Socio-economic and demographic aspects of dengue epidemiology evolution in Thailand, 1982-2012

Submitted by

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to the University of Barcelona as a thesis for the Master Degree in Internationalization, April 2014.

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Acknowledgements

This work has been conceived as a thesis for the Official Master Degree in Internationalization at the University of Barcelona and as a part of the interistitutional DENFREE project.

The research was supervised by Rachel Lowe Ph. D. from IC3, whom I would like to thank for giving me the possibility of participating in the project, as well as for inspiration, patience, and constant support provided.

This Master Thesis is fruit of all the courses undertaken as part of the Master Degree in Internationalization which gave me solid foundations for further studies on a complex relationship, growing interdependence, and globalization of many dimensions of the nowadays reality. Therefore, I would like to express here my gratitude for all the professors, lecturers, and colleagues who contributed to my exploring of this fascinating area of studies. This work was enriched as well by my stay in Brussels, where I was involved in the Erasmus exchange at Université Catholique de Louvain-la-Neuve and in the internship at the Department of Public Health at the Permanent Representation of the Republic of Poland to the European Union.

Collecting data for the project was an extremely difficult task due to linguistic, administrative, and geographical obstacles. Many of the attempts aiming at establishing contact in order to obtain necessary information or data were unfruitful. Therefore, I would like to thank the Statistical Office of Sa Kaeo Province, the Department of Civil Aviation of Kingdom of Thailand, Kamolnetr Okanurak Ph. D. from the Department of Social and Environmental Medicine at Mahidol University for having responded to my mails and kind requests.

Finally, I am eternally grateful to all my family, and in particular to my husband and parents. Without their unconditional loving support this work would not have been accomplished.

Abstract

Dengue is the world's most important and fastest spreading viral vector-borne disease. Due to international trade and travel, demographic and climate changes, the global incidence of dengue increased 30-fold during last 50 years and it is now estimated that 50-250 million cases occur each year. Only a small percentage of cases are symptomatic and reported. Two fifths of the human population live in area at risk of dengue transmission. About 500 000 annual dengue infections are cases of potentially fatal severe dengue disease. The social and economic burden of dengue is very high, although poorly understood.

The aim of this study is to examine demographic and socio-economic changes in Thailand from 1982 to 2012 and to compare them with the evolution of dengue epidemiology in Thailand. Some 160 dengue epidemiology-related articles, reports and guidelines have been revised to investigate the potential impact of socio-economic and demographic factors on dengue. Socio-economic and demographic changes in Thailand 1982-2012 were analysed. A comprehensive database was created and the data collected for each indicator was interpreted in the context of dengue epidemiology.

An improvement in many relevant indicators, such as the access to health security, units and services, or decreasing poverty, was found. Despite that, the incidence of dengue was found to remain high. It was hypothesised that high morbidity might be related to the increase of international air traffic, cross-border and internal migration, trade in vehicles, tyres and natural rubber, expanding paddy crop plantations, disparities in learning rates, and health care and services distribution among regions and between urban and rural zones, low housing, social security, and health services standards among illegal and low-skilled working immigrants. Disparity in the access to health and social services might have also provoked errors in dengue reporting. The demographic transition towards an ageing-society in Thailand was found to challenge dengue epidemiology. This calls for establishing new symptoms, control, and treatment guidelines. Dengue epidemiology management was found to be challenged by the economic burden of dengue, parallel to significant poverty rates, low dengue-related knowledge, inappropriate attitudes and practice in execution of daily-life and traditional practices.

The study supports dengue epidemiology control and management as it identifies and analyzes demographic and socio-economic factors which 1) determine the scale of dengue incidence, 2) contribute to dengue reporting and surveillance system improvement, 3) challenge dengue epidemiology mangement and 4) contribute to determining dengue economic and disease burden. The data collected can be incorporated into dengue prediction models to help capture the impact of socio-economic and demographic factors on dengue risk.

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1 Introduction

1.1 Motivation

Dengue fever is an arboviral disease, caused by dengue virus and transmitted by a bite of infected *Aedes* mosquito, mainly *Aedes aegypti*. There are four closely related, but antigenically distinct virus stereotypes which may cause the disease. The infection with one of them does not provide cross-protective immunity, which means that a person living in an endemic zone can contract four dengue infections during their lifetime (Clark et al. 2005; WHO 2009). The disease is considered to be ubiquitous in the tropics and the subtropics, and is endemic in more than 110 countries. According to the World Health Organization (WHO) estimations, at least 50 million people each year suffer from dengue, other sources suggesting a number of 100 million (Cazelles et al. 2005; Rigau-Pérez et al. 1998), or even 230 million (Gubler, 2012). The disparity of the estimations is likely due to the low detection of the disease by the public health structures. 500,000 of these infections are cases of life threatening, severe dengue disease (Kyle and Harris, 2008). Studies provide estimations that about 2 million severe dengue cases occur annually (Gubler, 2012). Two fifths of the human population live in the infection-risk area. The geographic distribution of dengue and its potentially fatal form, dengue haemorrhagic fever (DHF) have expanded dramatically in the last decades. Dengue is now considered to be the world´s most important viral vector-borne disease.

The public health burden of dengue is poorly known, and the reasons for its dramatic global emergence are not well understood (Gubler and Clark, 1995). Several important factors of its spread should be outlined. First, an effective control of the mosquito is difficult to manage and is totally absent in many of the endemic countries. Second, recent demographic changes have greatly contributed to the acceleration of the disease spreading, uncontrolled urbanization and concurrent population growth being the most important of them (Gubler, 1998). The demographic, economic, behavioural and social factors often turn out to be key factors in the disease control; generally, however, they are underestimated and misunderstood. Third, the increased air traffic, a perfect mechanism for transporting dengue viruses, results in a constant exchange of the viruses between the endemic populations (Gubler and Clark, 1995).

In order to prevent and control the spread of dengue, the decision makers must be informed about the factors that cause the epidemics and which contribute to its increase. Several patterns of the spread, burden, management and prevention of the disease must be taken into consideration to act in a truly efficient way against the world's most important vector-borne disease.

In view of the challenges discussed, the present study is developed as the Master Thesis project at the Univeristy of Barcelona, Spain, and as a part of DENFREE programme aiming at preventing dengue epidemics in Europe (See: Appendix A). The programme has two main goals. First, identification of key factors determining dengue transmission, outcome of infection and epidemics. Second, development of novel diagnostic tools to detect asymptomatic infections.
The aim of this research is to identify and analyse dengue-related demographic, and socio-economic changes undergone in Thailand from 1982-2012 and on the basis of the results and their interpretation, to formulate important for dengue epidemiology hypothesis and conclusions.

1.2 Research Questions

The aim of the present study is, first, to revise the pertinent literature in order to collect and analyse the outcomes defining the relationship of dengue epidemiology and demographic, economic, and social factors. On the basis of this analysis, relevant data on the economic, demographic, and social indicators in Thailand will be collected for the period from 1982 to 2012. The indicators will be analysed and contrasted with the up-to-date knowledge on their relationship with dengue epidemiology. Therefore, important conclusions will be withdrawn on how the mentioned classes of factors shaped the dengue epidemiology in Thailand throughout the period from 1982 to 2012. Special attention will be paid to the changes that might have occurred in the epidemiology and which may be explained by demographic and socio-economic factors. These changes may also contribute to a re-statement of the control, prevention and treatment practices guidelines. Furthermore, in the context of a gradually wider international dengue spread, the factors which might contribute to this spread will be examined.

1. In what way do socio-economic and demographic factors influence dengue epidemiology?
2. What were the main changes in the socio-economic and demographic profile of Thailand from 1982 to 2012?
3. How did the socio-economic and demographic changes influence dengue epidemiology in Thailand, and how dengue epidemiology may influence Thailand socio-economic situation?
4. What conclusions can be withdrawn from the comparison of the evolution of dengue epidemiology and socio-economic and demographic changes for the future prevention, control, and treatment guidelines?

1.3 Thesis Plan

Chapter 2 provides the background for the present study. It analyses dengue epidemiology on the basis of a literature review. It embraces a description and classification of dengue infections, dengue transmission modes and vectors. It presents as well the present state of knowledge as far as such host and individual risk factors as serotype, age, ethnicity, and sex are concerned. Finally, information on the geographical distribution of dengue and its spread throughout last centuries and decades is provided.

