Health Implications of Infectious Diseases due to Climate Change: A Case Study of Ho Chi Minh City

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School of Environmental Sciences
Faculty of Sciences
University of East Anglia
HEALTH IMPLICATIONS OF INFECTIOUS DISEASES DUE TO CLIMATE CHANGE: A CASE STUDY OF HO CHI MINH CITY

by

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Thesis presented in part-fulfilment of the degree of Master of Science in accordance with the regulations of the University of East Anglia

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August 2010

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Climate change is rising as a pronounced threat to the development of Ho Chi Minh City since it is having adverse impacts not only on the environment and economy but also on social aspects, including public health. Among the climatic health outcomes, infectious diseases, namely malaria, dengue fever, water- and food-borne diseases, and rodent-borne diseases are emerging as a critical one. In the light of this, the research is aimed to study about the experts’ and public’s perceptions of the health implications of infectious diseases due to climate change in HCMC. Chosen methods for both studies of the experts’ opinions and the public’s awareness are questionnaire surveys. Two sets of questionnaire are sent separately to the experts in the three relating fields – environment, climate change, and public health, and to the public in HCMC. Based on the expert judgment, it is concluded that climate change could lead to heavy burdens on malaria, dengue fever, and water- and food-borne diseases. On the other hand, the experts are inclined to agree whether climate change could aggravate the health implications of rodent-borne diseases. Regarding public awareness, respondents agree that they and their family members are now at risk of getting water- and food-borne diseases most. In addition, that the public considers climate change increases their risks of catching infectious diseases is another finding of the survey.

Key words: Climate change, Human health, Infectious diseases, Ho Chi Minh City.
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<td>Adverse Health Effect</td>
<td>A change in body function or cell structure that might lead to disease or health problems</td>
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<td>Climate Change</td>
<td>Changes of climate in general, both natural and anthropogenic</td>
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<tr>
<td>Climate Variability</td>
<td>Climate change, with no presumption of cause</td>
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<tr>
<td>El Niño</td>
<td>A vast, naturally occurring pool of warm water that sometimes forms in the tropical central Pacific and affects the climate and global weather systems</td>
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<tr>
<td>El Niño-Southern Oscillation (ENSO)</td>
<td>A set of specific interacting parts of a single global system of coupled ocean-atmosphere climate fluctuations that come about as a consequence of oceanic and atmospheric circulation</td>
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<td>Endemic</td>
<td>The constant presence of a disease or infectious agent within a given geographic area</td>
</tr>
<tr>
<td>Epidemic/Outbreak</td>
<td>The occurrence in an area of a disease or illness in excess of what may be expected on the basis of past experience for a given population</td>
</tr>
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<td>Host</td>
<td>Organisms in which smaller organisms or viruses live, feed, and reproduce</td>
</tr>
<tr>
<td>Infection</td>
<td>The entry and development of an infectious agent in the body of a person or animal</td>
</tr>
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<td>Infectious Disease</td>
<td>An illness due to a specific infectious agent that is spread from an infected person, animal, or inanimate reservoir to a susceptible host, either directly or indirectly, through an intermediate plant or animal host, vector, or the inanimate environment</td>
</tr>
<tr>
<td>Reservoir</td>
<td>Any person, animal, arthropod, plant, soil or substance in which an infective agent normally lives and multiplies</td>
</tr>
<tr>
<td>Risk</td>
<td>The chance of becoming infected if exposed to an infectious agent by its specific transmission mechanism</td>
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<tr>
<td>Vector</td>
<td>An animal that transmits infectious agents from one host to another, usually a biting or piercing arthropod like the tick, mosquito, or fly</td>
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CHAPTER ONE

INTRODUCTION
1.0. Introduction

This chapter is to give background information about the study, which is presented in four parts:

- General information
- Organisation of the study
- Why infectious diseases: Justification
- Overall objective and specific aims

1.1 General Information

Ho Chi Minh City (HCMC), a tropical coastal city located on the estuary of Saigon - Dong Nai River system, is the most important regional economic planning unit in Viet Nam. According to a draft report of the Department of Construction of HCMC, the city will become a mega city with 10 millions of citizens by 2020 (Youth Online, 2009). Not interestingly, rapid increases in population size, density of settlement and use of natural resources may damage the buffering capacity of ecological systems against environmental adversity (Woodward et al. 1998). In actual fact, the city currently carries a burden of land and water resources management under high social and economic pressures due to urbanization. Even so, HCMC is under more substantial pressure due to the impacts of greenhouse warming. In particular, the city is facing with the problem of its expansion with the possible growth of the population due to climate migration (ICEM). Generally, changing climate is emerging as a pronounced threat to the development of the city since climate change and urban development often interact negatively (Wamsler 2008).

The observational records show the increase in the number of hot days during the period of 1991 – 2000, increases in precipitation in rain seasons but decreases in dry seasons, and increases in the frequency and severity of extreme weather for instance storms, floods and droughts (IMHEN). In addition, results of the International Centre for Environmental Management (ICEM)’s studies predict 61% of the city surface area is at risk of flooding by 2040, and there are some permanently flooded areas in the case of sea level rise (SLR) of 26 cm (Labour Daily 2009a). Altogether, HCMC, under added climate change circumstances, also have to face with the challenges of increases in tidal flooding, storm surges, saline intrusion and periodic drought (Rodgers 2009).

Consequently, climate change has adverse impacts not only on water resources, agriculture, traffic and energy, but also on public health in HCMC. Climate change would
affect the health of human populations via diverse pathways varying in their complexity, scale and directness (McMichael 2003, Frumkin et al. 2008). As classified to be a city having a limited capacity to protect from climate change based on GDP class by the Organization for Economic Cooperation and Development, HCMC will be both vulnerable to health hazards from climate change and, concurrently, an increasing contributor to the problem (Nicholls et al. 2008, Campbell-Lendrum & Corvalán 2007). Generally, the main areas of health outcomes identified are: heat-related illness and mortality; health impacts of extreme weather events i.e. floods, droughts and storm surges; infectious diseases including vector- and rodent-borne diseases and water-and food-borne diseases; health outcomes associated with air pollution such as allergic and respiratory diseases; and mental health (CDC). Among these health effects of climate change, infectious diseases are an emerging critical subject in the specific case of HCMC. In the light of this, the potential impacts of relevant infectious diseases, which are malaria, dengue fever, water-and food-borne diseases, and rodent-borne diseases, will be discussed in this research. Also, the study will present and analyse the experts’ and public’s awareness of this crucial subject based on questionnaire surveys.

1.2. Organisation of the Study

The research structure is based on the construction of five chapters. The first one contains the general information and justification of the topic. At the end, it will outline the objective and aims of this research. Following on from this introduction, the second chapter will review literature related to climate change in HCMC, the health implications of climate change in general, and specifically in the case of infectious diseases. Based on the broader background, health implications of some infectious diseases namely malaria, dengue fever under changes in climate in the city will be identified. In order to achieve the overall objective and specific aims, methodologies employed have been described in detail in the third chapter. This chapter refers to methods to review literature, and conduct two surveys on expert judgment and public awareness of the issue. Furthermore, the fourth one is to present, analyse and discuss results obtained from these two surveys. Previous outcomes are the basis to generate conclusions, which will be incorporated in the fifth chapter of the research. In addition, recommendations to improve the communication of the health implications of infectious diseases under warming condition to the public are also incorporated in this last chapter.
1.3. Why Infectious Diseases: Justification

Being in the Top 10 of cities with high population exposure of the world (Nicholls et al. 2008), HCMC confronts the economic, social and environmental issues under added global warming pressure. The situation possibly downplays the importance of climate change impacts on human health, which are projected to be adverse ones (Patz et al. 2008). Among these health implications of climate change, infectious diseases related to changes in vector ecology, water and food contamination are emerging to be a crucial aspect in the case of HCMC as:

- Infectious diseases are major causes of death, disability, and social and economic disruption for millions of people. In addition, they can be possibly transmitted via several ways through pathogens, vectors, non-biological physical vehicles (water, soil, etc), non-human reservoirs and human host (WHO, Patz et al. 2003).

- Vector- and rodent-borne diseases and water- and food-borne diseases have currently increasingly affected the population in the city (HCMC Department of Health, HCMC Hospital for Tropical Diseases – HTD, Institute of Malariology – Parasitology – Entomology (IMPE) of HCMC).

- As climate change advances, the burden of these diseases is expected to increase; even some controlled diseases tend to occur like cholera (WHO, CDC, Ebi et al. 2006, Frumkin et al. 2008).

Therefore, it is critical to conduct surveys on the experts’ and public’s awareness about the impacts of climate change on infectious diseases in HCMC to identify the health implications of infectious diseases given by climate change.

1.4. Overall Objective and Specific Aims

The overall objective of the research is to study about the health implications of some relevant infectious diseases due to climate change in HCMC.

This objective will be attempted by the following specific aims:

1. *Identify the potential influences of climate change on infectious diseases*, including vector- and rodent-borne diseases and water- and food-borne diseases in HCMC. Generally, the evaluation is based on the literature review addressing the potential impacts of changes in climate variability and in the health outcomes of relevant infectious diseases.

2. *Identify the experts’ opinions of the climate impacts on infectious diseases*. The expert judgment through questionnaire survey is applied to find out the experts’ opinions of the health implications of infectious diseases under greenhouse gas (GHG) effects. Also the
survey will come up with the recommended priority actions of these experts for communicating the issue to the public in the future.

3. Identify the public’s awareness of infectious diseases and the linkage between climate change and the diseases. This survey aims to review whether the public is aware of climate change, infectious diseases, and the link between these two perspectives. Moreover, which infectious diseases are considered the most severe or at highest risk of being infected are expected outcomes of the survey. Also, the survey results will indicate whether there is a need of education and raising public awareness about possible health outcomes of infectious diseases in the city, as well as what kind of information is required.
CHAPTER TWO

LITERATURE REVIEW
2.0. Literature Review

In this chapter all the findings are analyzed, discussed, and presented in three parts:

- Climate change in Ho Chi Minh City
- Climate change and human health
- Climate change and infectious diseases

2.1. Climate Change in Ho Chi Minh City

Climate change scenarios in HCMC in this paper are mostly based on the scenario-building work by the Ministry of Natural Resources and Environment (MONRE 2009). Criteria for the selection of methods for climate change scenario development in Vietnam used by MONRE include plausibility of global climate change scenarios, level of details of climate change scenarios, inheritability, up-to-date, local appropriateness, completeness of scenarios, and possibility of self updating. As a consequence, MAGICC/ SCENGEN 5.3 software and statistical downscaling method were selected for the development of climate change and sea level rise scenarios in the 21st century.

Moreover, based on scenarios arranged from low to high GHG emissions recommended by IPCC and on practical requirements and computing capacity, the MONRE selected these following scenarios: Low emission scenario (B1), Intermediate emission scenario of the medium scenario group (B2), and Intermediate scenario of the high scenario group (A2). However, due to the complexity of climate change, the uncertainties of GHG emissions scenarios and of model-estimated scenarios results, together with the specifically psychological, social, and economic factors in Vietnam, MONRE recommends the medium scenario (B2) as the most suitable scenario for ministries, sectors and provinces/ cities to use as an initial basis in climate change and sea level rise impact assessment.

Going into details, climate change scenarios for temperature and rainfall are developed for seven climate zones in Vietnam, including the Southern zone in which HCMC is situated. In addition, the baseline period is 1980 – 1999 as used in the 4th IPCC Assessment Report.

