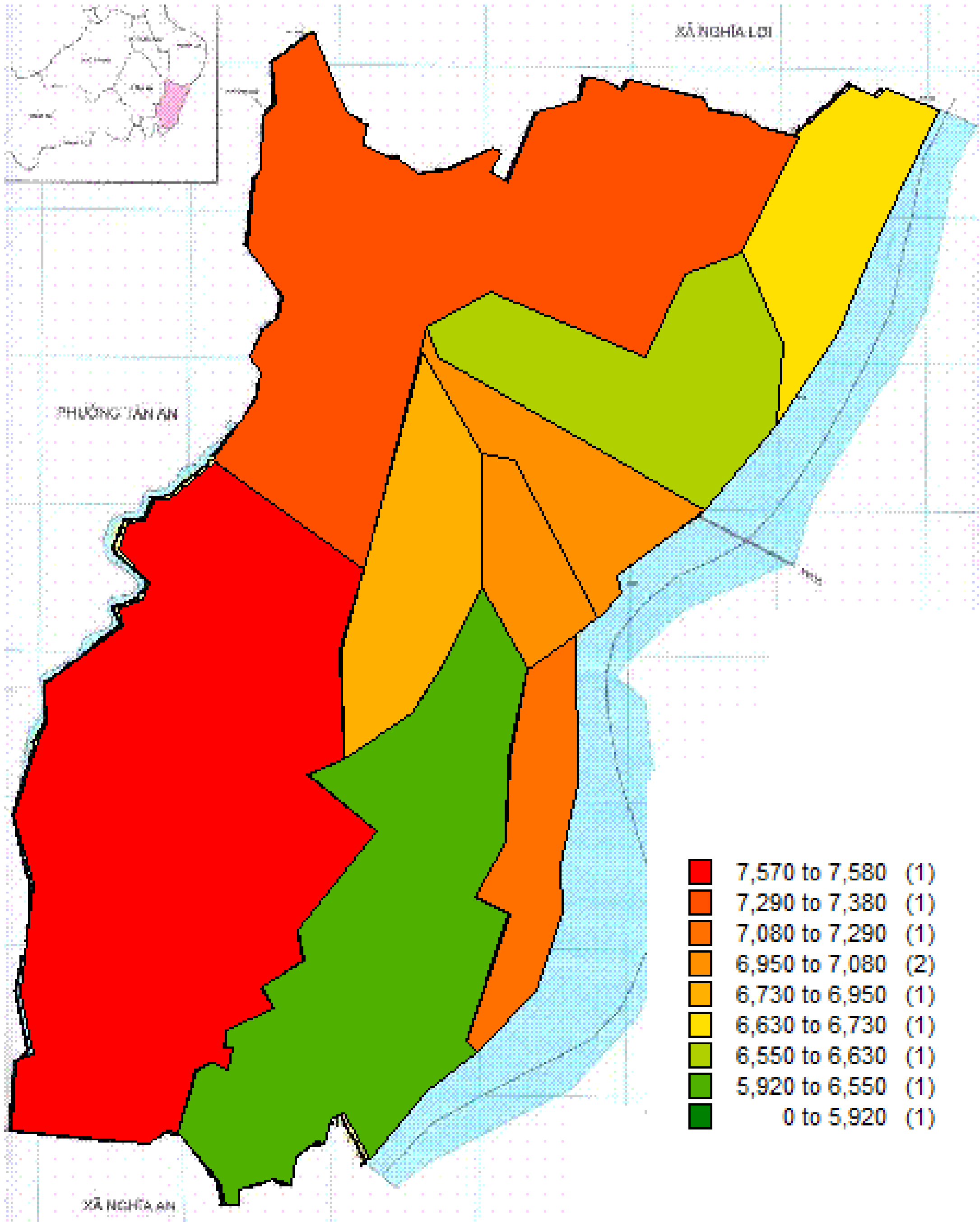


Figure 7. Maps of adaptive capacity to climate change of Cau Thia Ward

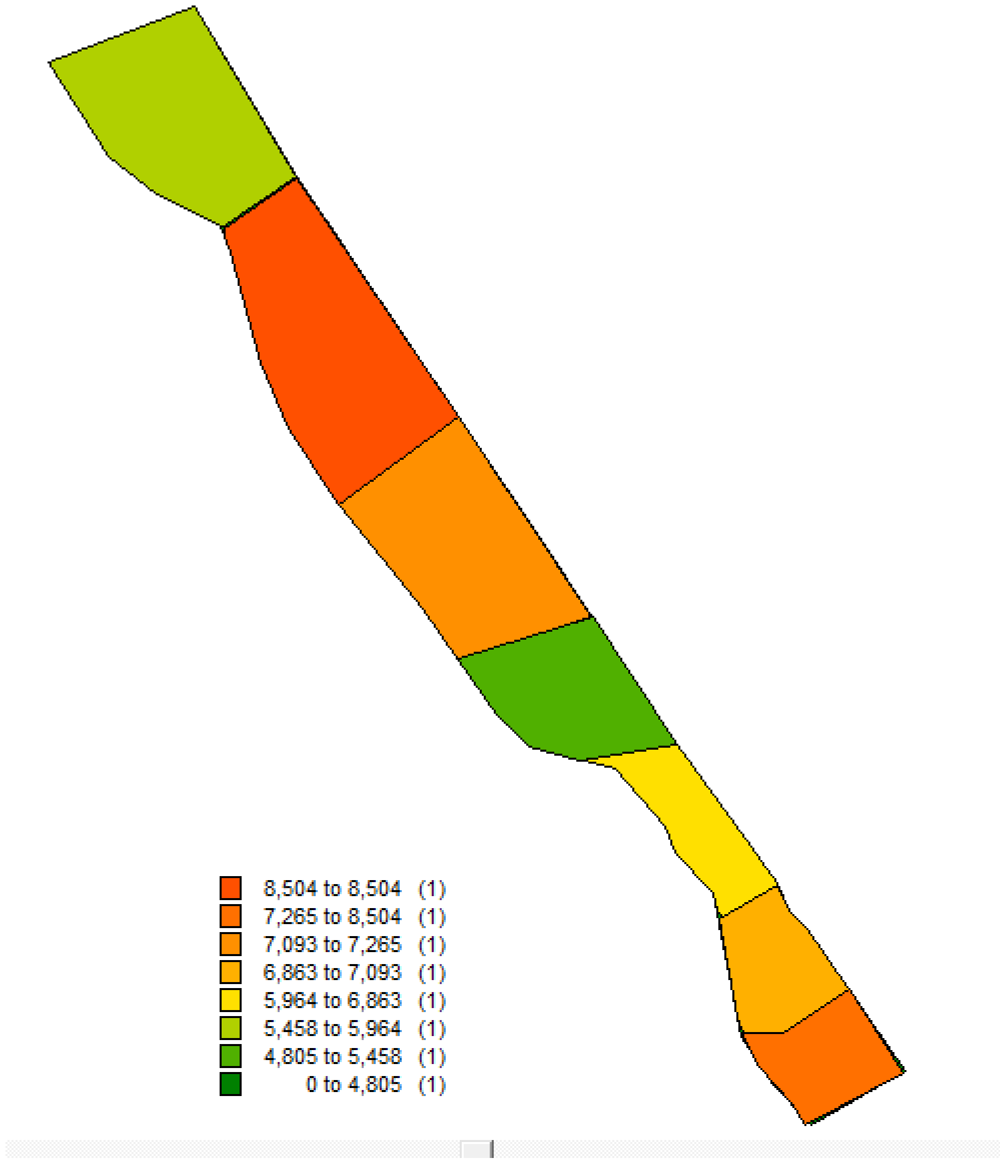


Figure 7. Maps of adaptive capacity to climate change of Tam Thanh Commune

In Vietnam, the readiness of local communities in response to climate change in general and natual disasters in particular is assesses by availability of four factors: managing capacity, population trainned on response to climate change, materials (including food reserves and other esential materials for living and construction), and logistic capacity (including infrastructure facilities and their operation capacity) at the locality. We have made effort to include these four factors in our indicator set reflecting adaptive capacity. Analysing results of measuring and mapping the adaptive capacity to climate change, we have some following remarks:

- Infrastructure facilities are important for response to climate change, especially to narural disasters. At the commune and village level, it's dificult to collect comparable data of infrastructure, such as road density, because the types, location and quality of roads are diversified. Rivers and channels, for example, are convenient and effective transpotation roads in some regions, but such natually made roads used not to be considered