Chapter 3 is devoted to the description of methods applied in the present study.

Chapter 4 provides the results of the research. Issues such as the demography, migration and international trade, economic and infrastructure, knowledge, attitude and practice regarding dengue among the population are examined. The section devoted to the demography discusses the age trends in dengue incidence, provides an analysis of the demographic transition in Thailand and of the urbanisation process undergoing in the country. The second section, on migration and international trade, first, revises the main findings relating these issues with dengue spread and distribution, and with dengue prevention and control. Then, an analysis of the internal and international migration flows, of the air travel from and to Thailand, and of the international trade flows flow/to Thailand is provided, and the results are contrasted with the dengue epidemiology evolution. The section devoted to the economics and infrastructure, analyses dengue-related aspects of the national health infrastructure, 'hard' infrastructure, and economic and disease burden of dengue in Thailand. The section on dengue-related knowledge, attitude and practice (KAP) of Thai population revises the findings on the KAP and Health-Belief Model (HBM) in the context of dengue epidemiology in Thailand, analyses education trends in Thailand, and traditional and daily-life practices such as water harvesting, or paddy crop cultivation.

Chapter 5 provides the discussion, and Chapter 6 the conclusions of the thesis.

2 Background

2.1 Introduction

The background provides information on dengue diseases and epidemiology which is essential for the understanding of the problem in the context of socio-economic and demographic factors. It presents a literature review on dengue infections, transmission, host and individual risk factors, geographical spread and distribution. General aspects of Thailand geography and climate are described.

2.2 Dengue

2.2.1 Dengue infections

Dengue is a viral infection transmitted by the bite of an infected female *Aedes* mosquito, the virus transmitted (DENV) being the most prevalent arthropod-borne virus affecting humans nowadays (Kyle and Harris, 2008). There are four distinct serotypes of the dengue virus (DEN 1, DEN 2, DEN 3 and DEN 4). Dengue is characterized by a variety of its clinical presentations parallel as well to the often unpredictability of its clinical evolution and outcome (WHO 2009).

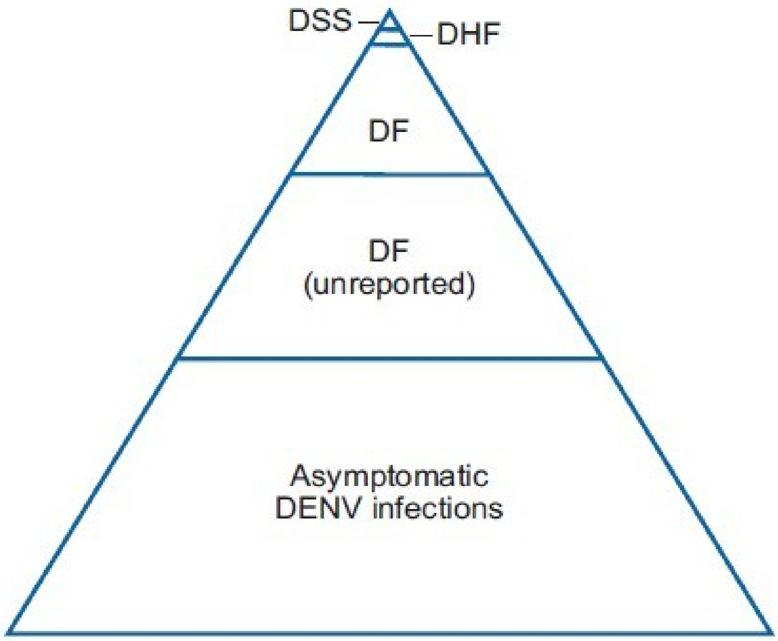

Figure 1: DENV infection and disease pyramid. Source: (Kyle and Harris 2008).

Figure 1 presents a pyramid reflecting dengue clinical presentations and the proportions of the frequency of their occurrence.

The majority of dengue infection cases are asymptomatic and tend to be not reported. As far as the symptomatic cases are concerned, according to the WHO estimations, the symptoms appear in 3–14 days (average 4–7 days) after the infective bite of the mosquito. Dengue fever is a flu-like illness that affects infants, young children and adults. The majority of the patients affected recover from the dengue fever (DF) after a non-severe clinical course. A small proportion of the patients, normally due to rather secondary than primary infection, progress to severe disease (DHF - which may result in Dengue Shock Syndrome - DSS) mostly characterized by plasma leakage with or without haemorrhage. DSS takes place when fluid leakage into the interstitial spaces is followed by a hypovolemic shock, which without appropriate treatment may eventually lead to death (Kyle and Harris, 2008).

According to the World Health Organization, the definition of the severe dengue may be based on the fever maintaining for 2-7 days and occurrence of more than one of the following: (i) plasma leakage that may lead to shock (dengue shock) and/or fluid accumulation, with or without respiratory distress, and/or (ii) severe bleeding, and/or (iii) severe organ impairment (WHO 2009).

Figure 2 proposes a classification of dengue cases and of its severity levels. The WHO divides dengue cases into dengue and severe dengue cases. The contraction of dengue fever may be suspected when a simultaneous occurrence of some of the symptoms and warning signs, as listed in Figure 2. The warning signs are an alert of probable complications which may transform into a severe dengue with repercussions such as severe plasma leakage which may lead to DSS or fluid accumulation with respiratory distress, severe haemorrhage or severe organ impairment.

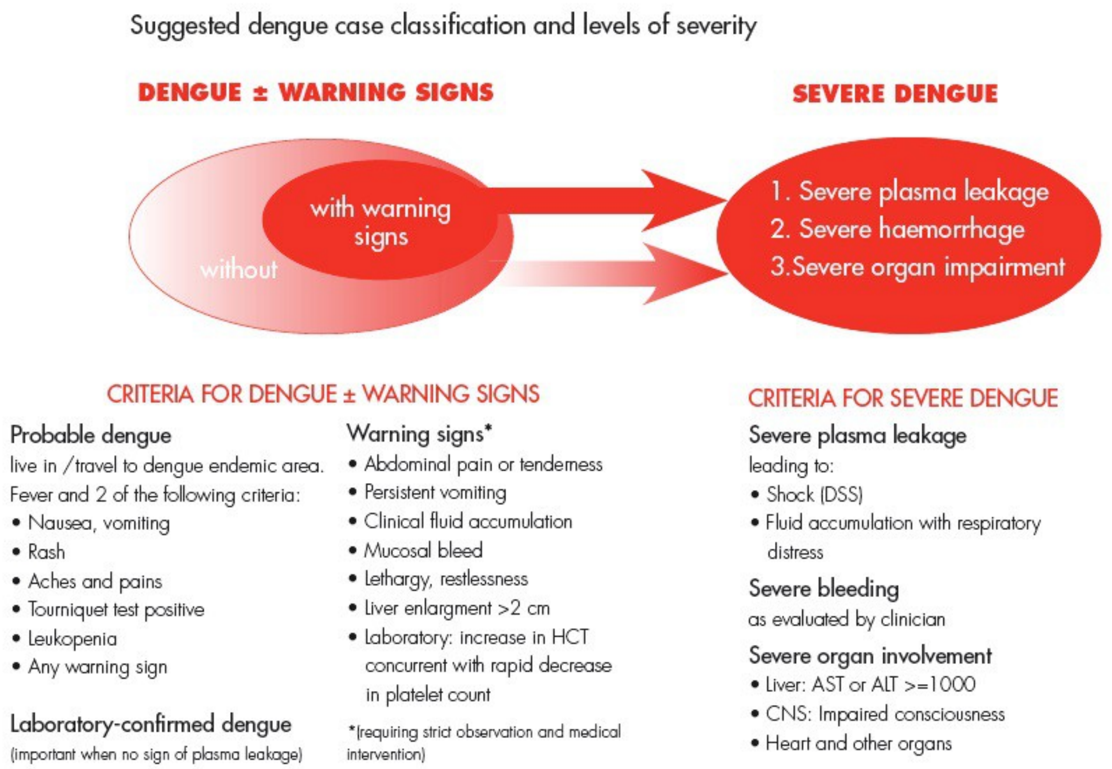

Figure 2: Suggested dengue case classification and levels of severity. Source: (WHO 2009)

After the incubation period following the infective bite of mosquito, the illness begins abruptly and consists of three phases - febrile, critical and recovery (WHO 2009).