According to MONRE’s scenarios, HCMC is one of the most sensitive areas in Vietnam due to the following changes in climate variability (MONRE 2009).
2.1.1. Temperature

According to observational data, the annual average temperature in HCMC during the 1991 – 2000 period was higher than that of the 1931 – 1940 decade by + 0.6°C (MONRE 2009). The trend has continued into the first decade of the 21st century. In 2007, the annual average temperature of the city was higher than the average in the 1931 – 1940 decade by 0.8 – 1.3°C and similarly higher than the one in the 1991 – 2000 decade by 0.4 - 0.5°C (MONRE 2008).

As regards modelling data, temperatures in the rainy season (June – November) can increase faster than those in the dry season (December – May) (MONRE 2009). Table 2.1 below summarizes temperatures changes by periods of year in the medium emission scenario. The annual mean temperatures in 2020, 2050, and 2090 are increasing from 0.4°C, 1.0°C to 1.9°C respectively, relative to the baseline period (1980 – 1999). Additionally, the annual mean temperature by the end of the 21st century is projected to increase by 2.0°C.

Table 2.1. Mean temperature change (°C) in the South relative to the average for 1980 – 1999, medium emission scenario (B2) (adapted from MONRE 2009)

<table>
<thead>
<tr>
<th>Periods</th>
<th>Dec 2020</th>
<th>2030</th>
<th>2040</th>
<th>2050</th>
<th>2060</th>
<th>2070</th>
<th>2080</th>
<th>2090</th>
<th>2100</th>
</tr>
</thead>
<tbody>
<tr>
<td>Dec-Feb</td>
<td>0.3</td>
<td>0.5</td>
<td>0.7</td>
<td>0.8</td>
<td>1.0</td>
<td>1.3</td>
<td>1.5</td>
<td>1.8</td>
<td>2.1</td>
</tr>
<tr>
<td>Mar-May</td>
<td>0.4</td>
<td>0.6</td>
<td>0.8</td>
<td>0.9</td>
<td>1.2</td>
<td>1.5</td>
<td>1.9</td>
<td>2.1</td>
<td>2.7</td>
</tr>
<tr>
<td>Jun-Aug</td>
<td>0.5</td>
<td>0.7</td>
<td>0.9</td>
<td>1.2</td>
<td>1.5</td>
<td>1.8</td>
<td>2.2</td>
<td>2.6</td>
<td>2.9</td>
</tr>
<tr>
<td>Sep-Nov</td>
<td>0.6</td>
<td>0.7</td>
<td>1.0</td>
<td>1.2</td>
<td>1.5</td>
<td>1.8</td>
<td>2.1</td>
<td>2.5</td>
<td>2.9</td>
</tr>
<tr>
<td>Annual</td>
<td>0.4</td>
<td>0.6</td>
<td>0.8</td>
<td>1.0</td>
<td>1.3</td>
<td>1.6</td>
<td>1.8</td>
<td>1.9</td>
<td>2.0</td>
</tr>
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</table>

2.1.2. Rainfall

Projected rainfall changes in specified years using the medium emission scenario are summarized in Table 2.2. The total annual rainfall in 2020, 2050, and 2090 are increasing from 0.3%, 0.8% to 1.4% respectively, relative to the baseline period (1980 – 1999). Additionally, the annual mean temperature by the end of the 21st century is projected to increase by 1.5%. Nevertheless, regarding seasonal periods, the rainy season’s rainfall would increase while the dry season’s rainfall tends to decrease distinctly in the South.
Table 2.2. Rainfall change (%) in the South relative to the average for 1980 – 1999, medium emission scenario (B2) (adapted from MONRE 2009)

<table>
<thead>
<tr>
<th>Periods</th>
<th>Decades in the 21st century</th>
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<tbody>
<tr>
<td></td>
<td>2020 (%)</td>
</tr>
<tr>
<td>Dec - Feb</td>
<td>-3.0</td>
</tr>
<tr>
<td>Mar - May</td>
<td>-2.8</td>
</tr>
<tr>
<td>Jun - Aug</td>
<td>0.3</td>
</tr>
<tr>
<td>Sep - Nov</td>
<td>2.6</td>
</tr>
<tr>
<td>Annual</td>
<td>0.3</td>
</tr>
</tbody>
</table>

2.1.3. Sea Level Rise

The average sea levels of the whole country were calculated based on observed data at Vung Tau station located in the South from 1979 – 2007. In the medium emission scenario, SLR by mid 21st century is projected to be about 30 cm, and by 2100 sea level may rise about 75 cm relative to the baseline period of 1980 – 1999 as in Table 2.3.

Table 2.3. Sea level rise (cm) in Vietnam relative to the average for 1980 – 1999, medium emission scenario (B2) (adapted from MONRE 2009)

<table>
<thead>
<tr>
<th>Medium emission scenario</th>
<th>Decades in the 21st century</th>
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<tbody>
<tr>
<td></td>
<td>2020 (cm)</td>
</tr>
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<td></td>
<td>12</td>
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Based on sea level scenarios, inundation maps were constructed initially for HCMC areas, in which overlaying maps scale 1/2000 and 1/5000. As demonstrated in Figure 2.1, if the average sea level rises by 65cm, 128 square kilometres of land (6% of HCMC) will be submerged (red areas). The flooded area will increase to 204 square kilometres (10%) if the sea level rises by 75cm and 473 square kilometres (23%) in the event of a one-metre rise.
Figure 2.1. Inundation maps of HCMC at 65 cm, 75 cm, and 100 cm sea level rise scenarios (MONRE 2009)
2.2. Climate Change and Human Health

Changes in climate variability and SLR are projected to have adverse impacts not only on the environment, but also on the society and economy of the city. There would be a wide range of sectors and areas affected by climate change, for instance agriculture, forestry, energy, tourism, water supply, and public health (Tran 2009).

In the case of public health, scientists foresee a change in global climatic conditions would have a range of health impacts (McMichael et al. 2006, Ebi et al. 2006) because of the climate-society relationship (Frumkin 2002, McMichael 2003, Haines & Patz 2004). Regarding climate change effects, the impacts on human health are identified based on the pathways recommended by McMichael (2003) as in Figure 2.2. The direct factors impacting on health are heat waves (caused by changes in exposure to weather extremes), floods, storm-surges, droughts (due to increases in other extreme weather events), and spores and moulds (due to a rise in production of certain air pollutants and aeroallergens).

![Diagram showing pathways by which climate change affects human health](image)

Figure 2.2. Pathways by which climate change affects human health, including local modulating influences and the feedback influence of adaptation measures (based on Patz et al. 2000)

Human health is also affected via less direct mechanisms. These impacts would include changes in the pattern of transmission of many infectious diseases – especially waterborne, food-borne and vector-borne diseases. Further, temperature-related changes in the life-cycle
dynamics of both the vector species and the pathogenic organisms would increase the potential transmission of many vector-borne diseases such as malaria and dengue fever – although schistosomiasis may undergo a net decrease in response to climate change (Martens 1998, Patz et al. 1996). Generally, the main areas of health impact are: heat-related illness and mortality; health effects associated with floods, droughts and storm surges; infectious diseases; allergic and respiratory diseases; and mental health.

2.2.1. Heat Waves

Heat-related deaths are the consequence of prolonged exposure to ambient heat, which results in heat exhaustion, cramps, heart attacks and stroke (McMichael 2003). Much of the excess mortality from heat waves is concentrated in the elderly and people under intense physical stress, and those with cardiovascular and respiratory disease (Guest et al. 1999, McMichael 2003, Haines et al. 2006, Frumkin et al. 2008). In the case of global warming, there is expected to be an increase in the frequency and intensity of heat waves and warmer dry seasons, hence the mortality accordingly rises in hot weather (Kovats et al. 2001, Haines et al. 2006). Additionally, the city is often particularly affected because of the urban heat island effect, which can cause the temperatures to be higher than the surrounding suburban and rural areas. Air pollution concentrations, also, may rise during heat waves and may contribute to raised death rates (Haines et al. 2006).

2.2.2. Floods, Droughts, and Storms

The health impacts of natural disasters vary from immediate effects of physical injury, morbidity and mortality through to potentially enduring effects on mental health (in the context of tidal flooding) (Ahern et al 2005, Haines et al. 2006). Most flood-related deaths can be attributed to rapid rise floods as a result of the increase of drowning (French et al. 1983). Following floods, there are possible increases in diarrhoea and respiratory diseases (Siddique et al. 1998, Ahern et al. 2005). Furthermore, the impact on the local economy may still be severe and increases in common mental disorders such as anxiety and depression, which result from damage to the home environment and economic losses (Haines et al. 2006). Therefore, there is an increase in vulnerability of populations in low-income areas at high-risk of flooding, with limited presence of public-health infrastructure (Few & Matthies 2006). On the other side, droughts may have wide-ranging effects on health including on nutrition and infectious diseases, particularly when the country is in the area influenced by the El Niño cycle (Haines et al. 2006, Bouma et al. 1997).
2.2.3. Infectious Diseases

One of the earliest health impacts of climate change may be altered distribution and incidence of infectious diseases. The movement of people and goods, changes in hosts and pathogens, land use and other environmental factors may influence patterns of diseases (Hales et al. 2003). For example, transmission of many infectious disease agents, namely pathogens and vector-borne agents, is sensitive to weather variability including temperature, humidity, rainfall, soil moisture and SLR (Gubler 1997, Kovats et al. 2003, Haines et al. 2006). Additionally, climate change could affect arthropod vectors in terms of their life cycles and life histories. As a consequence, there would be changes in both vector and pathogen distribution, and in the ability of arthropods to transmit pathogens, resulting in changes in the way pathogens interact with both the arthropod vector and the human or animal host (Martens et al. 1997, Patz et al. 2003, Tabachnick 2010). Therefore, even small increases in disease distributions may cause more serious clinical disease whereas new populations lacking acquired immunity are exposed (Tabachnick 2010). In general, infectious diseases can be classified according to the natural reservoir of the pathogen (anthroponoses or zoonoses), or according to the mode of transmission of the pathogen (direct or indirect) (Patz et al. 2003).

2.2.4. Respiratory and Allergic Diseases

Certain aspects of air quality known to affect health are highly influenced by weather and climate conditions. Particularly, ozone which is formed in warm, polluted air in the presence of sunlight has well documented human health effects. Ozone causes direct but reversible lung injury and may cause lasting lung damage; increases premature mortality, and worsens respiratory diseases (CDC 2009a).

Similarly, plant metabolism and pollen production, and possibly fungal growth and spore release, may increase due to rises in ambient temperatures over land and in ground-level carbon dioxide concentrations. Substances like pollen and mould, which produce allergic reaction so-called aeroallergens, can aggravate allergic rhinitis and several respiratory diseases, namely asthma and chronic obstructive pulmonary disease. Furthermore, in the specific case of respiratory diseases, aeroallergens could also worsen these diseases through its interrelation to other harmful air pollution (CDC 2009b).

2.2.5. Mental Health

Climate change is likely to increase mental health burdens in several ways (CDC 2009c). Changes in lifestyle and the increases in the frequency and severity of weather events are
clearly associated with climate change. Inasmuch as extreme weather events, extensive infrastructure damage, economic slowdown, and interruptions of medical and psychiatric care, dislocation, or even loss of life can be correspondent with increase in depression and post-traumatic stress disorder.

On another level, the magnitude of the climate crisis, especially flooding at 163 flooding points within the city, has already generated concern in the public (Vietnamnet 2010). This health burden resulting in worry over future effects on health and the environment can also have significant mental health effects like stress and despair (CDC 2009c).