as an infrastructure facility and could not be compared to man-made roads. In an another case, a national highway crossing the village might not be useful for local population as a rural road. Therefore, our effort for measuring and comparing road density was defeated with such arguments from local key informants.

- In three pilot communes, the infrastructure and technology factors diversify not significantly, because such indicators as coverage of telephone, tivi and permanent house are high and almost the same in all surveyed localities. The indicator of density of big vehicles (car, bus, ship, boat) is different in communes and villages, while the density of individual vehicles (motocycle, bicycle) is high and therefore makes small differences between communes and villages.

- Value of the adaptive capacity index depends very much on indicators of socio-economic factors. In particular, the variables reflecting the availability of funds and material supports for response to climate change are significantly diversified among surveyed communes and villages. They have linear relationship to adaptive capacity index.

4.2.4. Measuring and mapping climate change vulnerability

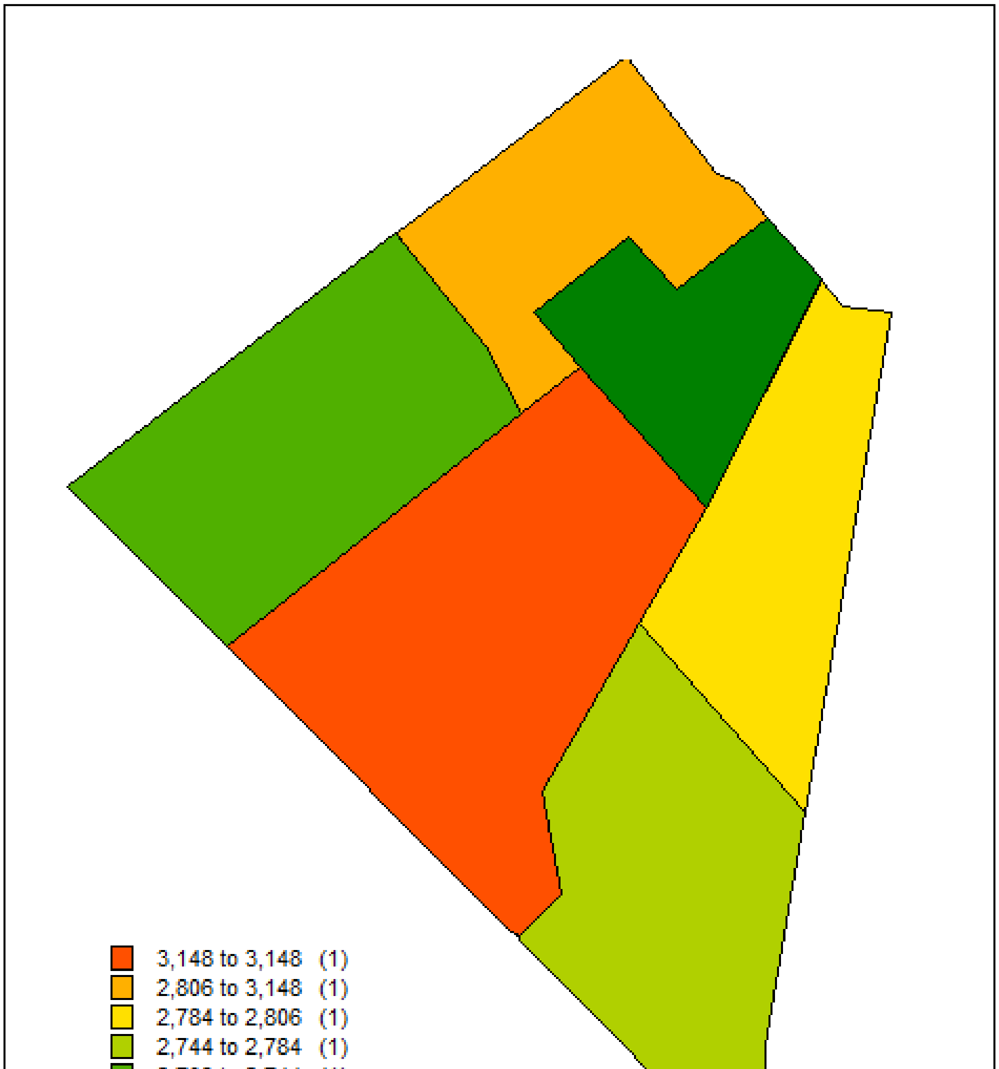
As mentioned above, the climate change vulnerability index is calculated with the following formula:

Vulnerability = 1/3 Exposure + 1/3 Sensitivity + 1/3 (1 – Adaptive capacity)

Table 7. Climate change vulnerability index of three pilot communes

Indicator	**Kim Trung**	**Cau Thia**	**Tam Thanh**
Commune/Ward	**0.2774**	**0.1604**	**0.1916**
Village 1	0.2806	0.2096	0.1958
Village 2	0.2302	0.1639	0.1879
Village 3	0.2784	0.1726	0.2337
Village 4	0.2744	0.1790	0.2544
Village 5	0.3148	0.1579	0.1148
Village 6	0.2709	0.1862	0.1863
Village 7		0.1861	0.2337
Village 8		0.1739	

Village 9		0.1429	



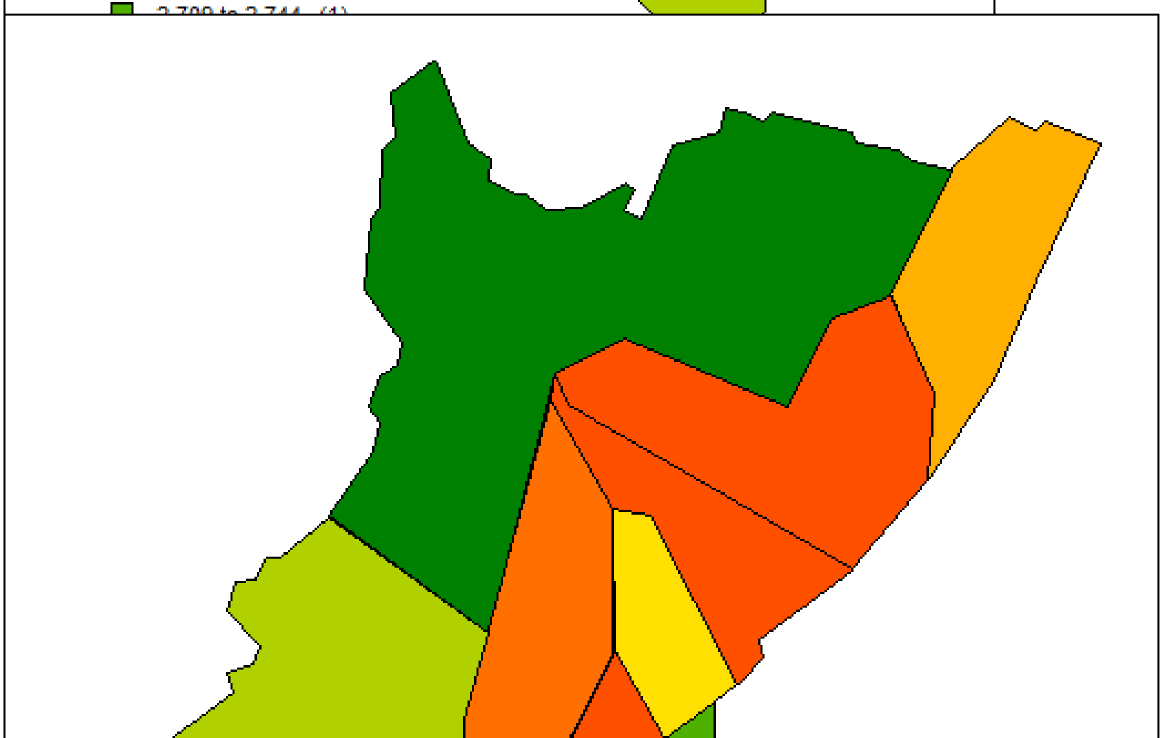


Figure 8. Maps of climate change vulnerability of Cau Thia Ward

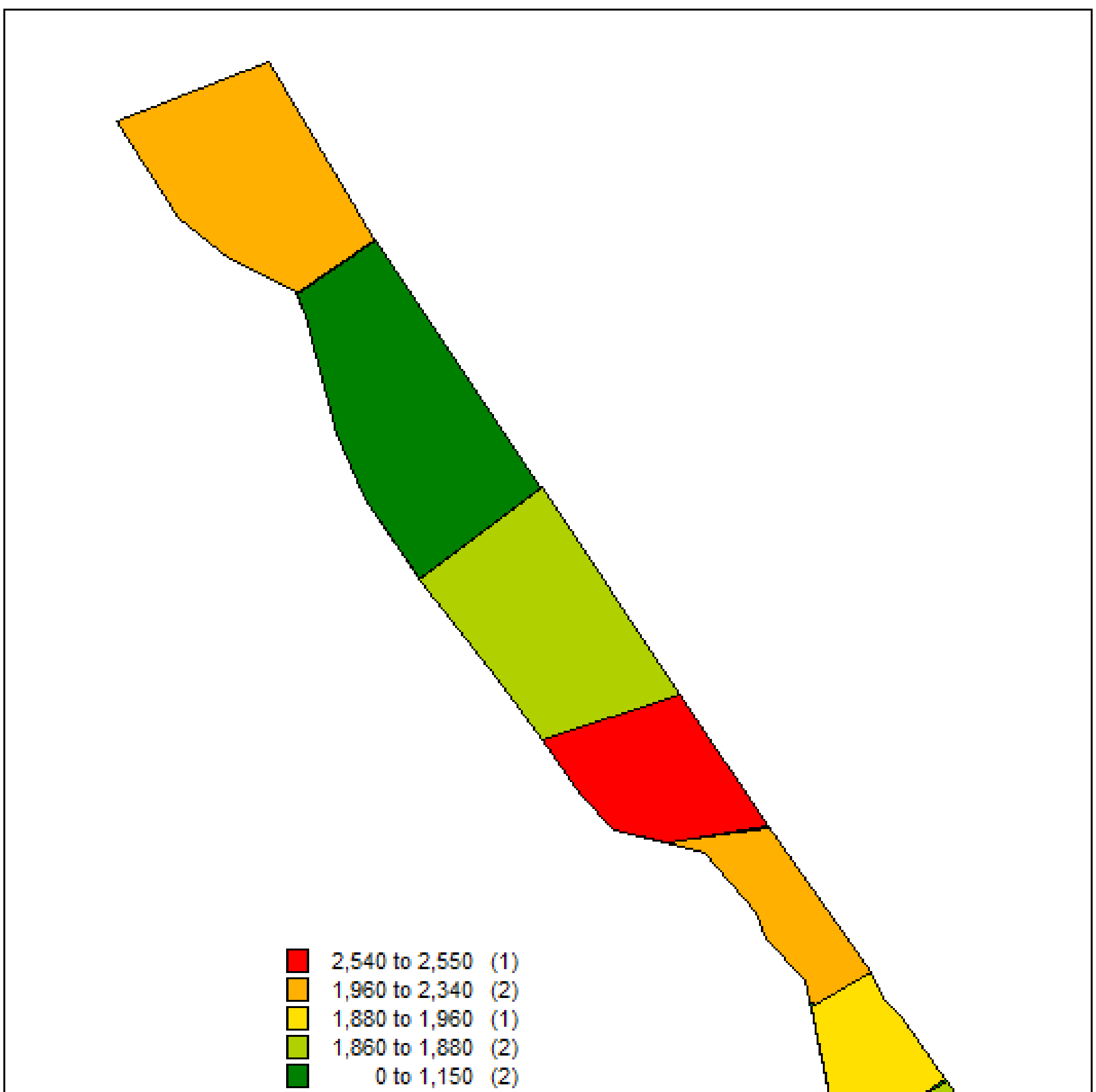
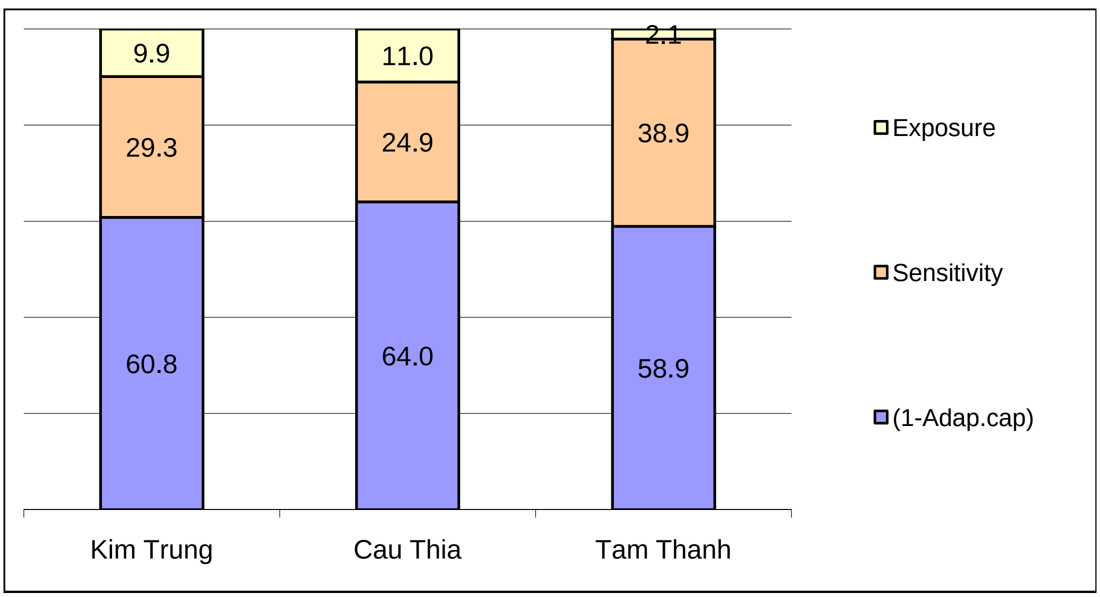


Figure 8. Maps of climate change vulnerability of Tam Thanh Commune

Analysing results of measuring and mapping the climate change vulnerability, we have some following remarks:

- Comparing the CCVI of three communes, we found that Cau Thia commune in the mountainous region is less vulnerable than Tam Thanh and Kim Trung communes in the coastal regions. The rural areas have higher CCVI than the urban areas.

- Among three components being background for computing CCVI, the exposure sub-index contributes the smallest share. It share in total value of CCVI is only 2% in Tam Thanh commune, and 10-11% in Kim Trung and Cau Thia communes. The sensitivity sub-index contributes 25-40% of CCVI value. The weakness of adaptive capacity contributes 60-64% of CCVI value in the pilot communes (Figure 9).