The febrile phase typically begins with a sudden onset of a high-grade fever which potentially reaches over 40°. The acute febrile phase extends from 2 to 7 days and generally implies frontal headache, retroocular pain, muscle and joint pain, nausea, vomiting, and rash (Rigau-Pérez et al. 1998).

Critical phase tends to take place on days 3-7 of illness and is characterized by a drop in the patient's temperature to 37,5-38°C or less and remains below it (WHO 2009). At this point, a risk exists that two parallel processes will undergo at the same time: an increase in capillary permeability and an increasing haematocrit levels. The lack of increase in capillary permeability implies an improvement in the patient's state, in the contrary case, the patient's states worsens in

parallel to the increasing loss of plasma volume. A clinically significant plasma leakage usually takes from 24 to 48 hours. Often preceded by warning signs, in case of loss of a critical plasma volume, a shock occurs. If it prolongs, the consequent organ hypoperfusion results in progressive organ impairment, metabolic acidosis and disseminated intravascular coagulation. Subsequently, severe haemorrhage causes the haematocrit to decrease in severe shock.
When it comes to the recovery phase, it takes place if the patient survives the critical phase. Within the subsequent 48-72 hours, a gradual reabsorption of extravascular compartment fluid takes place (WHO 2009) and a general improvement symptoms appear and the patient's state stabilizes.

2.2.2 Transmission

Virus

Dengue virus belongs to the genus *Flavivirus*, family *Flaviviridae* and embraces four serotypes DEN1, DEN2, DEN3, DEN4 (WHO 2009). Each serotype has a distinct genotype or lineage. However, in spite of this extensive genetic variability, the serotypes keep certain common characteristics such as the purifying selection. The purifying selection implies for dengue epidemiology, among others, such important feature of viral evolution as maintaining only those virus which fit for both human and vector.

Mosquito

The dengue virus is transmitted through the bites of infected mosquitoes *Aedes*. The principle DENV vector is *Aedes aegypti* but it is also transmitted on a large scale by *Aedes albopictus, Aedes polynesiensis* and several species of the *Aedes scutellaris* complex. Each of the vector mosquitoes is characterized by its particular ecology, behaviour and geographical distribution (WHO 2009). However, these characteristics have evolved throughout time and mosquito adapted to its feeder habits. *Aedes aegypti* has adapted particularly well to the changing ecology and human behaviour. Believed to have its origins in African jungles, *Aedes aegypti* mosquito perfectly adapted to the urban environment. Its breeding sites and activity area are placed in housing surroundings, both indoors and outdoors. As investigators observe, the larvae is usually located in the artificial containers such as discarded tyres, buckets, flower pots, wading pools, and blocked rain gutters, but natural sites such as bromeliads, treeholes, and coconut shells are also habitual larvae location (Rigau-Pérez et al. 1998). The biting activity of *Aedes aegypti* female mosquitoes concentrates during the day, the importance of this fact being reflected in greater difficulties of vector control as compared to the mosquitoes which biting activity takes place mainly at night. Important to the epidemiology is the fact that the *Aedes aegypti* female mosquito feeding habits characterize by partial feeding, which means that it can probe and/or feed, and subsequently, infect, several people until obtaining a replete meal (Focks et al. 1990; Rigau-Pérez et al. 1998). The peak of this activity is reached in the morning and in the afternoon until the sunset, the decrease taking place at midday. As far as the geographical distribution of the *Aedes* mosquitoes is concerned, it has undergone as well determining changes throughout time. The geographic distribution of the *Aedes aegypti* has supposedly spread from Africa to mainly tropical and subtropical area and extended between geographic latitudes 35ºN and 35ºS. Although *Aedes aegypti* has been found as far north as 45ºN, its presence was notified only during warm months as the mosquitoes did not survive decreased temperatures. The *Aedes albopictus* mosquito is believed to have its origins in Asia but its presence has spread to Europe, the Americas, the Caribbean, Africa and the Middle East. The *Aedes albopictus* eggs adapt well to temperatures much lower than other *Aedes* mosquitoes and that is why the widest stretch of the dengue endemic area towards the north is being subscribed to this mosquito species. For instance, the re-emergence of dengue and other infections transmitted by the *Aedes* mosquitoes in the United States or Europe is believed to be motivated by the spread of the *Aedes albopictus* to these areas (Kyle and Harris 2008).

2.2.3 Host and individual risk factors

Most of dengue virus infections are asymptomatic, a small percentage of them may progress to a severe dengue. The risk of disease evolution to the severe dengue depends on several possible personal circumstances such as previous contraction of a dengue infection, age, ethnicity, sex, simultaneous suffering from a chronic disease (i.e. bronchial asthma, sickle cell anaemia, diabetes mellitus) (WHO 2009; Guha-Sapir and Schimmer 2005).

Serotype

The infection with a serotype is believed to create the immunity for the same serotype, although it is not a cross-protective immunity. The secondary infection seems to have a decisive impact on increasing the probability of developing a severe form of disease. Certain studies conducted in Thailand give statistical evidence for the correlation between the secondary dengue infection and the clinically apparent cases, the studies estimating such simultaneous occurrence in 90% of the clinically apparent cases (Cummings et al. 2009). Other studies contribute to the research with a hypothesis of Antibody-Dependent Enhancement which would explain the increased probability of a severe dengue in cases of secondary infection or a primary infection of infants born to dengue-immune mothers (Halstead et al. 2001). According to this model, during the primary infections non-neutralizing and cross-reactive antibodies emerge and can be passively inherited by infants from their mothers. In case of a secondary infection or a primary infant infection, these antibodies and the cross-reactive memory cells facilitate the entry of the virus causing the proliferation of the infected cells and by these means triggering several subsequent processes correlated to increasing severity of the disease.

Age

The age of the individual is another important potential risk indicator. The dengue fever has been generally described as a childhood disease. However, for several recent years some important shifts in the age have been noticed in the epidemiology. Dengue-epidemiology researchers recompiled the studies on the shift in age-related specific hazard and pointed out to the studies conducted in Cuba, Puerto Rico, Nicaragua, Brazil, and especially in the South-East Asia, hyperendemic since several decades region, which gave clear evidence of the shift towards older ages and of the highest age-specific morbidity and mortality rates in older age groups (more than 15 years old) (Guha-Sapir and Schimmer, 2005). Very important studies have been conducted, from which interesting results relevant to the demographic factors have been obtained in Thailand (Cummings et al. 2009). Despite the evidence provided by the studies mentioned above, some researchers still consider children as the most hazard-exposed group which may be related to highest rates of the Dengue Shock Syndrome occurrence in this group, due to children-specific increased capillary fragility and decreased tolerance for insult to microvascular integrity (Gamble et al. 2000; Kyle and Harris, 2008).

Ethnicity

Studies show that there might be a relationship between certain genetic patterns and the increased risk of developing severe dengue forms. Researchers provide evidence of reduced hazard of people of Negroid race for severe dengue as compared to the representatives of the Caucasoid race (Sierra et al. 2007).

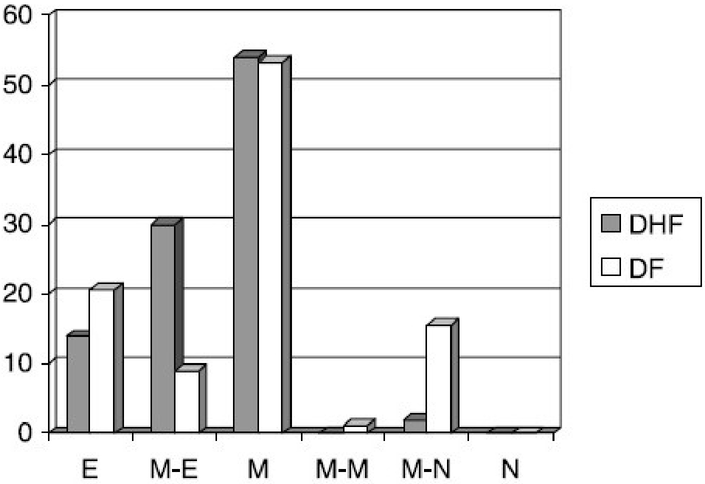

Figure 3: Racial distribution of DF, DHF/DSS cases and fatalities. Source: (de la C Sierra, Kourí, and Guzmán 2007).