2.3. Climate Change and Infectious Diseases

2.3.1. Malaria

The first analyses of the impacts of climate change on vector-borne diseases have been aimed at malaria because of its dominant global and regional impact (Sutherst 2004, Githeko & Woodward 2003). Malaria is a life-threatening disease caused by Plasmodium parasites that are transmitted exclusively to people through the bites of infected Anopheles mosquitoes, called ‘malaria vectors’. Malaria symptoms are fever, headache, chills and vomiting – may be mild and difficult to recognize as malaria. If not treated within 24 hours, P. falciparum malaria, the most severe human malaria type, can progress to severe illness often leading to death (WHO 2009a).

As regards the transmission of malaria, its intensity depends on factors related to the parasite, the vector, the human host, and the environment (WHO 2009a). When the parasite has time to complete its development inside the long-lived mosquito, the transmission is more intense. Besides, transmission also depends on climatic conditions such as rainfall patterns, temperature and humidity that may affect the abundance and survival of mosquitoes (WHO 2009a). In any case, human immunity reducing the risk that malaria infection will cause severe disease is another important factor, especially in areas of moderate or intense transmission conditions. Immunity is developed over years of exposure, thus most malaria deaths occur in young children; however, whereas in areas with less transmission and low immunity like HCMC, all age groups are at risk (WHO 2009a, HTD 2010a).

2.3.1.1. Exposure and Sensitivity

There are many studies in the world highlighting the link between climate change and changes in the epidemiology of malaria (i.e. Githeko et al. 2000, Watson & McMichael 2001, Sutherst 2004, Pascual & Bouma 2009). It is evident from theory that changes in temperature
or moisture will trigger the greatest responses from vector-borne diseases. Particularly, there is likely an increase in transmission of malaria in Vietnam as it has high temperatures and rainfall associated with El Niño (Hales et al. 2003).

The initial emphasis has been focused on development of the parasites and longevity of the adult mosquitoes on account of the direct effects of changes in temperature (Sutherst 2004). It is stated that, as temperature increases, the malaria parasite reproduces at a higher rate, and mosquitoes take blood meals more frequently, up to a certain ceiling determined by individual species (CDC 2009d). Therefore, small increases in temperature may increase the risk of transmission disproportionately as maximum values for malaria transmission potential given a certain vector density are found in the ranges 29 – 33°C (Martens et al. 1997). Conversely, since the temperatures are close to the physiological tolerance limit of the parasite, a small increase would be harmful to the mosquito and the parasite and would consequently decrease malaria transmission (Hales et al. 2003). Altogether, an increase of 12 to 27% in the epidemic potential of malaria has been projected for intense transmission areas, including South-east Asia, as an indication of the sensitivity of malaria to climate change (Martens et al. 1997).

Also, it is considered that changes in precipitation and, indirectly, changes in land use may affect malaria transmission. According to several studies (Martens et al. 1997, Sutherst 2004), it was concluded that the most likely effects of climate change would be on the availability of habitats for larvae and mosquitoes. It may be assumed that any increases in the density of foliage of plants growing in an enriched CO₂ atmosphere, in residual soil moisture, and in the amount of surface water during the season, will provide more favourable shelter for larvae and adults of some species of mosquitoes that extends their longevity. Though it is not only climate variability, but also weather events have the potential to have profound effects on the incidence of malaria (Kovats 2000). Droughts that dry out rivers into ponds or floods that cause malaria epidemics in arid areas can provide favourable breeding sites for mosquitoes (Bouma & Van der Kaay 1996, Bouma et al. 1997, Linthicum et al. 1999). On the other hand, floods can temporarily suppress breeding in some habitats while washing away vector population in humid environments (Bateman 2000, Lindsay et al. 2000).

Last but not least, it is noteworthy that El Niño Southern Oscillation (ENSO), which is increasing in frequency and intensity in the region (UNDP 2007, MONRE 2009), is associated with changes in the risk of certain vector-borne diseases, most notably malaria (Kovats et al. 1999).
2.3.1.2. Past and Current Trends

According to the report of the IMPE of HCMC at the Conference of the Prevention of Malaria and Cysticercosis in South Vietnam (2010), the number of patients getting malaria in the past 5 years in the area has increased. It was reported that there were 11 deaths due to malaria in 2009, in comparison with 2 cases in 2008. Notably, these deaths mainly occurred in the provinces with no or unstable malaria transmission, including HCMC. This may result from the number of persons travelling to areas of intense transmission like Binh phuoc, Lam Dong provinces, particularly 54,000 times in 2009 in the case of HCMC citizens. Remarkably, HCMC reported 2978 malaria cases with 2 deaths in May 2010, reflecting the increases in the percentage of patients in shock of 5.34%, and in the number of deaths of 1 case compared to the same period of 2009 (HTD 2010b).

Due to the unavailability of modelling of malaria transmission, health impact assessment of malaria under the changes of climate in HCMC is mostly qualitative. It is not yet clear what effect the projected increase in temperature and rainfall, combined with fewer but heavier weather events, will have on malaria transmission rates, but the above figures suggest that there will be more variability, and likely an increase on average, in malaria infectious cases in HCMC.

2.3.2. Dengue Fever

About two fifths of the world's population are now at risk of dengue, which is a mosquito-borne infection that causes a severe flu-like illness, and sometimes dengue haemorrhagic fever (DHF). Dengue viruses are transmitted to humans through the bites of female Aedes mosquitoes. Mosquitoes generally acquire the virus while feeding on the blood of an infected person, and are capable of transmitting the virus for the rest of their lives. Therefore, infected humans, serving as a source of the virus for uninfected mosquitoes, are the main carriers and multipliers of the virus (WHO 2009b).

The clinical features of dengue fever vary from fever with rash in infants and young children, to mild or high fever, severe headache, pain behind the eyes, muscle and joint pains, and rash in older children and adults. DHF, a potentially lethal complication, has become a leading cause of hospitalization and death among children in most Asian countries where dengue is found, predominantly in urban and semi-urban areas. Significantly, the disease is now endemic in some countries in South-east Asia, one of the two most seriously affected areas in the world (WHO 2009b).
2.3.2.1. Exposure and Sensitivity

There are many researchers in the world underlining the link between climate change and changes in the epidemiology of dengue (i.e. Patz et al. 1998, Hales et al. 2002, Hales et al. 2003, Benitez 2009). Similar to malaria, higher temperatures are associated with increased transmission of arboviral diseases while rainfall may affect vector abundance. Accordingly, as temperatures rise and rainfall patterns alter, there is potential for dengue fever to spread to large non-immune populations within urban areas.

Relating to temperatures, the maximum value for transmission potential given a certain vector density is found at 40°C in the case of dengue (Martens et al. 1997). On the other hand, there is evidence that increased rainfall may affect the vector density and transmission potential (Hales et al. 2003). Also, an increase in the frequency and severity of water-related extreme weather events, for example floods and hurricanes, could alter existing conditions governing human–mosquito interactions, potentially increasing mosquito–human contact (Gubler et al. 2001). However, it is noted by Hales et al. (2003) that *Ae. aegypti* mosquitoes live in domestic habitats such as artificial and natural container water; therefore, rainfall plays less of a role in dengue epidemiology.

In addition, the El Niño cycle is associated with changes in the risk of dengue transmitted that changes in the Southern Oscillation Index (SOI) are positively correlated with the number of epidemics of dengue (Hales et al. 1996, Kovats et al. 1999, Hales et al. 2003). It was recorded that high positive values of the SOI in the South Pacific between 1970 and 1995 were associated with much warmer and wetter conditions (La Niña years) that were ideal for breeding of mosquitoes. Incidentally, several studies put forward the fact that there are positive correlation between the warmer temperatures and less rainfall during El Niño years and the increases in reported dengue cases in the region (MacDonald 1957, Hay et al. 2000) and in Vietnam (Lien & Ninh 1996). In the light of this, the fact that El Niño/ La Niña weather events have become more intense in the last 50 years (UNDP 2007, MONRE 2009) may increase the risk for dengue and cause more epidemics in Vietnam, and consequently in HCMC. On the whole, an increase of 31 to 47% in the epidemic potential of dengue has been projected for intense transmission areas, including South-east Asia, as an indication of the sensitivity of dengue fever to climate change (Martens et al. 1997).

Moreover, internal migration together with lifestyle changes due to excessive urbanization has increased the habitats for larvae and mosquitoes, resulting in the increase in dengue transmission (Labour Daily 2009b).
2.3.2.2. Past and Current Trends

According to Dr Tran Tinh Hien, Deputy Director of HTD, in addition to the increase in outbreaks in South Vietnam, dengue disease has changed to affect more adults (over 15 years) with more severe symptoms, increasing mortality rates (Labour Daily 2009b). Further, the Pasteur Institute of HCMC has reported recently 338 cases of DHF in southern provinces in the 8th week of 2010 (from February 15 – 21), increasing 4.6% compared to the previous week, but decreasing 46.2% in comparison with the same period in 2009. It should be stressed that HCMC was still the most endemic area with 100 dengue cases, approximately 30% of the infectious cases of the region (HTD 2010c). Additionally, the HCMC Department of Health recorded the first dengue death in May 2010 (Labour Daily 2010). Not surprisingly, the number of dengue cases in HCMC is projected to increase extraordinarily to 65 cases per week in the rainy season.

Due to the unavailability of modelling of dengue transmission, health impact assessment of dengue under the changes of climate in HCMC is mostly qualitative. It is not yet clear what climate parameters are primarily responsible for (temperature, rainfall, humidity…), and what effect they may have on, dengue transmission rates. The above figures suggest that there will be more variability, and very likely an increase on average, in dengue infectious cases, and changes in dengue ecology in HCMC as well.

2.3.3. Water- and Food-borne Diseases

2.3.3.1. Exposure and Sensitivity

The burden of disease from water- and food-borne pathogens i.e. bacteria, viruses, and parasites is substantial. Several water- and food-borne diseases are subject to environmental changes, which have effects on pathogen replication, survival, and persistent rates; transmission rates; and disease ranges overall (CDC 2009e). Temperature and precipitation, both of which will increase with climate change, affect the spread of infectious diseases via contaminated water or food (Hales et al. 2003, CDC 2009e).

In general, increased temperature results in higher pathogen replication, persistence, survival, and transmission for bacterial pathogens. Possibly, it has mixed effects on viral pathogens but often reduces the overall transmission rate (CDC 2009e). Madico et al. (1997) stated that higher temperatures are associated with an increase in gastro-intestinal infections. Also, Salazar-Lindo et al. (1997) found that the number of patients with diarrhoea and dehydration in Peru was 25% higher than usual when temperatures were higher than normal due to the emerging El Niño.
Overall, increased precipitation is associated with increased burdens of disease for bacteria, viruses, and parasites, particularly where water supplies and sanitation often are inadequate (Hales et al. 2003, CDC 2009). Rose et al. (2001) and Curriero et al. (2001) concluded an increase in the frequency and severity of extreme precipitation events attributed to climate change would increase the loading of contamination to waterways. Going into details, outbreaks of cholera and diarrhoeal diseases can occur after flooding due to the contamination of surface water with sewage. Conversely, drought conditions can also lead to hygiene-related diseases, given by decrease in water availability for washing and sanitation, and the increased concentration of pathogens in surface water (Martens et al. 1997, Hales et al. 2003).

2.3.3.2. Past and Current Trends

According to the report from Hospital for Children II, in March 2010, there were approximate 5000 cases of children patients getting diarrhoeal illnesses; with 900 hospital cases, increasing from 500 cases compared with the same period of 2009. Generally, diarrhoeal outbreaks have been increasing in frequency and severity in recent years in HCMC (Health & Life 2010).