Measuring and Mapping Climate Change Vulnerability at District Level

In this study, we collected data of communes in the three pilot districts/towns and calculated indicators and sub-indices, then computed the CCVI of communes and districts. The results of measuring and mapping CCV of one of pilot district, namely Nghia Lo Town, are presented below as a representative case.

Nghia Lo town consists of 4 urban wards and 3 rural communes. Analysing results of measuring and mapping the climate change vulnerability of wards and communes in Nghia Lo Town, we have some following remarks:

- Compared to the rural communes, the wards are not very much different in most of the natural and social aspects, except the occupation of population. Therefore, the differences of sub-indices between wards and communes are also not significant. The average CCVI of three rural communes is 0.2363, while the average CCVI of four urban wards is 0.2350.

- The highest value of the exposure sub-index is 2.0 times compared to the lowest value of this sub-index. This gap in the case of the sensitivity sub-index is 1.5 times, and the adaptive capacity sub-index is 1.3 times. Finanly, the gap between the highest and the lowest CCVI of wards and communes in the Nghia Lo Town is only 1.2 times (Table 8).

- Similar as the structure of CCVI at the commune level presented in the previous section, the exposure sub-index at the district level here contributes 11%, the sensitivity sub-index 20% and the weakness of adaptivity capacity 69% of the CCVI value (Figure 11).