Figure 3 presents DF, DHF/DSS and fatal cases distribution according to the anthropometric classification of 120 individuals clinically and serologically confirmed as having dengue disease during the 1997 dengue 2 outbreak in Santiago de Cuba municipality. *E* stands for Europoid, *M-E* for mixed race with predominance of Europoid characteristics, *M* for mixed race without predominance of any racial group, *M-M* for mixed race with predominance of Mongoloid characteristics, *M-N* for mixed race with predominance of Negroid characteristics, *N* for Negroid. The figure demonstrates that the Negroid-race representatives did not contract the severe dengue and the representatives of mixed race with predominance of Negroid characteristics experienced it in a much smaller percentage than the Europoid or Mulatto representatives. For the purpose of the present paper, it is important to underline that the small percentage of the dengue severe cases for the Mongoloid race representatives must be interpreted in accordance to the small representation of the Asian-origins individuals in the Cuba population during the years of the outbreaks measured in the study - ~0,1%, according to the data provided in the paper. In their paper, the researchers cite as well other relevant studies which demonstrate that in other dengue endemic regions inhabited mostly by the Negroid race, the epidemiological burden is lesser, absent or present for mostly non-Negroid representatives (Gubler and Clark, 1995; Halstead et al. 2001). The results of the research contribute significantly to the research on dengue, its control and prevention.

Sex

Few studies have undertaken researches on the sex differences in the epidemiology although a better understanding of the hypothetical correlation between the sex and the epidemiology would be of great importance for the better understanding of the dengue epidemiology, for its prevention, surveillance and control. Studies conducted in India and Singapore had shown a great predominance of the male cases of the dengue fever and severe dengue (Guha-Sapir and Schimmer, 2005). Differently, studies is South America point to an equal distribution of cases between the both sexes, and even describe the female cases predominance. Studies conducted in Asia and other interesting researches gave important results pointing out to the males as contracting more infections but a significantly higher incidence of severe cases was observed in females (Guha-Sapir and Schimmer, 2005; Halstead et al. 1970).

2.2.4 Geographical spread and distribution of dengue

Dengue is the fastest-spreading mosquito-borne viral disease in the world. Due to the geographic spread of dengue to new countries and from urban to rural settings, the incidence of dengue has increased 30-fold during the last 50 years. The nowadays geographic distribution the dengue virus exposes two fifths of the human population to the risk of infection (WHO 2009).

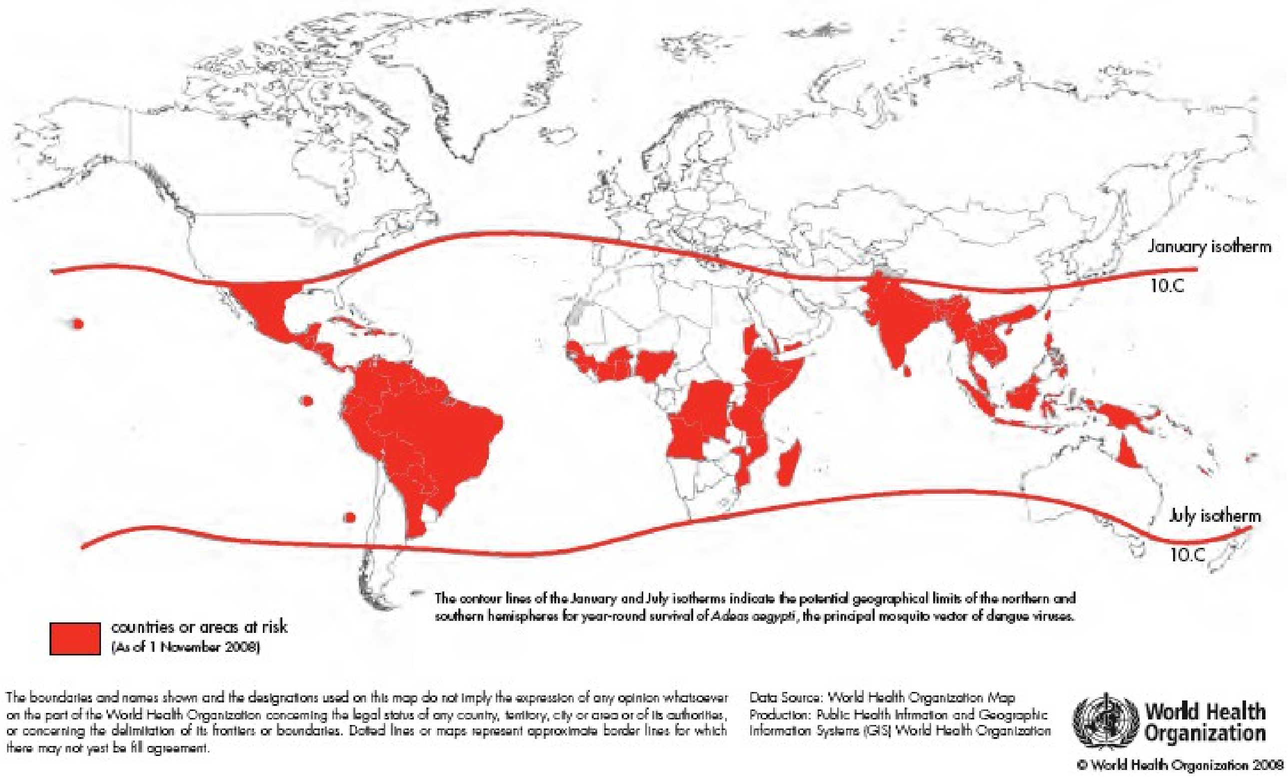

Figure 4: Countries/areas at risk of dengue transmission. Source: (WHO 2009)

The most important factors considered to be responsible for this dramatic spread of dengue include the environmental and socio-behavioural changes (Cazelles et al. 2005) such as: explosive population growth, unplanned urban overpopulation with inadequate public health systems, poor control of standing water and vectors, viral evolution, increased international recreational, business, and military travel to endemic areas.

Evolution of dengue spread throughout time.

Dengue fever has a long history. The probably first records date back to the Chin Dynasty (265 to 420 A.D.), were published in the *Chinese Encyclopedia of disease symptoms and remedies* and describe a disease called *water poison* associated to flying insects (Gubler, 1998).
However, the spread of the epidemics of dengue probably had not taken place until the 18th/19th century when the first reported epidemics simultaneously occurred in three continents, in Asia, Africa and North America (Gubler, 2002). The spread was given as a result of the developing shipping industry and international trade. In this context, the transmission cycle was assured given the adequate conditions of the *Aedes* mosquitoes breeding sites, such as the stored water. However, researchers argue that the epidemics were infrequent and would occur infrequently, in intervals of 10-40 years, as the mode of transport was relatively slow and the voyages themselves were relatively infrequent.
The story of dengue epidemics changed dramatically as a consequence of the World War II (Gubler, 2002). Firstly, the changes and the disruption of the ecology due to the war, and secondly, the movement of the military troops had a substantial impact on the distribution of the mosquito in the Southeast Asia and the Western Pacific. The first factor strongly contributed to the extension of the geographic distribution and the increase of the *Aedes aegypti* density, the second one determined an acceleration in the spread of virus between the population centres. Approximately from the end of the War, the Southeast Asia remains hyperendemic for all four DENV stereotypes (Kyle and Harris, 2008).
The first severe dengue epidemics occurred in Manila, Philippines, in the beginning of the 1950s and within the next 20 years spread throughout the South-East Asia and became the major reason for children hospitalization (Gubler, 1998). Studies indicate that in the following years dengue and severe dengue epidemics spread from the East Asia to India, Sri Lanka, Maldives, Pakistan, China, countries of the South and Central Pacific (Niue, Palau, Yap, Cook Islands, Tahiti, New Caledonia, and Vanuatu).
The Americas experienced a particularly tragic shift in the history of the dengue epidemiology. In parallel to the dramatic acceleration in the spread of the disease in Asia in 1950s, 60s and 70s, the incidence of dengue was very infrequent thanks to the *Aedes*-mosquito eradication programme launched in the beginning of the XX century (Brathwaite Dick et al. 2012). Unfortunately, in the

1970s the programme aiming at eliminating the mosquito from the Americas was discontinued, what resulted in a re-invasion and expansion of the mosquito distribution (See: Figure 5).