Besides, in April 2010, the Hospital for Tropical Diseases reported 10 cases of diarrhoea possibly relating to cholera, in addition to the first 3 cholera cases in the city (Health & Life 2010). As a result, HCMC is now at risk of cholera outbreak if there are no proper prevention measures (Department of Health of HCMC 2010). Nevertheless, observational data showed there were scattered and isolated cholera outbreaks and no cholera epidemic in Vietnam, particularly in HCMC (HTD 2010d).

In short, water- and food-borne diseases are likely to increase due to the impact of climate change owing to the seasonal pattern.

2.3.4. Rodent-borne diseases

2.3.4.1. Exposure and Sensitivity

The uncertain potential effects of climate variability and change on infectious agents transmitted by mammals to humans have received less attention than have vector-borne diseases (Gubler et al. 2001). Rodents act as intermediate infected hosts or as hosts for arthropod vectors such as fleas and ticks to be reservoirs for a number of diseases. Certain rodent-borne diseases, notably plague, Hantavirus and Lyme diseases, are associated with
flooding while the others are connected with rodents and ticks (Kovats et al. 1999, Hales et al. 2003).

As rodent-borne diseases do not always involve an arthropod host, they are less directly affected by temperature. Transmission of these infections frequently depends on rodent population density and behaviour that is sensitive to weather conditions (Gubler et al. 2001). Parmenter et al. (1999) found that human plague cases in New Mexico occurred more frequently correlating with above-average precipitation. Regarding Hantaviruses, it was recorded in the U.S. that increased temperatures and high rainfall associated with El Niño raised rodents’ population by virtue of food sources growth and promoted breeding of flea populations (Rodriguez-Moran et al. 1998, Hjelle & Glass 2000, Hales et al. 2003, Zeil 2004). In addition, McLean (2001) and Subak (2003) concluded that conditions associated with climate variability and change could increase tick populations and the incidence of Lyme disease. Even though, Gubler et al. (2001) expressed uncertainty about the impacts of climate change on rodent-borne illnesses because of a lack of available research and because of the potentially different impacts resulting from climate change such as population explosions and crashes that could increase disease risk.

2.3.4.2. Past and Current Trends

In the period between 1960 and 1970, according to Dr Tran Tinh Hien (Saigon Marketing 2009), Vietnam was reported to be one of the most affected countries by plague in the world with about 10,000 cases per year, which primarily happened in the South. However, from 1996 to 2000, the number of plague cases decreased enormously to only 140 cases with 7 cases causing death. In more recent years, there has been no reported plague case nationwide. Until recently, the plague outbreak in China on 30 July 2009 got the public’s attention, though that later had no effects on Vietnam.

In relation to Hantavirus, so far there are few reports about the disease in Vietnam. A Sero-epidemiological survey of Hantavirus Hemorrhagic Fever with Renal Syndrome (HFRS) in Southern Vietnam in 1998-1999 revealed that there was a prevalence of Hantavirus in HCMC and its surrounding areas at the average positive rate of 14.15% (Medical Vietnam). However, it is not evident that there would be an increase in Hantavirus transmission in the city in the future.

As for Lyme disease, there is currently no reported incidence of this disease in Vietnam (IMPE of Quy Nhon 2010).

Altogether, it is unlikely that HCMC is now at risk of getting rodent-borne diseases.
CHAPTER THREE

METHODOLOGY
3.0. Methodology

In order to achieve the overall objective and specific aims, the full research combines the following methods: a literature review of the health implications of infectious diseases due to climate change and two surveys on expert judgment and on the public’s awareness about the issue. The reasons why these methods were chosen and how they were conducted are discussed in this chapter in two parts:

- Literature review
- Questionnaire survey

3.1. Literature Review

Initial research was undertaken to understand the projections of climate change, the relationship between climate change and public health, and the role of these changes on the pathways that lead to human exposure to infectious diseases.

Literature review was conducted from the initial to the final stages of the research, including:

- Literature refers to printed or electronic material, either published or unpublished, that is issued by a range of organizations including international, national, regional and local government, research centers, and voluntary organizations.
- Systematic reviews are published in academic or medical journals, institutional or organizational reports.
- Data on demographic, socioeconomic, environmental and climate change, and health status in HCMC.

Subsequently, several key words were developed from the climate change, health outcome, and infectious diseases categories, for instance climate change, climate impacts, vulnerability, human health, health impact assessment, risk assessment, burden of disease, infectious diseases, vector-and rodent-borne diseases, and water- and food-borne diseases. These key words were then combined to identify relevant reports and publications from electronic reference databases. The following databases were searched because they were valuable and reliable sources of e-books and scholarly journal articles concerning scientific and health sciences: Springer Link, SCOPUS, Science Direct, Web of Science/ Web of Knowledge, EBSCO, and Wiley Interscience - Journals.
In general, the following sources were reviewed to gain an in-depth knowledge of the research:

- International organizations namely the Intergovernmental Panel on Climate Change (IPCC), WHO, Centers for Disease Control and Prevention (CDC), International Centre for Environmental Management (ICEM); and international academic or medical journals.
- National institutions in Vietnam like the Ministry of Natural Resources and Environment (MONRE), Institute of Meteorology, Hydrology and Environment (IMHEN).
- Local institutions i.e. the HCMC Department of Health, HCMC Institute of Malariology – Parasitology – Entomology (IMPE); local academic or medical journals; and key local hospitals’ websites and newspapers recently published.

In order to limit sources of uncertainty that would need to be accounted for in drawing conclusions, the chosen evidence was related to HCMC wherever possible, or related to similar cities where no evidence for HCMC was available.

Also it should be highlighted that there are only limited empirical observations of climate-health relationships yet available from research in HCMC and Vietnam in general. However, there is now a well-reviewed body of evidence from other countries and cities (for example, Nelson 2003, McMichael 2003, Casimiro et al. 2006, Kinney et al. 2001, Campbell-Lendrum & Corvalán 2007).

Last but not least, books on research case studies, journal articles and relevant reports on climate change and infectious diseases were sourced to determine the research framework, as well as methodology and questionnaire design.

### 3.2. Questionnaire Survey

A survey is a collection of information in standardized form from individuals to known populations and usually deals with relatively small amounts of data (Robson 1993). There are two main types of surveys, questionnaires and interviews. The method selected for this research was questionnaire survey, the most commonly used instrument (Gillham 2008). A questionnaire has many advantages over its alternative, the interview. First of all, it is both comprehensive and representative (Gillham 2008). Also, a questionnaire is a simple and straightforward method to study attitudes, motives, beliefs or values, and may be adapted to collect general information. Especially in the case of this research with time and budget constraints, it is also considered as a low cost and less time consuming technique (Robson 1993). On the other side, the response rate for questionnaires is typically low; there could be misunderstandings or ambiguities during the completion; and there is no chance to elaborate
on an answer which could give additional or new information to the research (Bryman 2004). For this research, the public sample could be affected by these disadvantages while for the experts this is not the case.

In addition, the self-administered questionnaire method where respondents answer questions by completing the questionnaire themselves was adopted for this research. This type of questionnaire was designed with a set of characteristics like having clear and short structure, using various types of questions, and applying simple wording that usually helps the respondent and increases the response rate (Bryman 2004). Additionally, the method tends to be much cheaper to administer, easier to get information from a lot of people very quickly, and also lacks of the potential for bias like in the case of interviews (Bryman 2004, Gillham 2008, Groves et al. 2009). Nonetheless, this method is faced with the problems of motivating respondents, especially in the case of experts (Gillham 2008, Knol et al. 2010).

Furthermore, due to distance issue, the survey was conducted via email. This will help the survey to easily reach the respondents and particularly experts in terms of administrative cost and time flexibility (Gillham 2008, Knol et al. 2010).

In brief, the study includes two questionnaire surveys on expert judgment and on the public’s awareness about the health implications of infectious diseases due to climate change, which are discussed as follow.

3.2.1. Expert Judgment

Expert judgment is an approach to obtain a rapid assessment of the state of knowledge about a particular aspect of climate change. This approach is frequently used in a panel format, aggregating opinions to cover a broad range of issues regarding a topic; and is most useful in conjunction with a full research study. It is important to be aware, however, of the subjective nature of expert judgment (Smith & Tirpak 1990). In this study, expert judgement, through questionnaire survey, was applied to review the gaps between the literature review and local experts’ opinions. This was a multidisciplinary assessment carried out by individuals from a range of backgrounds – environment, climate change and public health so that it allows the answers to reflect individual differences in experience (Mayer & Booker 2001).

3.2.1.1. Objectives:

The survey was guided by the following objectives:

- To indentify whether experts’ opinions generally confirm or contradict the findings of the assessment based on the literature review.
- To indentify whether the experts’ views provide more information about the health implications of infectious diseases, either adverse or advantageous, that was not identified from the literature review.

- To indentify what are their recommended priority actions for communicating the health implications of infectious diseases to the public in the future.

Based on these objectives, the questionnaire was designed properly which will be mentioned in the following designing questionnaire section.

3.2.1.2. Selection of Experts:

The main criterion used to select the experts were their familiarity with the subject and their eagerness to respond to the questionnaire. Thanks to personal network, the contact list of 30 experts, who were able to utilize a reasonably extensive literature, have been working in HCMC in the three fields - environment, climate change, and human health, and were interested in the subject as well as eager to complete the questionnaire, was identified. Some effort was made to get salient perspectives by involving experts from both governmental and non-governmental agencies, though the former was much more than the latter by virtue of the institutional nature of the city. Overall, the study was targeted to get at least 2 responses for each of the three mentioned groups.

3.2.1.3. Designing the Questionnaire:

The questionnaire was divided into three sections that cover the expert’s general information, section I and section II. Section I had the same questions with the questionnaire of the public’s awareness survey which would be described in detail in the following section. In order to achieve the mentioned objectives, Section II was aimed to ask the experts to judge the possibilities that climate change leads to a heavy burden of each specific infectious diseases, then to ask them to explain their judgment. Based on their explanation, the gaps between the experts’ opinions and literature review could be identified. Additional information provided by the experts might need further study to review. Finally, open questions would be apply to ask the experts to identify critical problems and key challenges in the case of health effects of infectious diseases due to climate change in HCMC, and from that, to propose priority actions for communicating the health implications of infectious diseases to the public in the future. In brief, the methods applied in designing the questionnaire for expert judgment survey are summarized in Table 3.1.
3.2.1.4. Sending the Questionnaire:

The questionnaire was sent via email to 30 experts in the three areas of expertise: environment, climate change, and public health. 10 responses were received three weeks from the day it was sent. A copy of the questionnaire is attached in Appendix I.