Table 8. Sub-indices and climate change vulnerability index of Nghia Lo town

Indicator	**Exposure**	**Sensitivity**	**Adaptive capacity**	**Vulnerability**
Commune 1	0.0932	0.1779	0.5160	**0.2517**
Commune 2	0.0632	0.1369	0.5147	**0.2285**
Commune 3	0.0878	0.1321	0.5335	**0.2288**
Ward 1	0.1185	0.1274	0.6100	**0.2120**
Ward 2	0.0582	0.1220	0.4245	**0.2519**
Ward 3	0.0614	0.1346	0.4848	**0.2371**
Ward 4	0.0675	0.1782	0.5283	**0.2391**

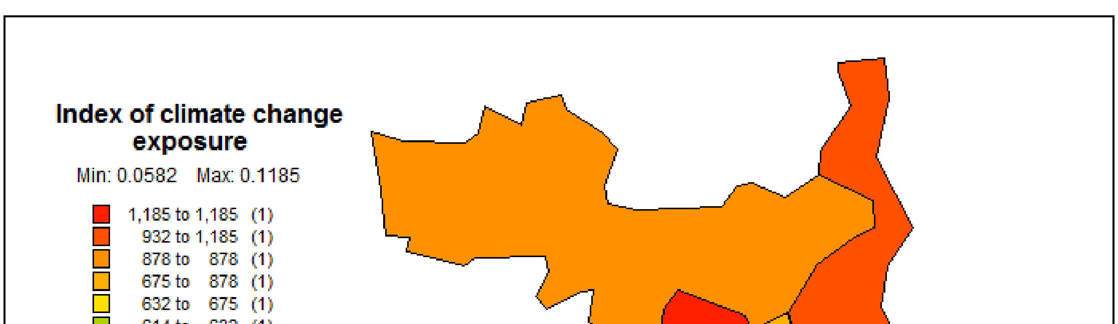


Figure 10a. Maps of climate change exposure of Nghia Lo Town

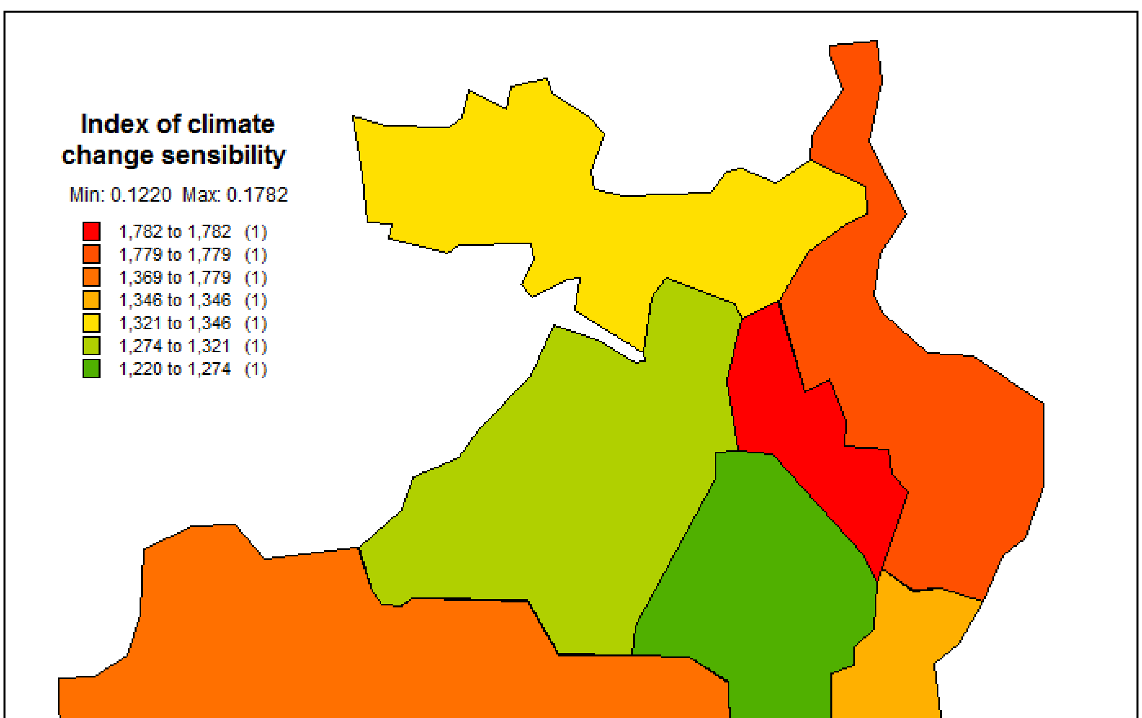
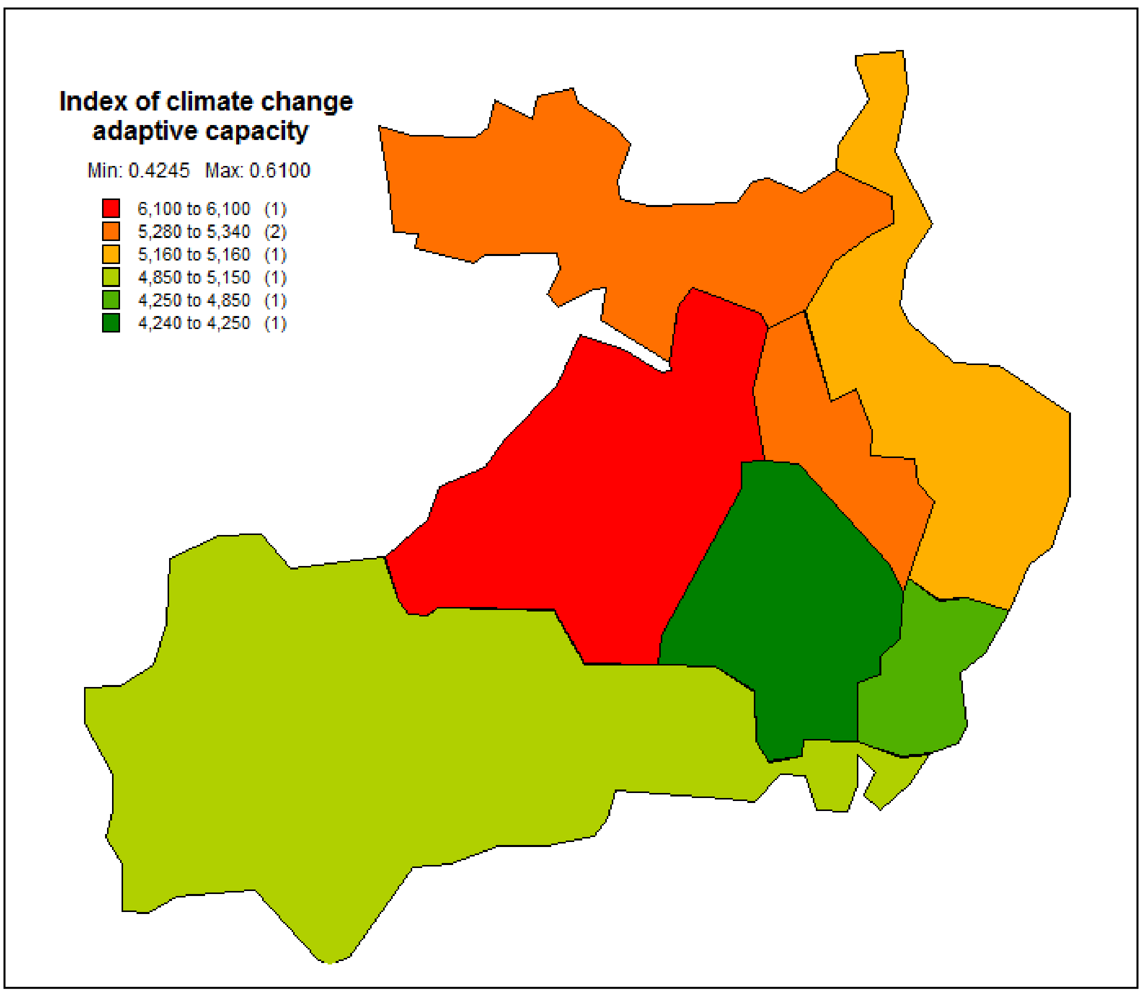
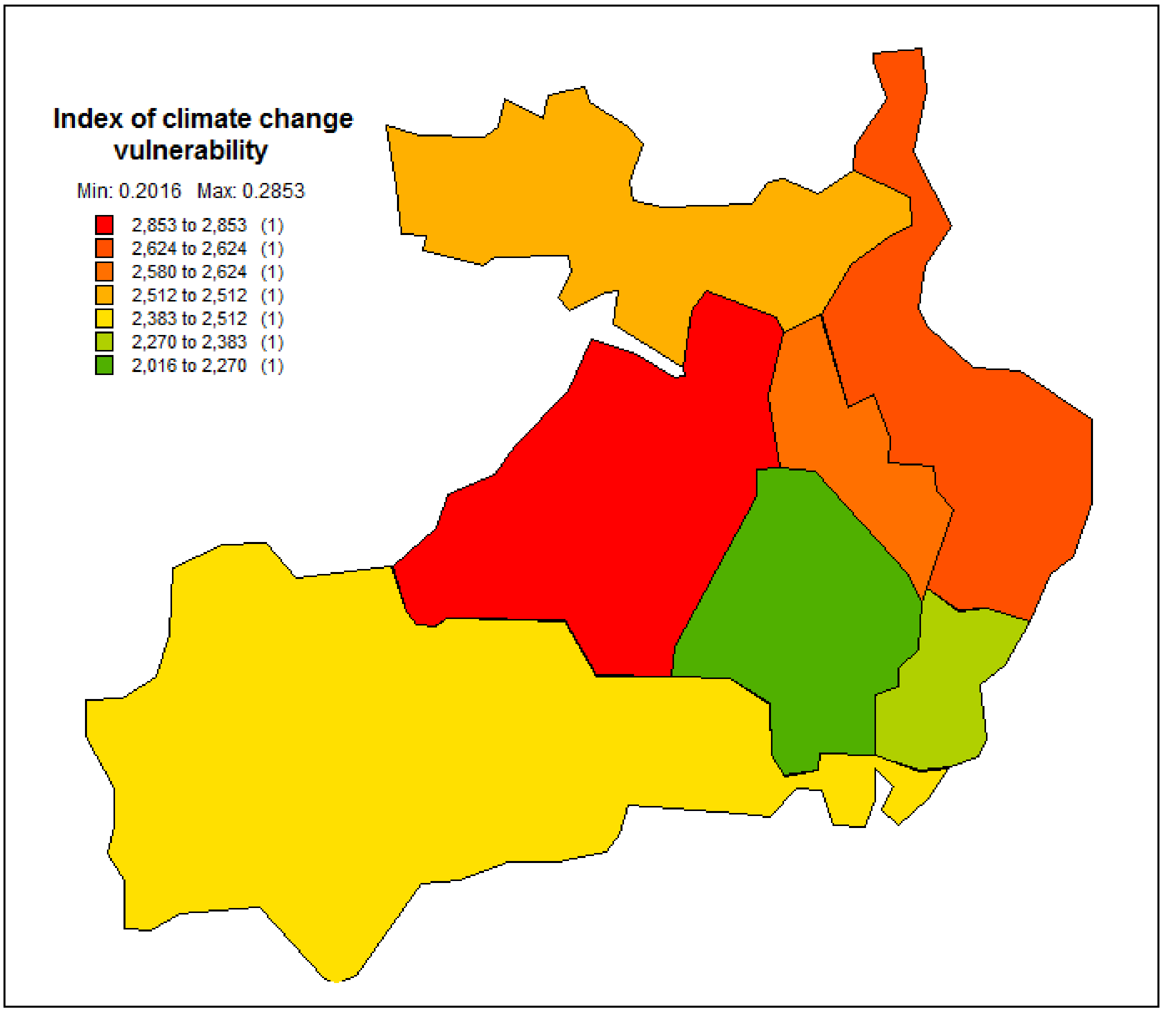
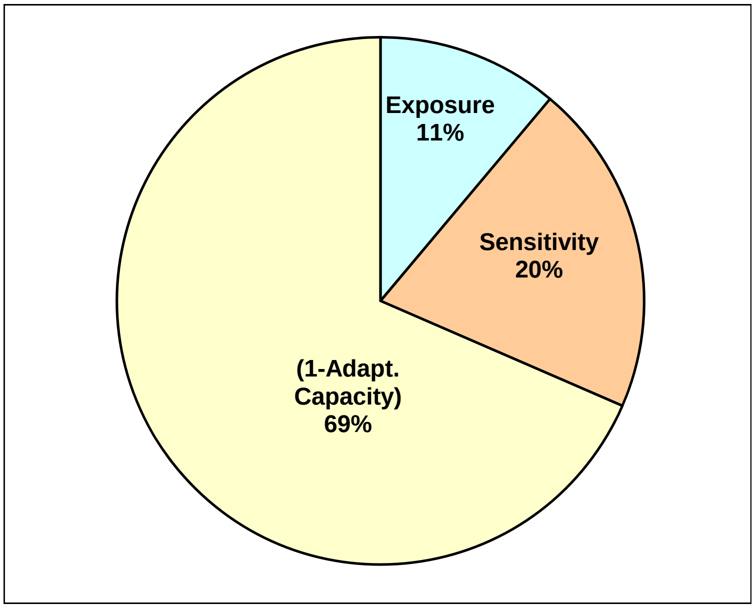