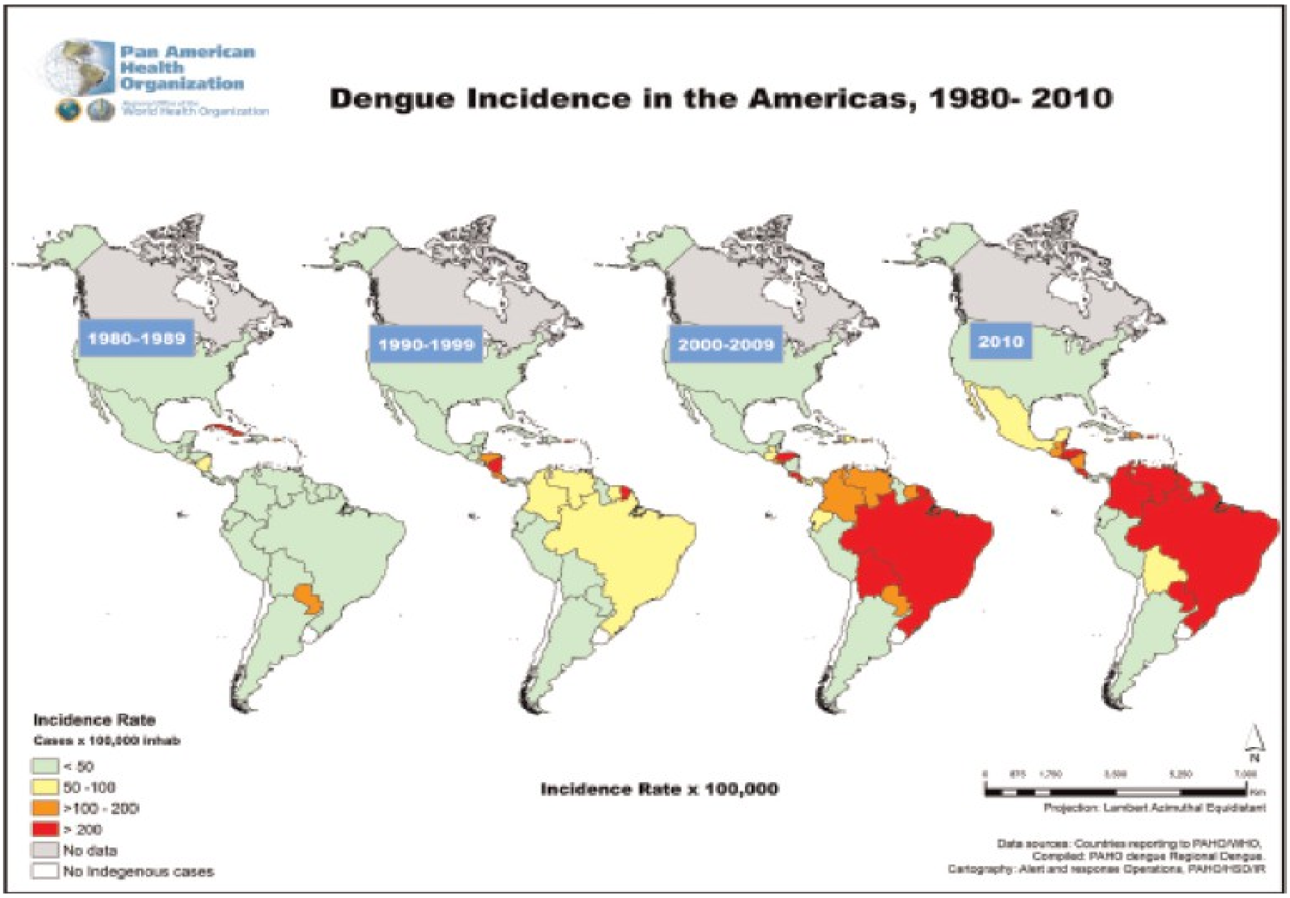

Figure 5: Dengue Incidence in the Americas, 1980-2010. Source: (Brathwaite Dick et al. 2012)

2.3 Thailand's geography and climate

The Kingdom of Thailand was established in the mid-XIV century. It is located in the centre of Indochina peninsula in South Eastern Asia, between the equator and the tropic of cancer, the area belonging to the tropic zone. Thailand territory extends for 518,000 km², from the 5º-21º North latitude and 97º-107º East latitude. It is bordered to the south by Gulf of Thailand, to the Southeast by Malaysia, to the North by Laos and Cambodia, to the West by Andaman Sea and the southern part of Burma. It is separated from Vietnam by the Gulf of Thailand and to Indonesia and India by the Andaman Sea. The country's climate is equatorial and humid, and characterizes with a high temperature of over 20°C and relative humidity of 80% throughout the year (Promprou, Jaroensutasinee, and Jaroensutasinee 2005). The peak of the wet season varies according to the region, the Andaman Sea wettest period extending from August to September and the Gulf of Thailand southern from November to January.

From the administrative perspective, Thailand is divided into 4 regions: Central, Southern, Northern, and North-Eastern, and 76 provinces (See: Figure 6).

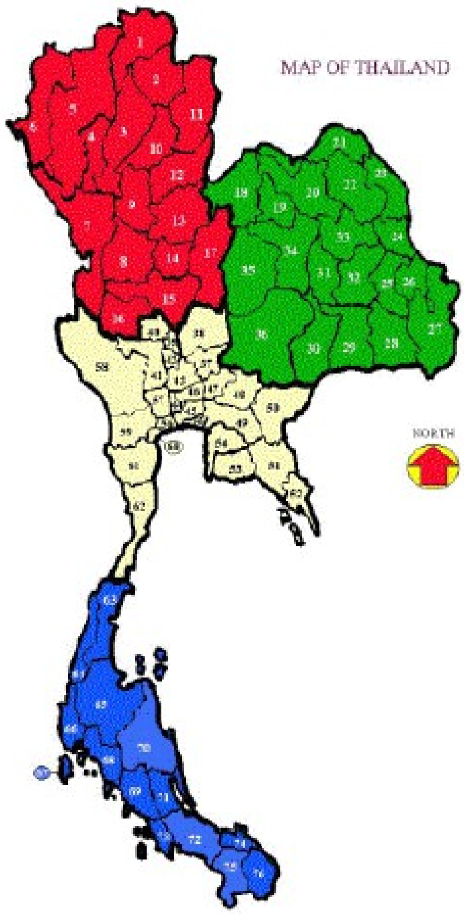

Figure 6: Administrative Division of Thailand. Source: Regional Data Exchange System on Food and Agricultural Statistics in Asia and the Pacific.

3 Methods

160 scientific dengue epidemiology-related articles, reports, and guidelines have been revised in order to contrast findings on socio-economic and demographic factors related to dengue epidemiology. Out of them, 58 publications have been cited here as the most pertinent results, selected in order to illustrate the evolution of the dengue epidemiology, and for the examination of its socio-economic and demographic context. Many differences among the scientific hypothesis have been detected and the research aimed, among others, at relating the vagueness of the findings with the changing socio-economic factors and dengue reporting system.

Data on socio-economic and demographic indicators has been collected and analysed, with help of models and tools from the social sciences area. A database and charts have been elaborated in order to present quantified results. The evolution of these indicators was studied and contrasted to obtain a comprehensive image. The original objective of the Master Thesis project was to collect data corresponding to each of the 76 Thai provinces. However, while searching for and collecting data, this objective turned out to be over-demanding in view of linguistic, geographic, institutional, and technical obstacles. Only two out of 76 provincial institutions have responded to repeated requests for data, and their response has been received with an immense gratefulness. The quest for obtaining the data on a regional and national scale was as well an extremely demanding task, as most of the data is not available in English, and most of the institutions contacted did not respond to the repeated requests sent by electronic mails. Therefore, it is extremely important to express here gratitude for those that did respond, such as the Statistical Office of Sa Kaeo Province, the Department of Civil Aviation of Kingdom of Thailand, Kamolnetr Okanurak Ph. D. from the Department of Social and Environmental Medicine at Mahidol University.