Table 3.1. Summarized table of objectives and methods used in the surveys

<table>
<thead>
<tr>
<th>Survey</th>
<th>Objective</th>
<th>Method</th>
</tr>
</thead>
<tbody>
<tr>
<td>Expert judgment</td>
<td>Indentify whether experts’ opinions generally confirm or contradict the findings of the assessment based on the literature review</td>
<td>Use table including both closed and open questions to ask the experts to judge the possibility that climate change leads to a heavy burden of each specific infectious diseases, then ask them to explain their judgment</td>
</tr>
<tr>
<td></td>
<td>Indentify whether experts’ views provide more information about health implications of infectious diseases, either adverse or advantageous, that was not identified from the literature review</td>
<td>Compare the gaps between the experts’ opinions and literature review</td>
</tr>
<tr>
<td></td>
<td>Indentify what are their recommended priority actions for communicating the health implications of infectious diseases to the public in the future</td>
<td>Use open questions to ask the experts to identify key challenges of the issue and from that to propose priority actions</td>
</tr>
<tr>
<td>Public awareness</td>
<td>Determine which infectious diseases are considered the highest risk</td>
<td>Use closed questions to ensure the public familiar with infectious diseases, then ask them to assess which infectious disease they are most at risk and/ or has the most severe health impacts</td>
</tr>
<tr>
<td></td>
<td>Test the hypothesis “Climate change in HCMC is considered to increase the public’s risks of getting infectious diseases”</td>
<td>Use closed questions to ensure the public familiar with the subject, then ask them to rank a list of potential climate health outcomes including infectious diseases</td>
</tr>
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</table>
3.2.2. Public awareness

The potential for population health problems depends on several factors, including the public's awareness. Thus it would be necessary to survey the public’s opinions on the issue. In the light of this, the questionnaire was elaborated to involve the citizens, and to have a wider knowledge of the infectious diseases and climate change. Further, it was to establish possible links between awareness of climate change and attitudes relating to infectious diseases.

3.2.2.1. Objectives:

The survey was guided by the following objectives:
- To determine which infectious diseases are considered the highest risk.
- To test the hypothesis “Climate change in HCMC is considered to increase the public’s risks of getting infectious diseases”.

Based on these objectives, the questionnaire was designed properly which will be mentioned in the following designing questionnaire section.

3.2.2.2. The Sample:

The sample is a set of adults (at the surveying period) who have been living in HCMC for at least 12 months. Owing to personal network and supports from researchers to whom HCMC is a case study, an email list of 150 probability sample was identified. A probability sample, also called random sample, is a sample in which each population element has an equal and known opportunity to be included. In view of this, sampling fractions was determined based on the city census in 2004 (Statistical Office of HCMC) to avoid problems of errors arising from measuring just a subset of the population. Therefore, it was expected to match the following demographic split of HCMC. In terms of age, almost respondents were at the ages of 18 – 34 (52%); the next range of ages of 35 – 49 was expected to get 29% of respondents, while the percentages of respondents at the ages of 50 – 64 and 65 and above were about 11% and 8% respectively. In terms of gender, there was fairly equal between the percentages of male and female respondents which were 48% and 52% respectively. Overall, the questionnaire was targeted to achieve the minimum response rate of 40%.
3.2.2.3. Designing the Questionnaire:

In order to achieve the mentioned objectives, the questionnaire designed was based on best practice methodology and covered issues to:

- Reveal how knowledgeable respondents are on infectious diseases
- Reveal respondents’ awareness of climate change in the city and its health implications
- Identify respondents’ attitude concerning the relationship between infectious diseases and climate change
- Identify which information in relation to the health implications of climate change is generally at needs of respondents

Close questions concerning these above issues was aimed to ensure the public familiar with infectious diseases, thus they could assess which infectious disease they were currently at risk and/ or had the most severe health impacts. Also, since getting familiar with the subject, the public would be asked to rank a list of climate health outcomes including infectious diseases to identify whether infectious diseases were considered the highest risk. Briefly, the methods applied in designing the questionnaire for the public’s awareness survey are summarized in Table 4.

In short, the respondents were asked to complete a questionnaire including 12 questions. The types of questions vary from demographic, categorical, attitudinal scales to open-ended questions. In addition, most questions are closed ones with relatively simple words to avoid misunderstandings. This could maintain respondents’ interests, as the questions didn’t take up too much effort and time to respond. In addition, analysis of answers to these questions would be relatively straightforward (Bryman 2004, Gillham 2008).

3.2.2.4. Sending the Questionnaire:

The questionnaire was sent via email to 150 respondents. 89 responses were received three weeks from the day it was sent. A copy of the questionnaire is attached in Appendix II.

3.2.2.5. Analyzing the Questionnaire:

Analysis of the questionnaire is to convert all responses into numerical data and further into diagrams and charts in order to draw conclusions on the findings. In this research, by using Microsoft Excel, responses of each questionnaire were entered in the appropriate rows and columns of a table. The accumulate totals and percentage of every option for each question answer then would be calculated. Notably, the total number of answered questions
was taken into account whereas the number of responses obtained differs from each question. This was because questions 4 and 5 of the questionnaire was only entitled for respondents whose family members are living in the city; besides, not all the questionnaires received had every question answered. From the results, analytical diagrams such as bar charts, column charts and pie charts were produced. In some cases, the analysis was broke up to find patterns by splitting the results obtained into age or monthly income groups. Producing diagrams to help analyze results was ideal for numerical data but the comments given by last open question was harder to interpret. The common or remarkable comments were used as advice about information should be communicated to the public about the health implications of climate change in general and about the subject in particular.
CHAPTER FOUR

RESULTS AND DISCUSSIONS
4.0. Results and Discussions
In this chapter all the findings are analyzed, discussed, and presented in two parts:

- Expert judgment
- Public awareness

The discussions of the methods used are detailed in Section 4.3.

4.1. Expert Judgment
All of the experts surveyed were either involved in activities or research activities pertaining to environment, climate change and public health. The area of expertise and the organization of the experts or researchers are indicated in Table 4.1.

<table>
<thead>
<tr>
<th>Expert</th>
<th>Expertise</th>
<th>Organization</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Climate change</td>
<td>Climate Change Research Center, Nong Lam University of HCMC</td>
</tr>
<tr>
<td>2</td>
<td>Environment</td>
<td>Preferred to withhold information</td>
</tr>
<tr>
<td>3</td>
<td>Public health</td>
<td>Department of Social Insurance of HCMC</td>
</tr>
<tr>
<td>4</td>
<td>Climate change</td>
<td>Energy Conservation Center of HCMC, Department of Science and Technology of HCMC</td>
</tr>
<tr>
<td>5</td>
<td>Environment</td>
<td>Energy Conservation Research and Development Center</td>
</tr>
<tr>
<td>6</td>
<td>Climate change</td>
<td>Energy Conservation Research and Development Center</td>
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<td>7</td>
<td>Environment</td>
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<td>8</td>
<td>Public health</td>
<td>Nong Lam University of HCMC</td>
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<td>9</td>
<td>Public health</td>
<td>National Hospital of Odonto – Stomatology - Ho Chi Minh City</td>
</tr>
<tr>
<td>10</td>
<td>Environment</td>
<td>Hoa Sen University</td>
</tr>
</tbody>
</table>
4.1.1. Climate Change and Human Health in general

In Figure 4.1, it can be seen that a large majority of the experts surveyed considered that climate change in HCMC is already having adverse effects on public health. On the contrary, there was only one expert doubted about the certainty of the link between these two aspects. From the environmental point of view, one expert pointed out that human health in some way or other is sensitive to climate as where people live and how they acquire a livelihood and welfare are affected by the ambient climate. In the respect of public health, some experts explained that the changes in weather and climate variability could lead to a heavy burden on epidemic diseases. Moreover, these experts referred to recent re-emergences of infectious diseases or emergences of new diseases due to climate change in the city.

![Figure 4.1. The percentage of experts agree climate change is already having adverse effects on public health](image)

Furthermore, some experts mentioned about the health equity of a part of the population. That several groups are more vulnerable to climate change is determined by their exposure, by their physical setting and sensitivity, and by their adaptive capacity. In the light of this, children and poor persons are most at risk of being affected adversely by changes in climate and weather.

4.1.2. Climate Change and Infectious Diseases

Regarding infectious diseases in general, the majority of the experts which was shown in Figure 4.2 agreed that climate change could lead to a heavy burden of the diseases. According to the experts, climate and weather affect the distribution and risk of many vector-
borne diseases, also the risk of water- and food-borne diseases and of emerging infectious diseases. It was highlighted that changes in temperature, humidity, rainfall, and sea level rise could all affect the incidence of infectious diseases. Going into detail, changes in the patterns of pests, parasites, and pathogens could affect wildlife, livestock, agriculture, and coastal marine organisms, carrying the implications for human health. Evidence provided by one expert was that there were numerous rises of reported infectious diseases cases in HCMC at the same period this year compared with the ones of recent years. Noticeably, the reported drug resistance cases could even worsen the situation. This reflects the fact that, in view of a changing climate, there are not only changes in transmission of vectors but also in diseases’ characteristics and even in human sensitivity.

![Pie chart showing the percentage of experts agree climate change could lead to a heavy burden of infectious diseases in general]

**Figure 4.2. The percentage of experts agree climate change could lead to a heavy burden of infectious diseases in general**

On the other hand, other experts called the link between climate change and increased adverse impacts of infectious diseases into question. Although there has been a resurgence of infectious diseases in recent years, the experts mentioned, it was unclear that climate change has played a significant role since infectious diseases were also dependent on many other interacting factors. Interestingly, it was also pointed out that climate change could not only lead to adverse impacts on infectious diseases, but also could reduce the lifetime of some vectors and decrease in the transmissibility of some infectious diseases, namely schitosomiasis.
The experts then were asked to judge whether climate change could impose heavy burdens of some infectious diseases separately. Figure 6 presents the results of the evaluation of the specific diseases, which are malaria, dengue fever, rodent-borne diseases, and water- and food-borne diseases. A general trend seemed to be that experts supported the view that climate change could lead to heavy burdens on almost surveyed infectious diseases, excepting rodent-borne diseases.

4.1.2.1. Malaria

Concerning malaria, the majority of the experts surveyed stressed that conditions associated with climate variability and change could increase mosquito populations and the incidence of malaria. Theoretically, the potential for malaria transmission is intricately connected to meteorological conditions such as temperature and precipitation. Increasing from a doubling of atmospheric carbon dioxide, conditions conducive to malaria transmission could lead to higher proliferation and reproduction rates of female Anopheles spp mosquitoes, as well as to an extended transmission season. It was also noted that increases in the transmission of malaria might also result from because of excessive warming of water and some regional drying.

Conversely, the concern pointed out by one expert was that there was only risk of localized outbreaks due to climate change in malaria-endemic regions where malaria has been locally eliminated but the vectors persist. In the view of this, the expert disagreed climate change could lead to a heavy burden of malaria in HCMC.

4.1.2.2. Dengue Fever

Figure 4.3 indicates that the majority of the experts went along with the hypothesis that climate change could lead to a heavy burden of dengue fever. The experts emphasized that weather could influence the survival and reproduction rates of the mosquitoes, in turn influencing habitat suitability, distribution, and abundance; intensity and temporal pattern of vector activity throughout the year; and rates of development, survival and reproduction of pathogens within vectors. In the respect of an important factor in dengue transmission in urban areas, the temperature threshold for Aedes mosquitoes that carry dengue fever could be crossed with increasing temperatures, potentially leading to more dengue cases.
Figure 4.3. *Experts’ opinions of whether climate change could lead to heavy burdens of some infectious diseases*

On the contrary, one of the experts seemed not to be worried about the risk of increased dengue fever epidemics due to climate change in the city. Even though increased rainfall and sea level rise could affect the breeding of mosquitoes by virtue of increases in mosquito and larval habitats, this might be less important in urban areas. In addition, it was not evident yet that there was a clear linkage between climate change and the actual changes in the incidence of dengue fever since the disease depend on many factors, including future patterns of social development, land use and urban growth. Moreover, the expert suspected that the effectiveness of available preventive measures such as vector control and vaccination in HCMC could eliminate the impacts of dengue fever epidemics.