Figure 10b. Maps of climate change sensibility of of Nghia Lo Town




Index of climate change vulnerability
Min: 0.2016 Max: 0.2853
2,853 to 2,853 (1)
2,624 to 2,624 (1)
2,580 to 2,624 (1)
2,512 to 2,512 (1)
2,383 to 2,512 (1)
2,270 to 2,383 (1)
2,016 to 2,270 (1)



4. **Climate Change Responses of Local Government**

A participatory SWOT analysis was done regarding the application of mapping CCV for improving responses of local governments to climate change. Participants in this analysis were representatives of provincial, district and commune administrations of the three pilot locations. The following remarks were raised:

(a) Strengths:

- The methodology of measuring and mapping climate change vulnerability is a good tool for presenting climate change phenomenons and assessing factors impacting on these phenomenons.

- Using the easily understandable and simple indicators based on available data in localities, and uncomplicated technique of index calculation, this methodology is appropriate for implementation in local conditions.

- Mapping climate change vulnerability and its component sub-indices is an effective tool for administrative work, since it helps to show quickly the more vulnerable areas that need to pay more attention, and to develop adequate policies and solutions to respond.

- Climate change vulnerability maps are helpful visual tools for increasing awareness of people on climate change issues.

(b) Weaknesses:

- The constructed methodology is still not perfect, because many variables reflecting climate change hazard/exposure, sensitivity and adaptive capacity are still not included in indicator set, as well as method of computing sub-indices and CCVI has to be improved.

- There is still a possible conflict in the concept of indicator selection: to reflect complexity of climate change phenomenons, more variables and huge database should be generated and used, while local human, technical and financial capacity is not enough strong to fulfill this requirement.

- This approach of climate change assessment provides tools to catch a snapshot of climate change hazard/exposure, impacts on communities, households and individuals. This approach based on the collected data of historical past of climate change exposure, current sensitivity and adaptive capacity of communities to respond to climate change. It seems that the weakness of this approach was the limitation on the projection of future impacts of ongoing climate change on socio-economic development and ecological protection.

(c) Opportunities:

Implementation of the National Climate Change Strategy and pushing up actions to respond to climate change in local, national and international dimensions require development of new tools of planning, monitoring and reporting. Such new initiatives like mapping CCV has wide space for application.

(d) Challenges:

- Implementation of mapping methods requires some necessary equipments (computers, projectors, screens, colour printers, etc.) and qualified staff, which are not available in many localities, especially in poor rural communes and villages.

- CBMS has been piloted in only few localities in Vietnam. Although it is a low-cost data collecting system, it can still not be expanded much due to limitation of financial resources of local governments. Therefore, using CBMS data for CCV mapping faces difficulties in expanding the implementation scope.

- In order to supply necessary and standardized data for regularly and systematically measuring and mapping CCV at district, provincial and national levels, a serie of indicators has to be included in the national and local statistical system, so that they would be systematically collected and processed. This requires a revision of the list of statistical indicators and the system of data collection.

In order to implement the CCV mapping methodology in broadened scope, it’s to take measures to overcome the above mentioned weaknesses in methodology, to strengthen capacity building for the agencies, especially those directly relating climate change responses and anti natural disasters at the local level of administration.

5. CONCLUDING REMARK

The vulnerability index we estimate addresses the question: where are the different climate change phenomenon happened, what are the factors that render some areas more vulnerable than others? This information can help policy makers to design adequate policies and solutions to respond to climate change problems, including to direct resources toward the areas with the highest vulnerability to climate change.

Measuring and mapping climate change vulnerability in some pilot locations in Vietnam showed that vulnerability could quantitatively reflected and spatially presented. Although methodology of measuring and mapping has to be further improved, and tools and instruments for vulnerability mapping and risk assessment has to be customized to local context, nevertheless, in general mapping of climate change vulnerability, is as useful for policy makers as poverty mapping. It is effective tool for assessing the past and current situation and trends, and for planning actions to respond and mitigate climate change in localities. It has been showed by the pilot test and is welcomed by staff of the local governments where it implemented.

Some additional questions/clarifications/comments:

1. In the questionnaire, item #23 indicates: Household's recommendations to policies of poverty reduction and climate change response. What were the most common responses of the households?

Requirements for more financial support to response to floods, storms, losses of crops and animals due to climate change.

2. Part of your objectives was to recommend adaptation strategies based on the results of the vulnerability assessment and mapping. Please include in the revised paper the adaptation strategies that can be integrated in disaster and other environment management plans of local government in the pilot areas.

We have mentioned this issue in the explanation on Strengths and Weaknesses. According to our opinion , adaptation strategies cannot be constructed based only on this vulnerability assessment and mapping. This methodology is to be used as one of supplemental tools for climate change management.

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APPENDIX

1. Household Questionnaire Used in CBMS Survey

1. **Name of HH head:** ....……………… Male /Female
2. **Village:** ....………………………….
3. **Commune:** ....………………………….
4. **District:** ....………………………….