The data collected in the project and presented here comes from the following sources: the Thailand Health Profile 2008-2010 published online by the Thai Ministry of Public Health (MoPH), the National News Bureau, the United Nations Economic and Social Commission for Asia and the Pacific (UNESCAP) Online Database, the United Nations Commodity Trade Statistics Database, the Thai National Statistic Database, and the Association of Southeast Asian Nations ASEAN Food Security Information System. The links to the data available online are provided in the Appendix B.

Rachel Lowe from Institut Català de Ciències del Clima, Barcelona, Spain, provided a wide support in defining the area of the research and in the search for literature.

4 Results

4.1 Dengue epidemiology in Thailand

The term 'dengue epidemic' may refer both to the detection of dengue virus circulation in an area previously free of the virus, or to a significant increase in the incidence rate where dengue was already endemic (Barbazan, Yoksan, and Gonzalez 2002).

The spread of dengue is related to both environmental and socio-behavioural changes (Cazelles et al. 2005). As researchers argue, the biology of the disease vectors is directly related to the climate. The patterns of the correlation between the climate and the vector, mainly *Aedes aegypti*, populations abundance and distribution have been studied in many researches. The geographic situation of Thailand and its climate make it one of the countries from the dengue endemic zone and since the 1950s-1960s it became hyperendemic for all dengue virus serotypes. Studies reported important associations between monthly dengue incidence in Thailand and the dynamics of the climatic phenomenon called el Niño (Cazelles et al. 2005) (See: Figure 7).

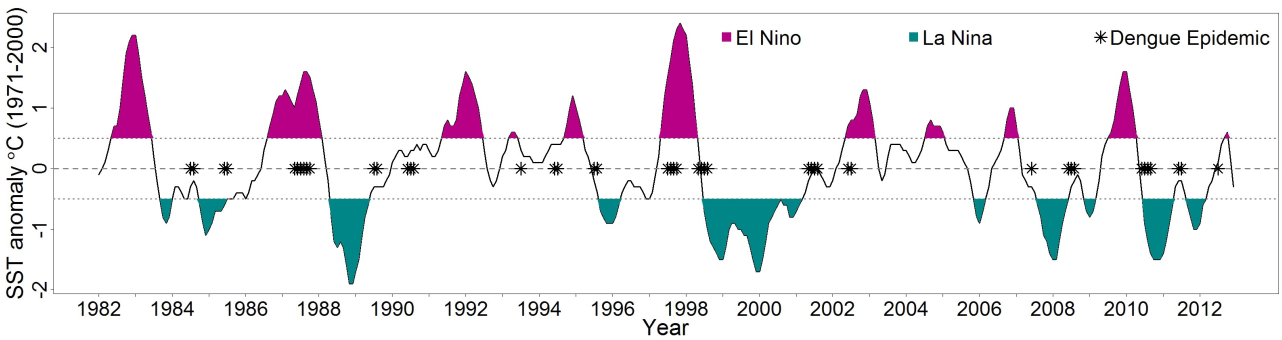

Figure 7: El Niño/La Niña events and doubled dengue risk. Source: Rachel Lowe, IC3.

DHF incidence and mortality in Thailand

In spite of the efforts made by both national and international actors in order to reduce the dengue incidence by undertaking actions such as increasing the scale and efficacy of the vector and disease control and prevention programmes, or conducting scientific researches in order to obtain a vaccine, dengue haemorrhagic fever incidence in Thailand remains very high. Figure 8 presents the evolution of the disease incidence in Thailand from 1982 to 2013. The values for 2013 have been included here despite exceeding the period covered by this study (1982-2012), as they were unusually high.

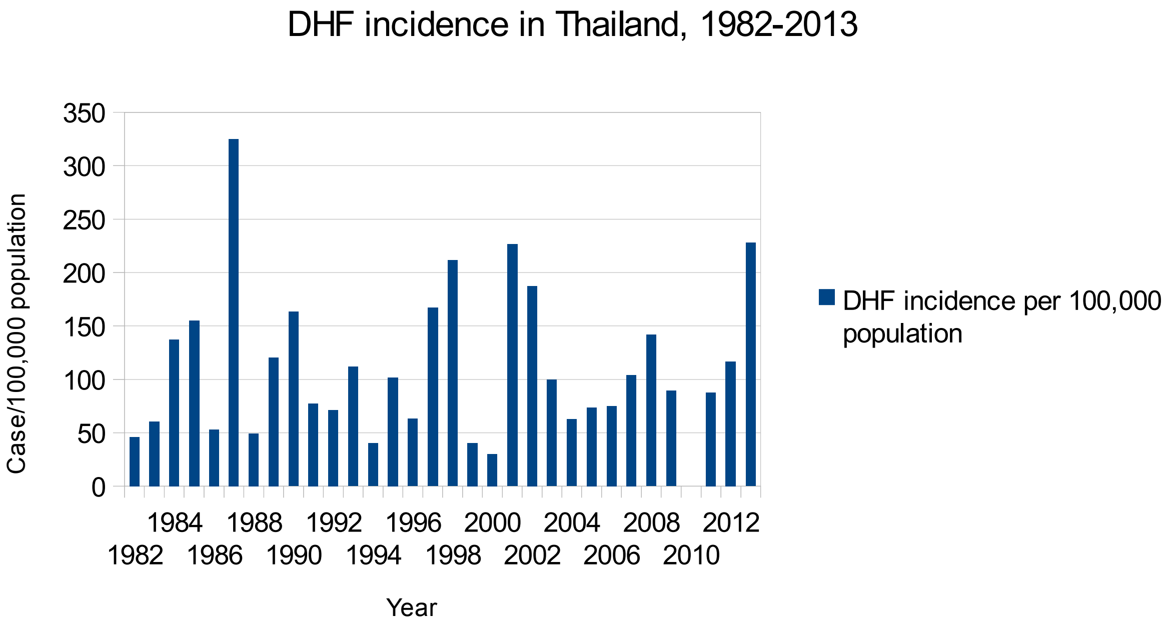

Figure 8: DHF incidence in Thailand, 1982-2013. Data source: Thailand Health Report 2008-2010 and Thai National News Bureau.

Figure 8 shows that a regular pattern characterizes the dengue haemorrhagic fever incidence in Thailand. The incidence hardly ever was below the value of annual 50 cases/100,000 population. The most frequent years with annual incidence values rounding 50-100 cases per 100,000 population were interrupted in more or less intervals by severe outbreaks exceeding 100 cases. Throughout the 32 years there have been 8 outbreaks exceeding 150 annual cases/100,000 population, 4 of them exceeding 200 cases. The biggest outbreak in this period occurred in 1987, with the rate of ~325 cases/100,000 population, and the second biggest outbreak took place in 2013, with the ratio of 228 cases/100,000 people.

Although the evolution of annual incidence rates of dengue haemorrhagic fever in Thailand did not have a decreasing tendency and even the second biggest outbreak in the period was registered in 2013, the annual disease mortality rate diminished significantly. Figure 9 shows a decreasing trend of mortality rates from 1982 to 2013. A significant comparison can be made if contrasting the disease incidence and mortality rates for the two biggest dengue haemorrhagic fever outbreaks. The biggest disease outbreak, which occurred in 1987, was characterized by the highest mortality rate in the period, of 1.85 fatal case per 100.000 population. However, the second biggest outbreak, in 2013, had a mortality rate of 0.2 fatal case/100,000 population. Comparing the value of this rate with the values of almost all the annual rates until 2013, which would normally exceed it importantly, the mortality rate in 2013 was relatively low. Nevertheless, in 2013 81 Thais died from the dengue haemorrhagic fever.