4.1.2.3. **Water- and Food-borne Diseases**

As can be seen in the figure 6, a few experts felt uncertain while the majority agreed or strongly agreed with the statement that the risk of water- and food-borne diseases would likely increase with climate change. It was pointed up that an increase in the frequency and severity of extreme precipitation events attributed to climate change would increase the loading of contaminants to waterways, which would increase the risk of water and food-borne illnesses. Specifically, these diseases would likely raise because of the increased transport of diseases causing organisms during extreme precipitation events and limits in the existing infrastructure for conveying and treating wastewater and sewage to avoid contamination events i.e. problems with combined sewer overflows.
With regards food-borne diseases, it was underlined that climatic factors influenced the growth and survival of pathogens, as well as transmission pathways. Particularly, higher ambient temperatures increased replication cycles of food-borne pathogens, and prolonged seasons might augment the opportunity for food handling mistakes. Furthermore, experts feared that climate change could increase the risk of illness associated with salmonellosis infections whereas there was an association between increases in mean temperature and increases in the number of notifications of these illnesses. Significantly, temperature had the most noticeable effect on salmonellosis resulting in food poisoning, which indicated inappropriate food handling and storage at the time of consumption.

4.1.2.4. Rodent-borne Diseases

It is interesting that many experts expressed uncertainty about the impacts of climate change on rodent-borne illnesses because of a lack of available research and because of the potentially different impacts that could result from climate change as opposed to increased climate variability.

As pointed out by several of the experts who were in agreement that climate change could lead to a heavy burden on rodent-borne diseases, there was an association between the increased climate variability and rodent-borne outbreaks. Climate anomalies in temperature and humidity were supposed to influence rodent populations and tick distribution. Basically, rodents could act as both intermediate infected hosts and as hosts for arthropod vectors such as fleas and ticks. It was reported that rodent populations were affected by weather conditions, while ticks’ developmental cycle, egg production, population density, and distribution were particularly accelerated by temperature. Additionally, one expert identified a greater interaction between human beings and rodents in urban areas that could lead to a higher risk of disease transmission.

4.1.3. Recommendations

After all, the experts were asked to point to the critical problems and key challenges in the case of health effects of infectious diseases due to climate change in HCMC. Firstly, the rapid population growth, mostly from migration due to urbanization, was identified. This could lead to many problems of environmental pollution because of air emissions, generations of wastewater and solid wastes from the industries and households, which were in favor of the transmission of infectious diseases. Also the urbanization caused several adverse social impacts, including the downgrade of living conditions, especially of the immigrants and their
families, and the increased demand for public health services. As a consequence, it could increase risk of getting infectious diseases and decrease the capability of preparedness of the whole community in case of epidemics. Secondly, the public’s awareness of climate change and infectious diseases in particular was determined as another big challenge. Significantly, one expert stated that the majority of the public was even not well aware of climate change. From some other experts’ opinions, public views of health and illness relating to climate change at the current time in many ways reflected the fact that need to inform, educate, and empower people about the subject was critical.

Based on the identified issues, the experts came up with the following recommended priority actions for communicating the health implications of infectious diseases to the public in the future:

- Improve training and general education of populations about climate change; integrate the communication about climate change and information about potential health effects of infectious diseases.

- Promote health and wellness through educating individuals and communities about healthy behaviors and disease prevention or management.

- Communication concerning the most appropriate adaptive measures, for example food handling under hot weather conditions, vector control measures, personal vector protection, etc.

- Improve risk communication and target the messages to vulnerable populations, including the poor, the immigrants, children and the elderly, etc.

- The communication needs to be targeted to specific groups, accounting for varying levels of understanding, cultural and ethnic differences, vulnerability to the health effects of climate change, and other factors.

- Research on the most effective means of communication i.e. television, radio, campaigns, posters, etc is needed.

- Integrate health education into education program to increase awareness of the potential impacts of climate change and its health effects

- Protecting human health is an issue that crosses institutional and scientific boundaries. No single institution can fully protect public health without cooperation from other institutions. Thus there is a requirement of collaborations on an unprecedented scale.
4.2. Public Awareness

The total number of questionnaires sent out was 150 and the number of questionnaires returned was 89. The other questionnaires which were not returned might be due to apathy or busy schedules of targeted respondents. Thus the percentage response rate is 59.3%. However, not all the questions were answered, therefore the number of responses obtained differs from each question. Interpretation of the results is divided by the three different sections of the questionnaire as follows:

- Demographic information of respondents
- The public’s perception of infectious diseases
- The public’s perception of climate change and the linkage between climate change and infectious diseases

4.2.1. Demographic Information of Respondents

The first part of the questionnaire was about the general information of respondents. The demographic information is summarized in Figure 4.4 are age and gender. The age group for 65% of respondents fell between 18 and 34. The other age groups ranging form 35 to 49, 50 to 64, and 65 and above are 12%, 17%, and 6% respectively. Besides, gender rate between females and males are mostly 1:1, equivalent to 51% male respondents and 49% female respondents.

It should be noted that the achieved sampling fraction is different from expected one, which was determined based on the population consensus of the city in 2004. The sampling fraction was targeted to be 52%, 29%, 11%, and 8% for age groups of 18 – 34, 35 – 49, 50 – 64, and 65 and above respectively. In terms of gender, expected percentages of male and female respondents were 48% and 52% respectively, in which female respondents were fairly predominant.

Next to age and gender, the research took education level and monthly income of respondents into account as there were a number of population subgroups likely to be more vulnerable to the adverse impacts of a changing climate, including the group of respondents obtained under high school education and the group of low income people (below 3.000.000 VND per month). The group obtaining low level of education is often at the greater risk for climate sensitive health outcomes because they have limited capacity to get health information and to undertake appropriate behavioral changes when exposed to infectious diseases. Also, poverty increases vulnerability to climate-sensitive health outcomes directly by reducing the capacity to adapt to changing conditions and is often positively correlated
with increasing susceptibility to climate-sensitive health outcomes.

Figure 4.4. Information of age and gender of respondents

Figure 4.5. Information of education level and monthly income of respondents

It can be seen from Figure 4.5 that the majority of respondents are graduates (72%) and the major income is in the range of 5.000.000 – 10.000.000 VND per month (40%). However, regarding education level, there are still representatives of the group of respondents who have the levels of under high school (5%) and high school (4%). As regards monthly income, 17% of respondents are representative of the low income group, and the same number of respondents falls to the group having average income (3.000.000 – 4.990.000 VND).
4.2.2. The Public’s Perception of Infectious Diseases

A summary of the findings about the public’s awareness of infectious diseases is shown in Figure 4.6. The majority of respondents (65%) strongly agreed or agreed that they knew a lot about infectious diseases and their health impacts. 34% of respondents were uncertain that they were well aware of the diseases, while only 1 respondent (1%) didn’t know about the subject. Briefly, the public was aware a lot about infectious diseases and their health effects. This could be explained by the good communication about the diseases of the responsibilities namely the Department of Health and the People’s Committees of the Districts (CAND 2010).

Figure 4.6. The extent to which respondents agree that they are well aware of infectious diseases and their health impacts

Figure 4.7. Respondents’ assessments of their own risks of getting infectious diseases
According to Figure 4.7, it is possible to identify that the majority of respondents (68%) suspected they were at risk of catching infectious diseases despite different extent from some risk (61%) to great risk (7%). On the other hand, there were 17% of respondents believed that they had no risk of being infectious. Besides, the rest of respondents were not sure (13%) or didn’t know (2%) about their own risks of getting the diseases.

Out of the respondents who have family members living in HCMC (63 respondents equivalent to 71% of all respondents), entitled respondents thought their family members might be at no risk (18%), some risk (49%) or great risk (6%) of catching infectious. However, more than a quarter of surveyed people felt uncertain to give the answer (22%) or even didn’t know the right answers (5%). The summary of these findings are shown in Figure 4.8.

Figure 4.8. Respondents’ assessments of their family members’ risks of getting infectious diseases

Surprisingly, comparison of the results between 63 entitled respondents’ assessments of their own risks and their family members’ risks in Figure 4.9 shows that these respondents supposed they were at more risk than their family members. It should be noted that 73% of these respondents are at the age ranging from 18 to 49 supposing they are at good health conditions. Nonetheless, in turn, the number of respondents thought they had no risk (9 respondents) was less than the number of respondents thought their family members had no risk (11 respondents). Moreover, there were more respondents were uncertain and didn’t know the answers about their family members’ risks than their own risks. This could be explained that respondents either thought their family members were protected from infectious diseases thanks to good living conditions (87% of respondents have the education level of graduate and above, and 63% of respondents have above average monthly income) or
felt uncertain to evaluate the others’ risks. The former point is worthy of note as the health of children, as well as other dependant members, is affected most by the education level and occupation (income) of main earners in the family (Bui & Pham 1999).

![Graph showing comparison of respondents' assessments of their own and family members' risks of getting infectious diseases.](image)

**Figure 4.9. Comparison of respondents’ assessments of their own and family members’ risks of getting infectious diseases**

Having asked about the awareness and the concerns of their own and family members’ risks, these respondents were further asked to identify which family members were at risk of getting infectious.

![Pie chart showing family members at risk of getting infectious diseases.](image)

**Figure 4.10. Family members at risk of getting infectious diseases**

The results in Figure 4.10 shows that children were thought to be in the majority (43%), equally following by the elderly and the other members (20%). The other members were
identified to be wife or husband, and family members who have high exposure to infectious diseases i.e. sister in law who is a doctor as determined by a respondent. Remarkably, there were 17% of respondents recognized that all family members could be susceptible. Altogether, it is indicated that respondents now considered anyone could be at risk of infectious diseases, not only the highly sensitive groups like children and the elders.

Respondents were then given the opportunity to select what infectious diseases they and their family members (only entitled respondents) were at risk of getting, which are indicated in Figures 4.11 and 4.12.

**Figure 4.11. Some infectious diseases all respondents think they might be at risk of getting**

**Figure 4.12. Some infectious diseases entitled respondents think their family members might be at risk of getting**
It is found in both cases that respondents reckoned that they and their family members might be at risk of getting water- and food-borne diseases most. The following infectious diseases considered in descending order were dengue, malaria, rodent-borne diseases, and other infectious diseases. The other infectious diseases identified by respondents were hepatitis, HIV/AIDS, tuberculosis, and measles also in descending order. Even though some literature suggests the influences of climate change on hepatitis C (WHO 2003), HIV/AIDS (WHO 2003, UNAIDS 2008), tuberculosis in Europe and Canada (Telegraph 2008, Dooley 2010), and measles in Ghana (e-Parliament), it is still not evident to state climate change leads to heavy burdens on the mentioned infectious diseases.

Interestingly, there are big differences in the perceived likelihood of catching the diseases, but there are not large differences in perceived severity. Figure 4.13 exemplifies the general average of how the respondents scored the severity of health impacts of some infectious diseases, in which 1 corresponding with very low severity, 5 corresponding with very high severity.

![Figure 4.13. Assessment of the severity of health impacts of some infectious diseases](image)

Beside of additional option HIV/AIDS which was scored 5/5 by 3 respondents, the four groups of surveyed infectious diseases were all considered to be severe to human health. The severity of each disease group was more or less and scored in the range from 3.4 to 3.8, with the following descending order: dengue, malaria, rodent-borne diseases, and water- and food-borne diseases. Last but not least, additional option hepatitis was scored 3/5 for its severity by 3 respondents.
4.2.3. The Public’s Perception of Climate Change and the Linkage between Climate Change and Infectious Diseases

As shown in Figure 4.14, the vast majority of respondent (91%) stated that they were fairly (55%) or very concerned (36%) about climate change. The remaining 9% stated they were not concerned or even had no idea about the subject. As a whole, it is considered that the generality to some extent were concerned about climate change in the city.