HOUSEHOLD MEMBERS BENEFITED FROM SOCIAL SAFETY PROGRAMS

5. War suffered *(number of persons, if yes)*

1	War invalid			3	Relatives of dead soldier	
2	Sick, unworkable			4	Dioxine suffered	

6. Beneficiary of social safety programs *(number of persons, if yes)*

1	Single old-aged			4	Unworkable	
2	Orphan			5	Blind	
3	Invalids			6	Mental sick	

7. Household members:

	Relation to HH head	Birth year	Sex	Education level	Child (6-15) shool enrolment	Main profession
1						
2						
3						
4						
…						
…						

8. Land ownership and land use: **(m2)**

	Owned and currently used by HH	Rented land	Released to other HHs
1. Agricultural land:			
(a) Annual crop land			
Of which: Paddy land			
(b) Perenial crop land			
(c) Other agric. land			
2. Garden and residential land:			
3. Forestry land:			
4. Water surface:			
Of which: Used for aquaculture			
5. Other land:			

9. Productive equipment and machinery: *(Number of pieces)*

1	Large tractor (over 15 CV)			5	Truck	
2	Small tractor (under 15 CV)			6	Bus	
3	Water pump			7	Car for rent	
4	Motor boat, ship			8	Other	

10. Consumption durable goods: *(Number of pieces))*

Bicycle	Motobyke	Car	Boat	Computer
Tiviset	Fridge	Telephone	Gas cooker	Electric fan

11. Animals (Number of head):

Buffalo:	Cow:	Pig:	Goat:	Pultries:	Others:

12. Housing: *(Circle)*

Multi-storey brick house	One-storey brick house	Good wooden house	Wooden house	Bamboo house, tent
Ownership of housing:		Private	Rented	Public

13. Electricity *(circle)*

National grid	Small hydro-power machine	Generator, accumulator	No

14. Fuel for cooking *(circle)*

Wood, leaves, straw	Coal	Electricity	Gas	Biogas	Other

15. Water: *(circle)*

Taped water	Communal reservoire, tap	Rain water	Deep-drilled well	Dug well	Mountainous well	Lake, river
Should HH carry water home?			Yes / No			

16. Toilet: (*circle*)

Flush toilet	Double-valve toilet	Simple toilet	Toilet on river, lake	No toilet

17. Income: Real income during the last 12 months

	Income source	**Value (VND)**
1.	Cultivation	
2.	Animal livestock	
3.	Fisheries	
4.	Forestry	
5.	Trading	
6.	Handicraft, , ,	
7.	Transportation	
8.	Construction	

9.	Other off-farm activities	
10.	Stable salary (in a month)	
11.	Casual salary of hired labour (in a month)	
12.	Pension, allowance, social security, etc. (in a month)	
13.	Remittance from relatives, aid	
14.	Other income *(specify)*	

18. Poverty status of HH? *(Yes/No)*

2008:	2009:	2010:	2011:

19. Health: Did someone in HH suffered by following diseases during 12 last months?

Malaria	Tuberculosis	Cancer	HIV/AIDS	Trafic acident

20. In which health facilities treated? *(Number of times)*

Commune health station	District hospital	Provincial hospital	Private clinics	Pharmacist
Village nurse	Traditional healer	Self-treartment	No treatment	

21. Did household affected by climate change, natural disasters, pests?

	Death (C), Injured (T) (person)			**Value of agricultural, forestry, fishery loss (mil VND)**			**Value of damaged property (mill. VND)**		
	2008	**2009**	**2010**	**2008**	**2009**	**2010**	**2008**	**2009**	**2010**
Typhoons, cyclones									
Floods									
Droughtd									
Saltwater intrusion									

Landslides									
Crop pests									
Aquacultural diseases									
Animal diseases									
Birth flu									
Other									

22. Did household got supports from government, social organisations, communities to respond to climate change phenomenons? *(Yes/No)*

	Trainnings	**Financial support**	**Labour support**	**Material support**
Typhoons, cyclones				
Floods				
Droughtd				
Saltwater intrusion				
Landslides				
Crop pests				
Aquacultural diseases				
Animal diseases				
Birth flu				
Other				

23. Household's recommendations to policies of poverty reduction and climate change responses? *(If any)*

2. Form for collecting statistical data of communes in a district

		Commune			
		1	2	3	….
1.	**LAND**				
1	Total area (ha)				
2	Agricultural land (ha)				
3	Paddy land (ha)				
4	Forestry land (ha)				
5	Forestry land covered by forest (ha)				
6	Land under construction (ha)				
7	Protected area *(if available)* (ha)				
8	Irrigated agricultural land (ha)				
9	Agricultural land under risk of floods, droughts (ha)				
10	Lanfd under risk of lanslides (ha)				
2.	**POPULATION, LABOR, POVERTY**				
1	Number of villages in commune				
2	Total number of households				
3	Population (person)				
4	Female population (persons)				
5	Laborers (15-65 years old)				
6	Old-aged population (over 65 years old)				
7	Children (under 15 years old)				
8	Number of poor HHs				
9	Number of poor people				
3.	ECONOMY (2010 data)				
1	Total production value (mil. VND)				
2	Production value of agriculture, forestry, fishery (mil. VND)				
3	Production value of agriculture (mil. VND)				
4	Production value of forestry (mil. VND)				

5	Production value of industry, construction (mil. VND)				
6	Value of services (mil. VND)				
7	Production of rice (1000 ton)				
8	Production of maize (1000 ton)				
4.	**INFRASTRUCTURE**				
1	Total length of road in the commune area (km)				
2	Total length of passable water way in the commune area (km)				
3	Total number of trucks and cars				
4	Total number of ships and boats				
5	Number of HH having permanent house				
6	Number of HH having TV				
7	Number of HH having telephone and mobile phone				
8	Are there permanent public buildings (school, office, pagoda, church…)?				
9	How many people can stay in these permanent public buildings during natural disasters (floods, storms, landslides, …)?				
5.	**IMPACTS OF CLIMATE CHANGE**				
1	Agricultural area affected by flood (ha)				
a	2008				
b	2009				
c	2010				
2	Agricultural area affected by droughts (ha)				
a	2008				
b	2009				
c	2010				
3	Total area affected by landslides (ha)				
a	2008				

b	2009				
c	2010				
4	Number of households which lost houses, property, crops due to storms, floods				
a	2008				
b	2009				
c	2010				
5	Number of households which lost due to animal diseases (bird flu, pig and cow infectious diseases)				
a	2008				
b	2009				
c	2010				
6.	**RESPONSE TO NATURAL DISASTERS AND CLIMATE CHANGE**				
1	How many villages which have action plan of response to natural disasters?				
2	Expenses of the commune budget for response to natural disasters				
a	2008				
b	2009				
c	2010				
3	Expenses for construction, upgrading irrigation systems, dikes in the commune				
a	2008				
b	2009				
c	2010				
4	Increase (+), decrease (-) of forest area				
a	2008				
b	2009				
c	2010				

5	Total number of people who have trainned on response to natural disasters and climate change during 3 last years (2008-2010)				