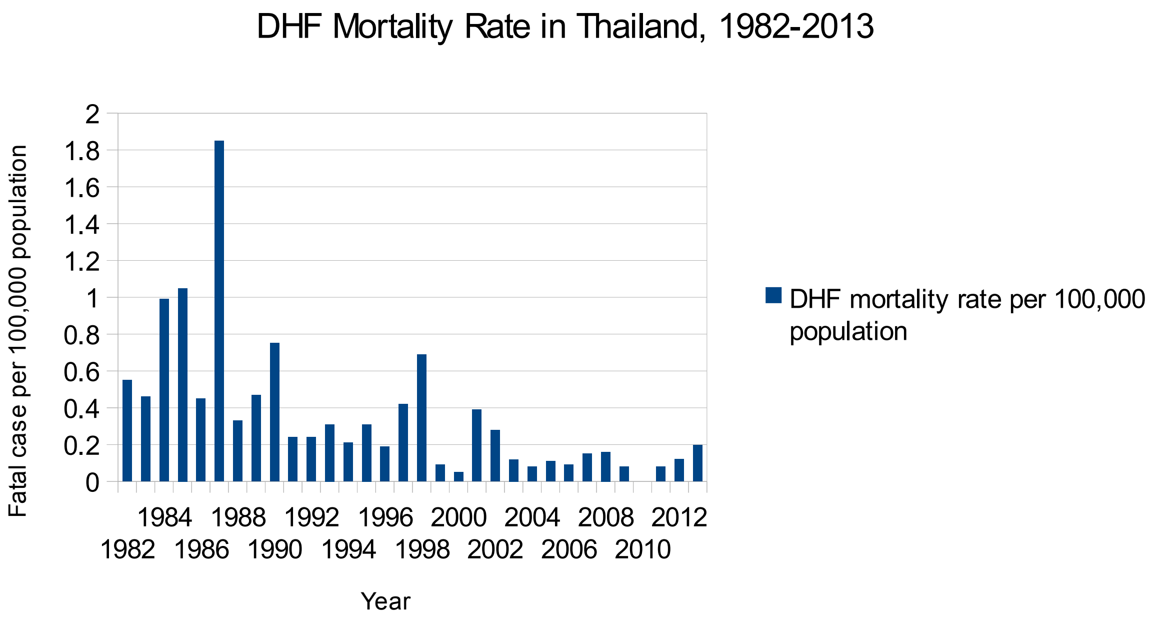

Figure 9: DHF Mortality Rate in Thailand, 1982-2013. Data obtained from the Thailand Health Profile 2008-2010 and Thai National News Bureau.

Dengue morbidity distribution in Thailand

Figure 10 presents the standardised morbidity ratios for dengue, defined as observed cases divided by expected cases - the expected cases based on the population*dengue ratio for all of Thailand. The provinces with the highest dengue incidence rates were Krabi, Rayong, Ratchaburi, Prachin Buri Provinces. The Krabi Province is situated in the Southern Region and all the other three in the Central region. The most affected areas by dengue incidence were, therefore, the Central, and the South Regions, and the southern part of the North Region.

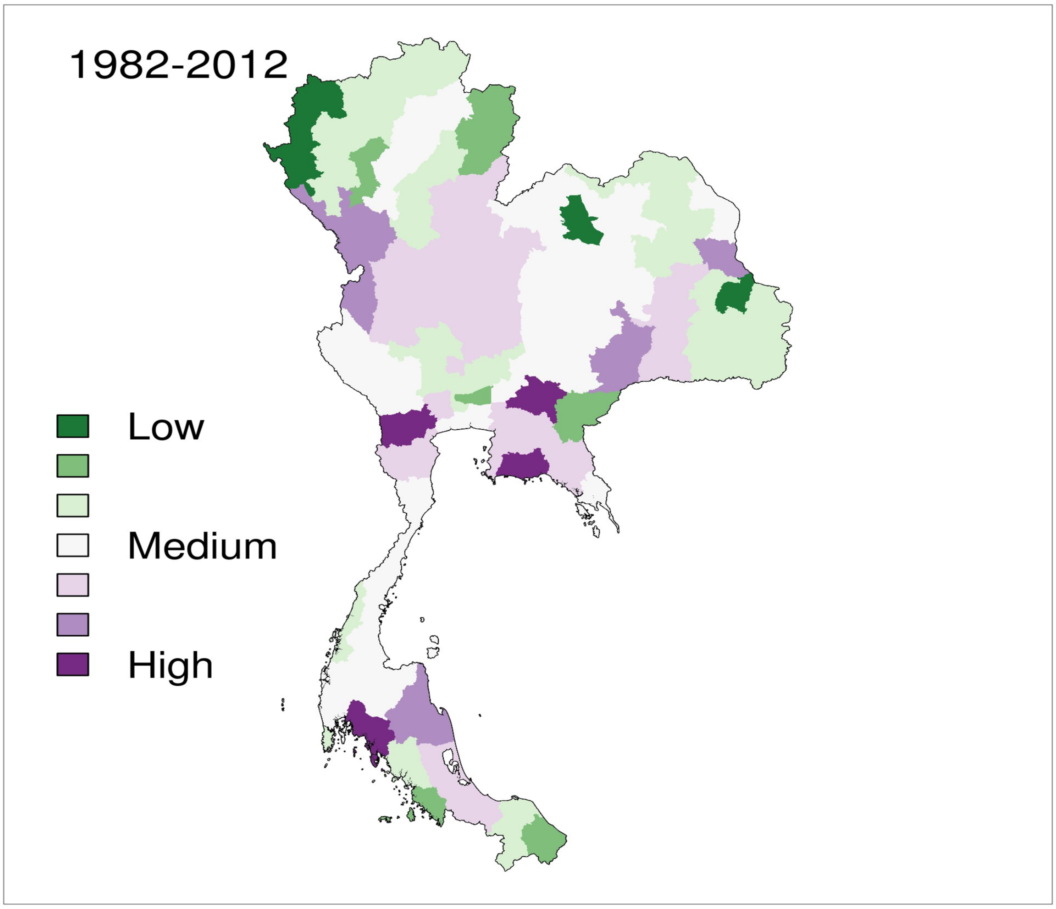

*Figure 10: Standardised morbidity ratios for dengue (i.e. observed cases divided by expected cases - the expected cases based on the population*dengue ratio for all of Thailand), by provinces, from 1982 to 2012. Source: Rachel Lowe, IC3.*

4.2 Demography

4.2.1 Age trends in dengue incidence

Dengue fever and more severe dengue diseases have been traditionally considered a childhood disease as the scientific research and the incidence data evaluation tended to point to the lower age groups as the groups statistically most exposed to the symptomatic and severe outcomes of the viral infection. In 2002 the World Health Organization published a fact sheet describing dengue haemorrhagic disease as almost exclusively (>95%) affecting children younger than 15 years old

(WHO 2002). However, over the last few years, a significant shift in the age trend has been observed in Thailand (Chareonsook et al. 1999; Cummings et al. 2009; Kongsomboon et al. 2004; Wichmann et al. 2004; Nagao and Koelle, 2008).

As compared to the traditional association of the highest rates of substantial morbidity and mortality to the children less than 15, nowadays studies provide evidence of a shift towards older age groups, particularly when it comes to the dengue haemorrhagic fever. Studies conducted in Bangkok gathered data revealing a progressive shift of the median age for the individuals most exposed to the dengue haemorrhagic fever from 3.8 years in the 1960s to 5.6 years in the 1970s and to 7.4 years in the 1980s (Wichmann et al. 2004). Other literature provides data for 2004, when the mean age of the dengue haemorrhagic fever was 17 years (Nagao and Koelle, 2008). Summing up the record for the last decades, the mean age for dengue haemorrhagic fever incidence increased from 1960 to 2004 ~4.5 fold and from 1980, as the objective period for the present study, to 2004, ~2.3 fold. Concerning the mean age for the dengue disease incidence as a whole, in 2004 there was published a study based on the outbreak in Chonburi, Thailand, in 2001, which outcomes defined the 10 years as the dengue disease median age (Wichmann et al. 2004). A paper from 1999 provide evidence for the shift in the age of highest incidence to the age group 5±9 years old (Chareonsook et al. 1999).