Figure 4.14. The extent to which respondents are concerned about climate change

Following to the question about the public’s concerns about climate change, respondents were asked to express their opinions on whether they agreed or disagreed that

Figure 4.15. The extent to which respondents agree that climate change is already affecting HCMC and having adverse impacts on human health

Following to the question about the public’s concerns about climate change, respondents were asked to express their opinions on whether they agreed or disagreed that
climate change is already affecting HCMC and having adverse impacts on human health there. Figure 4.15 shows that more than 90% of respondents agreed or strongly agreed that climate change is already having impacts on the city in general (96%), as well as having adverse impacts on human health (93%). This finding is compatible with the one obtained from the previous question that 91% of respondents were concerned about changes in climate in HCMC.

Going into detail about the health implications of climate change, respondents were then requested to indicate to what extent they think that climate change could lead to heavy burdens of some health effects by using the scale from 1 to 10, where 10 is the highest likelihood and 1 is the lowest likelihood. The following Figure 4.16 illustrates respondents’ assessments of a short list of health impacts provided on the questionnaires.

Figure 4.16. Assessments of the possibility climate change could leave heavy burdens on some health effects

As scored respectively 4.6/10 and 5/10, heat-related illness and death and mental health were considered to be not much influenced by climate change. This reflects the fact that these two health impacts are not much concerned by the public in a tropical and developing city like HCMC, where inhabitants have high adaptive capacities to hot climate and pay more attention on the physical health implications than mental ones. Next to that, injury and death due to flooding was assessed to be fairly affected by climate change with the score of 5.5/10. Besides, respondents evaluated there were higher possibilities that climate change could impose heavy burdens on infectious diseases, allergic diseases, and respiratory diseases in ascending order, which were scored 6.5, 7.1, and 7.6 respectively. It seems that, in the case of
allergic and respiratory diseases, the more visible the health outcomes are, the more attention they attract from the public. In brief, infectious diseases were believed to be given a heavy burden by changing climate, but were not considered to be affected most by climate change in comparison with other climate health outcomes.

In addition, respondents were asked to consider whether climate change increases their own and family members’ risks of getting infectious diseases. Results of respondents’ evaluations presented in Figure 4.17 show that the vast majority (82%) stated that they agreed (52%) or strongly agreed (30%) that there was a link between the increases in infectious diseases and the changes in climate in HCMC. A small proportion of respondents (16%) were uncertain when questioned on considerations given to that link. Only 2% of respondents didn’t perceive that they and their family members were at higher risk of getting infectious diseases due to climate change. Overall, it was concluded that climate change in HCMC was considered to increase the public’s risks of getting infectious diseases.

![Figure 4.17. The extent to which respondents consider that climate change increases their own and family members’ risks of getting infectious diseases](image)

In addition, an open question about which information in relation to the impacts of climate change on human health respondents like to know more was included on the questionnaire to get more depth. The results obtained reflected that the public was in need of information relating to climate change, its health outcomes and particularly infectious diseases. The majority of respondents who gave comments on this question were graduates. Half of respondents who had low education levels (under high school or high school) commented that the above mentioned information was in need.
There were two respondents, including one postgraduate, cast down on climate change and requested officially published data about changes in climate in HCMC. Some respondents inquired more information about health effects of climate change as well as prevention measures of these impacts. Some specific health outcomes were asked for more information like the health implications of extreme weather, impacts of heat waves, or even some potentially invisible climate health impacts like cancer or impacts on reproductive health.

A majority of comments were queries related to infectious diseases. The following information was gathered about the key demanded information:

- General information about the linkage between infectious diseases and climate change, for instance the mechanisms that climate change affects infectious diseases (source – pathway – receptor), the severity of these health implications (not only the existing ones but also the re-emerging and new ones), human exposure and sensitivity, and health equity (the poor’s vulnerability).

- Information officially published by the government or concerned organizations about the linkage such as scenarios and facts and figures.

- Prevention measures of these health impacts, and information about the facilitations and supports from the city government and NGOs.

4.3. Discussions of the Methods Used

4.3.1. Expert Judgment

It is interesting to note that in most cases there is a wide range between the lowest and the highest responses received, which is indicative of the diversity of expert opinions on particular issues. This diversity is not unusual for expert elicitation (Mayer & Booker 2001). However, for a variety of reasons, different experts can interpret the same question differently due to different interpretation or that personal biases might have an influence, which causes uncertainty of the judgment (Mayer & Booker 2001, Krauss et al. 2004). Large sample sizes can reduce that (Mayer & Booker 2001) but this method is not practical in this case. Therefore, the questionnaire should include one question to ask the experts to assess the level of uncertainty of their answers.

In addition, the answers in general are not much in detail as expected. This may result from survey method which is questionnaire survey. Without budget constraint, the results from expert judgment would be at higher quality thanks to face to face surveys or group discussion.
4.3.2. Public Awareness

The survey attains a good response rate of 59.3% but its actual sampling fraction doesn’t match the expected one determined from the demographic split of HCMC. Moreover, email survey is not really a good method to generalize findings to the whole populations (Bryman 2004, Gillham 2008). People who have emails are different from those who do not, even when matched on demographic characteristics, such as age and gender. These mentioned matters may affect the results of the survey. Though the problem could be solved if the survey was administered on a one-to-one basis, the timing and budget implications could not make this possible.

Besides, the question about the public’s assessment of the extent that climate change leads to heavy burdens of some specific diseases should be included in the public awareness questionnaire. The findings from this question in comparison with the same one in the expert review questionnaire could give a better view of the health implications of these infectious diseases with changing climate.

It is also noteworthy that there are two completed questionnaires are the same. This can be explained that one person responded or sent the questionnaires back two times. Thus it is necessary to check the duplication of responses to eliminate people responding multiple times to bias the results.
CHAPTER FIVE

CONCLUSIONS AND RECOMMENDATIONS
5.1. Conclusions

In summary, based solely on the literature review, it is concluded that climate change is causing some health implications in HCMC, among them are the increases in frequency and severity of getting infectious diseases. There is likely to be an increase on average in malaria infectious cases in HCMC. In the specific case of dengue fever, there is very likely to be an increase on average in dengue infectious cases as well as changes in dengue ecology. Also, water- and food-borne diseases are likely to increase due to the impact of climate change owing to the seasonal pattern. However, it is unlikely that HCMC is now at risk of outbreaks of rodent-borne diseases.

Relating to expert judgement, the experts’ views about the health implications of infectious diseases are mostly the same as those found in the literature review. It is agreed that climate change in HCMC is already having adverse effects on public health. As a consequence, the experts agree that changes in climate could lead to a heavy burden of the infectious diseases. Concerning malaria, the experts highlight that conditions associated with climate variability and change could increase mosquito populations and the incidence of malaria. Similarly, most experts go along with the hypothesis that climate change could lead to a heavy burden of dengue fever. Also, the majority of experts agree with the statement that the risk of water- and food-borne diseases would likely increase with climate change. Nevertheless, many experts expressed uncertainty about the impacts of climate change on rodent-borne illnesses. Ultimately, the experts come up with some recommended priority actions for communicating the health implications of infectious diseases to the public in the future which will be developed in section 5.2.

As regards public awareness about infectious diseases, respondents think that they and their family members are now at risks of catching infectious diseases, and everyone is susceptible, especially the children. In addition, respondents believe that all infectious diseases have severe health impacts, though dengue fever is supposed to have the most severe health implications. However, the perceived severity is different from the perceived likelihood of getting the diseases. The survey results show that respondents and their family members are suspected to be at risk of getting water- and food-borne diseases most. In terms of climate change, respondents agree that climate change is already affecting HCMC and having adverse impacts on human health. In the specific case of infectious diseases, they are believed to be given a heavy burden by changing climate, but are not considered to be affected most by climate change in comparison with other climate health outcomes. Being asked about the perceived likelihood of getting the infectious diseases due to climate change,
the respondents state that climate change increases their own and family members’ risks of getting these diseases. Finally, the survey also asserts that the public is in need of information relating to climate change, its health outcomes and particularly infectious diseases.

Overall, the general objective and specific aims of the study are achieved by the virtue of chosen methods. The information learnt from the literature review is used as a valuable resource to design the questionnaires and to analyze and discuss the survey results. Despite the limitations discussed in section 4.3, the two questionnaire surveys on the expert judgment and public awareness are considered as a proper method to study about the experts’ and public’s perceptions of the health implications of infectious diseases due to climate change in HCMC.

In conclusion, climate change in HCMC could lead to heavy burdens of the three infectious diseases, malaria, dengue fever, and water- and food-borne diseases. As a consequence, inhabitants in HCMC are now at higher risk of catching these diseases due to their sensitivities and exposures to the increased frequency and severity of diseases with changing climate. From either point of view of mitigation or adaptation to climate change, it is critical therefore to raise public awareness about the health implications of infectious diseases due to climate change in the city. The communication and education about the subject are discussed in the following section.

5.2. Recommendations

5.2.1. Raising public awareness about the health implications of infectious diseases due to climate change

Climate change differs from many other environmental health problems because of its gradual onset and its effects will probably be indirect. Hence it may be too late to respond effectively, or a substantial cost has already been incurred when the problem is recognized (Haines et al. 2006). In response to climate change impacts on human health in HCMC, the city government should take lead in implementing an action plan to mitigate and adapt to climate change, including raising public awareness through communication and education, based on valuable information of climate change scenario and its consequent human health effects (Campbell-Lendrum & Corvalán 2007).

The communication and education of the subject defined to be in need of the surveyed representations of the public requires an effective strategy namely action plans, including contents and methods, and responsibilities. As determined by the surveyed experts and respondents, communication and education should focus on the appropriate adaptive
measures and healthy behaviors, and disease prevention or management. Especially risk communication should be targeted to vulnerable populations, including the poor, the immigrants, children and the elderly. In the specific case of HCMC, communication and education about the health implications of infectious diseases due to climate change can be integrated into the existing effective one about infectious diseases that already get the public’s attention, namely the communication and education about dengue fever. In long term, awareness about the subject should be developed on the communication and education about issues on climate change which are not officially in place yet.

5.2.2. Further research or suggested study

It is recommend to do further studies using methods proposed in this study with a larger number of samples of respondents and experts (preferably group discussion), to compare if further studies conclude with similar results about the potential climate health implications of infectious diseases. Moreover, a qualitative and quantitative health impact assessment of the infectious diseases’ implications under changing climate is highly recommended. In addition, it is also urged to include other types of climate health effects such as allergic and respiratory diseases, health impacts of extreme weather like flooding and heat waves, and mental health in further studies.

Furthermore, future works could look at the relationship between urban poverty, age, gender and climate change as unequal exposure and sensitivity to climate change are not only harmful for the health of the vulnerable groups but also affect the well-being of the entire population.
<table>
<thead>
<tr>
<th>Abbreviation</th>
<th>Words/ Phrase</th>
</tr>
</thead>
<tbody>
<tr>
<td>CDC</td>
<td>Centers for Disease Control and Prevention</td>
</tr>
<tr>
<td>DHF</td>
<td>Dengue Haemorrhagic Fever</td>
</tr>
<tr>
<td>ENSO</td>
<td>El Niño Southern Oscillation</td>
</tr>
<tr>
<td>GDP</td>
<td>Gross Domestic Product</td>
</tr>
<tr>
<td>GHG</td>
<td>Greenhouse gas</td>
</tr>
<tr>
<td>HCMC</td>
<td>Ho Chi Minh City</td>
</tr>
<tr>
<td>HFRS</td>
<td>Hemorrhagic Fever with Renal Syndrome</td>
</tr>
<tr>
<td>HTD</td>
<td>Hospital for Tropical Diseases</td>
</tr>
<tr>
<td>ICEM</td>
<td>International Centre for Environmental Management</td>
</tr>
<tr>
<td>IPCC</td>
<td>Intergovernmental Panel on Climate Change</td>
</tr>
<tr>
<td>IMHEN</td>
<td>Institute of Meteorology, Hydrology and Environment</td>
</tr>
<tr>
<td>IMPE</td>
<td>Institute of Malariology – Parasitology – Entomology</td>
</tr>
<tr>
<td>MAGICC/SCENGEN</td>
<td>Model for the Assessment of Greenhouse-gas Induced Climate Change/ A Regional Climate Scenario Generator</td>
</tr>
<tr>
<td>MONRE</td>
<td>Ministry of Natural Resources and Environment</td>
</tr>
<tr>
<td>SLR</td>
<td>Sea Level Rise</td>
</tr>
<tr>
<td>SOI</td>
<td>Southern Oscillation Index</td>
</tr>
<tr>
<td>UNAIDS</td>
<td>The Joint United Nations Programme on HIV/AIDS</td>
</tr>
<tr>
<td>UNDP</td>
<td>United Nations Development Program</td>
</tr>
<tr>
<td>WHO</td>
<td>World Health Organization</td>
</tr>
</tbody>
</table>
LIST OF REFERENCES


Ministry of Natural Resources and Environment (MONRE) (2008). *National Target Program to respond to Climate Change*. Hanoi.


EXPERT REVIEW QUESTIONNAIRE

Thank you for taking the time to answer the following questions. These questions only relate to the situation in Ho Chi Minh City.

Background
The questionnaire is divided into three sections that cover the topics A - General information, B – Questionnaire I and C – Questionnaire II.

- Questionnaire I is about your awareness about climate change in HCMC and its potential health impacts, typically the infectious diseases.
- Questionnaire II aims to discuss the reasons why you chose the answers to the questions for the first part.

A - General information
Please provide your information
Name: _______________________________________________________
Contact email: ________________________________________________
Organisation type: ____________________________________________
Area of Expertise: ____________________________________________
B – Questionnaire I

Personal information

Age
☐ 18 – 34  ☐ 35 – 49  ☐ 50 – 64  ☐ 65 and above

Gender
☐ Male  ☐ Female

Highest degree or level of school
☐ Under high school  ☐ High school  ☐ Undergraduate  ☐ Postgraduate

Monthly income
☐ Below 3.000.000 VND  ☐ 3.000.000 – 4.990.000 VND
☐ 5.000.000 – 10.000.000 VND  ☐ Above 10.000.000 VND

1. Do you agree or disagree that you know a lot about infectious diseases and their health impacts?
☐ Strongly agree  ☐ Agree  ☐ Uncertain
☐ Disagree  ☐ Strongly disagree  ☐ Don’t know

2. In terms of your own risk now of getting infectious diseases, do you think you are at risk of getting diseases?
☐ Great risk  ☐ Some risk  ☐ No risk  ☐ Uncertain  ☐ Don’t know

3. Which infectious diseases do you think you might be at risk of getting?
☐ Malaria  ☐ Dengue fever
☐ Diarrhoeal illness  ☐ Rodent-borne diseases (e.g. plague, Lyme disease…)
☐ Other ________________  ☐ None
☐ Don’t know

Please skip questions 4 and 5 if your family is not living in HCMC.

4. Do you think any of your family members are now at risk of getting infectious diseases?

Please indicate which family member(s) if applicable.
☐ Great risk  ☐ Some risk  ☐ No risk  ☐ Uncertain  ☐ Don’t know

Family member(s) at risk ____________________________
5. Which infectious diseases do you think your family member(s) might be at risk of getting?

- [ ] Malaria
- [ ] Dengue fever
- [ ] Diarrhoeal illness
- [ ] Rodent-borne diseases (e.g. plague, Lyme disease…)
- [ ] Other ______________________
- [ ] None
- [ ] Don’t know

6. On a scale from 1 to 5, where 5 is very high, and 1 is very low, please indicate the how severe you think the level of health impacts would be for of the following infectious diseases.

<table>
<thead>
<tr>
<th>Infectious diseases</th>
<th>Very low</th>
<th>2</th>
<th>3</th>
<th>4</th>
<th>Very high</th>
</tr>
</thead>
<tbody>
<tr>
<td>Malaria</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Dengue fever</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Rodent-borne diseases</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Diarrhoeal illness</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
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<tr>
<td>Other ______________________</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

7. In general, how concerned are you about climate change?

- [ ] Very concerned
- [ ] Fairly concerned
- [ ] Not concerned
- [ ] Don’t know

8. Do you agree or disagree that climate change is already affecting HCMC?

- [ ] Strongly agree
- [ ] Agree
- [ ] Uncertain
- [ ] Disagree
- [ ] Strongly disagree
- [ ] Don’t know

9. Do you think climate change is already having adverse effects on human health?

- [ ] Strongly agree
- [ ] Agree
- [ ] Uncertain
- [ ] Disagree
- [ ] Strongly disagree
- [ ] Don’t know
10. What might be the effect of climate change on human health? (You can choose more than one option)

Please also indicate to what extent you think that climate change could lead to a heavy burden of each chosen health effect. (Please use the scale from 1 to 10, where 10 is the highest likelihood and 1 is the lowest likelihood)

For each chosen option, its likelihood is

☐ Allergic diseases (e.g. allergic rhinitis, asthma…) __________

☐ Respiratory diseases (e.g. asthma, chronic obstructive pulmonary disease…) __________

☐ Injury and death due to flooding __________

☐ Heat-related illness and death __________

☐ Mental health (e.g. stress, despair…) __________

☐ Infectious diseases (e.g. malaria, dengue fever…) __________

☐ Other ______________________________ __________

11. Do you consider that climate change increases your/ your family member(s)’ risk of getting infectious diseases?

☐ Strongly agree ☐ Agree ☐ Uncertain

☐ Disagree ☐ Strongly disagree ☐ Don’t know

12. What would you like to know more about in relation to the impacts of climate change on human health?

________________________________________________________________________

________________________________________________________________________

________________________________________________________________________
C – Questionnaire II

Please restate to what extent you agree or disagree with the following statements, then explain the reasons for your judgements.

*Please use the scale from 1 to 5 for your judgement*

1 – *Strongly agree*
2 – *Agree*
3 – *Uncertain*
4 – *Disagree*
5 – *Strongly disagree*

<table>
<thead>
<tr>
<th>Statement</th>
<th>Judgment</th>
<th>Reasons</th>
</tr>
</thead>
<tbody>
<tr>
<td>Climate change is already having adverse effects on human health in HCMC.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Climate change could lead to a heavy burden of infectious diseases in general.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Climate change could lead to a heavy burden of malaria.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Climate change could lead to a heavy burden of dengue fever.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Climate change could lead to a heavy burden of rodent-borne diseases (e.g. plague, Lyme disease...)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Climate change could lead to a heavy burden of diarrhoeal illness.</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
Climate change could lead to a heavy burden of other infectious diseases (please specify)

Conclusion/ Recommendation

1. Overall, what are critical problems and key challenges in the case of health effects of infectious diseases due to climate change in HCMC?


2. What are your recommended priority actions for communicating health implications of infectious diseases to the public in the future?


Your contribution to this effort is greatly appreciated. Please kindly return your completed questionnaire to the email address t.q.nguyen@uea.ac.uk, also please advise your contact email if you wish to receive the results of this survey.
Appendix II. Public awareness questionnaire

PUBLIC AWARENESS QUESTIONNAIRE

Thank you for taking the time to answer the following questions. These questions only relate to the situation in Ho Chi Minh City. Your responses will be anonymous.

Age
☐ 18 – 34  ☐ 35 – 49  ☐ 50 – 64  ☐ 65 and above

Gender
☐ Male  ☐ Female

Highest degree or level of school
☐ Under high school  ☐ High school  ☐ Undergraduate  ☐ Postgraduate

Monthly income
☐ Below 3.000.000 VND  ☐ 3.000.000 – 4.990.000 VND
☐ 5.000.000 – 10.000.000 VND  ☐ Above 10.000.000 VND

1. Do you agree or disagree that you know a lot about infectious diseases and their health impacts?
☐ Strongly agree  ☐ Agree  ☐ Uncertain
☐ Disagree  ☐ Strongly disagree  ☐ Don’t know

2. In terms of your own risk now of getting infectious diseases, do you think you are at risk of getting diseases?
☐ Great risk  ☐ Some risk  ☐ No risk  ☐ Uncertain  ☐ Don’t know

3. Which infectious diseases do you think you might be at risk of getting?
☐ Malaria  ☐ Dengue fever
☐ Diarrhoeal illness  ☐ Rodent-borne diseases (e.g. plague, Lyme disease…)
☐ Other _________  ☐ None
☐ Don’t know
Please skip questions 4 and 5 if your family is not living in HCMC.

4. Do you think any of your family members are now at risk of getting infectious diseases? Please indicate which family member(s) if applicable.

☐ Great risk ☐ Some risk ☐ No risk ☐ Uncertain ☐ Don’t know
Family member(s) at risk __________________________

5. Which infectious diseases do you think your family member(s) might be at risk of getting?

☐ Malaria ☐ Dengue fever
☐ Diarrhoeal illness ☐ Rodent-borne diseases (e.g. plague, Lyme disease…)
☐ Other _______ ☐ None
☐ Don’t know

6. On a scale from 1 to 5, where 5 is very high, and 1 is very low, please indicate the how severe you think the level of health impacts would be for of the following infectious diseases.

<table>
<thead>
<tr>
<th>Infectious diseases</th>
<th>Very low</th>
<th>Very high</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>1</td>
<td>2</td>
</tr>
<tr>
<td>Malaria</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Dengue fever</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Rodent-borne diseases</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Diarrhoeal illness</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Other</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

7. In general, how concerned are you about climate change?

☐ Very concerned ☐ Fairly concerned
☐ Not concerned ☐ Don’t know

8. Do you agree or disagree that climate change is already affecting HCMC?

☐ Strongly agree ☐ Agree ☐ Uncertain
☐ Disagree ☐ Strongly disagree ☐ Don’t know
9. Do you think climate change is already having adverse effects on human health?

☐ Strongly agree  ☐ Agree  ☐ Uncertain
☐ Disagree  ☐ Strongly disagree  ☐ Don’t know

10. What might be the effect of climate change on human health? (You can choose more than one option)

Please also indicate to what extent you think that climate change could lead to a heavy burden of each chosen health effect. (Please use the scale from 1 to 10, where 10 is the highest likelihood and 1 is the lowest likelihood)

For each chosen option, its likelihood is

☐ Allergic diseases (e.g. allergic rhinitis, asthma…) ________
☐ Respiratory diseases (e.g. asthma, chronic obstructive pulmonary disease…) ________
☐ Injury and death due to flooding ________
☐ Heat-related illness and death ________
☐ Mental health (e.g. stress, despair…) ________
☐ Infectious diseases (e.g. malaria, dengue fever…) ________
☐ Other ______________________________ __________

11. Do you consider that climate change increases your/ your family member(s)’ risk of getting infectious diseases?

☐ Strongly agree  ☐ Agree  ☐ Uncertain
☐ Disagree  ☐ Strongly disagree  ☐ Don’t know

12. What would you like to know more about in relation to the impacts of climate change on human health?

____________________________________________________________________
____________________________________________________________________

____________________________________________________________________

____________________________________________________________________

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____________________________________________________________________