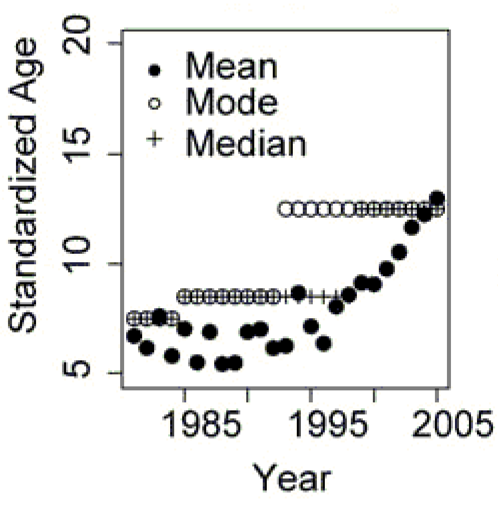

Figure 11: Mean, median, and modal age of age-standardized dengue incidence data in Thailand 1981–2005. Source: (Cummings et al. 2009)

A more recent study presented a radical change it the risk-factor age trends (Cummings et al. 2009). The researchers measured mean, mode and median age of standardized age-specific dengue disease incidence as reported to the national surveillance system each year during the period 1980-2005. The outcomes of the study have demonstrated significant changes in the age trends (See: Figure 11).

A sharp increase in the average age group most exposed to dengue has been observed. The estimations achieved with all three statistical figures for the beginnings of the 1980s would point to the 5-8 years age-group as most affected. Since this point, the rates of the mode, and median standardized age started progressively increasing. The increasing tendency would apply to the mean age only after the 1990, a slight decrease preceding the rise. A decisive change in the tendency is observed in the chart with the shoot-up of the results for the mode age in approximately 1993, determining the ±13 years age group as the most hazard-exposed.

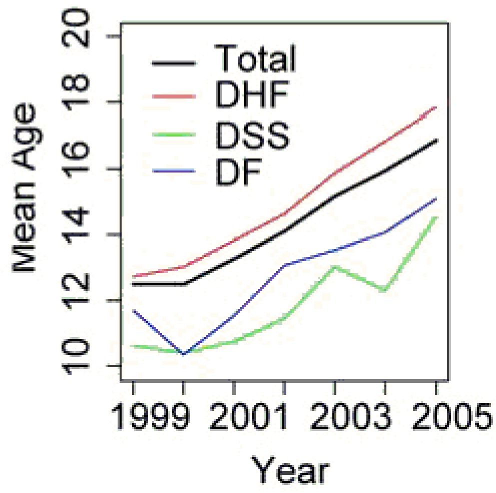

Figure 12: Mean age of DHF (red), DSS (green), DF cases (blue), and total (black) cases reported to the national surveillance system 1999–2005. Source: (Cummings et al. 2009)

Studies measuring the mean age trends for the incidence of dengue fever, dengue shock syndrome, and dengue haemorrhagic fever, were conducted separately for the period 1999-2005 (Cummings et al. 2009) (See: Figure 12). The trends present a clear increase of the mean age in all of the course-types of the disease. Meanwhile the rates of dengue fever and dengue shock syndrome increased from ±11 years mean age to 14-15 years, the trends for dengue shock syndrome being slightly lower than those of the non-severe dengue, the trends for the mean age of the dengue haemorrhagic fever rose from 12-13 years to 17-18 years mean age. The total mean age trend for both non-severe and severe symptomatic dengue cases increased from 12-13 years to 16-17 years age.

Several studies of great significance to the epidemiology research were conducted in order to measure and understand the observed global shift in the age distribution of dengue cases towards older age groups. In Southeast Asia the shift in the trend has been detected for several years until now by passive surveillance and it has been as well the subject of a few researches and papers.

A new trend in Singapore has been identified, which might serve to anticipate the emergence of the same patterns in Thailand (Low and Ooi, 2013). Researchers observe that throughout the recent years there has been a simultaneous tendency of a decreasing proportion of the cases below 15 years of age and an increasing proportion of the dengue incidence among the age group ≥55 years (See: Figure 13). According to the authors' estimations, from 1977 to 2011 the dengue incidence proportion among the age group below 15 years in Singapore decreased from 30% to just 11% meanwhile the proportion of the incidence among 55 or older age group emerged from 0 to constitute 19% of the cases.

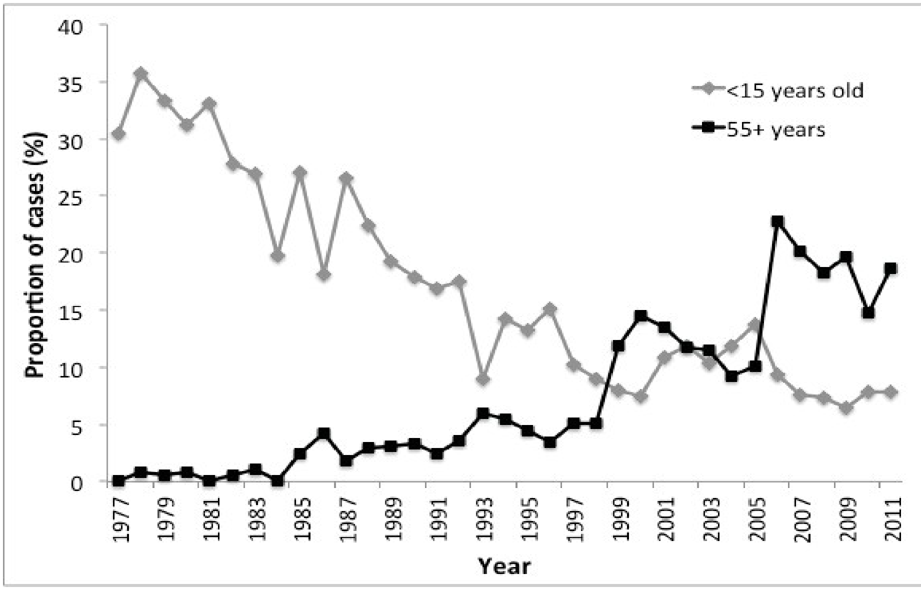

Figure 13: Proportion of dengue cases in Singapore who are either less than 15 years old or 55 years old and above, from 1977to 2011. Source: (Low and Ooi 2013)

Hypothetical reasons for the shift in the age distribution of dengue cases

The reasons for the shift in the age distribution of dengue cases in Thailand are not confirmed. However, several hypothesis have been proposed. Some investigators argue that the steady decline in transmission rates, probably due to an effective vector-control measures applied by the public health structures and to the economic development, influence and reduce the force of infection, described as the per capita rate at which susceptible individuals become infected (Cummings et al. 2009; Nagao and Koelle 2008). The outcome of this relation would imply an increase of the average age of infection as a result of the reduced force of infection. Researchers point to other studies which observe the same pattern in the evolution of other diseases (Cummings et al. 2009).

Yet other examples of hypothetical reasons of the age-distribution pattern can be found in the literature (Cummings et al. 2009). Attention should be drawn to the explanation raised by some researchers consisting in the interpretation of the phenomenon as a falsely considered shift in the age distribution of dengue cases, the statistical outcomes resulting rather from a change in the Thai national reporting system in the 1990s. The surveillance system was modified to report larger numbers of dengue fever cases and the apparent shift of the age distribution could be a consequence of the increase in the dengue fever case rates.

The hypothesis is based on the reasoning relating the shift in the average age with the evolution undergoing in the structure of the population and its implications on the force of the infection (Cummings et al. 2009). It is argued that as the birth rates decline, the proportion of the immune population increases therefore the force of the infection is reduced. This explanatory proposal will be further discussed in this paper and on the basis of this hypothesis further research will be made focusing on the demographic transition undergone in Thailand in 1982-2012 and its implications for the dengue epidemiology in the country and in its regions.

4.2.2 Demographic transition in Thailand in 1982-2012

Throughout the recent decades Thailand´s population has undergone several important changes in demographic terms. The changes in the population composition, vital statistics, age structure, urbanisation and migration indices seem to have exercised influence on the dengue epidemiology trends in the country.

Population growth in Thailand

There has been a radical increase in the Thai population from 1950-present (See: Figure 14). The figure displays a radical increase in the Thai population visible in the period covered, from 1950 to 2050, the predictions being based on the UNESCAP estimations. A more extended time frame of the demographic evolution was included here to provide the context for the trend characterising the objective period. The red area corresponds to the target period for the present study, from 1982 to 2012. According to the UNESCAP estimations, the Thailand´s population size grew during this period from approx. 49 247 000 people in 1982 to approx. 66 785 000 people in 2012, which gives an outcome of the 1.35-fold increase, with the Thai population´s size growth of approximate 17 538 000 people.

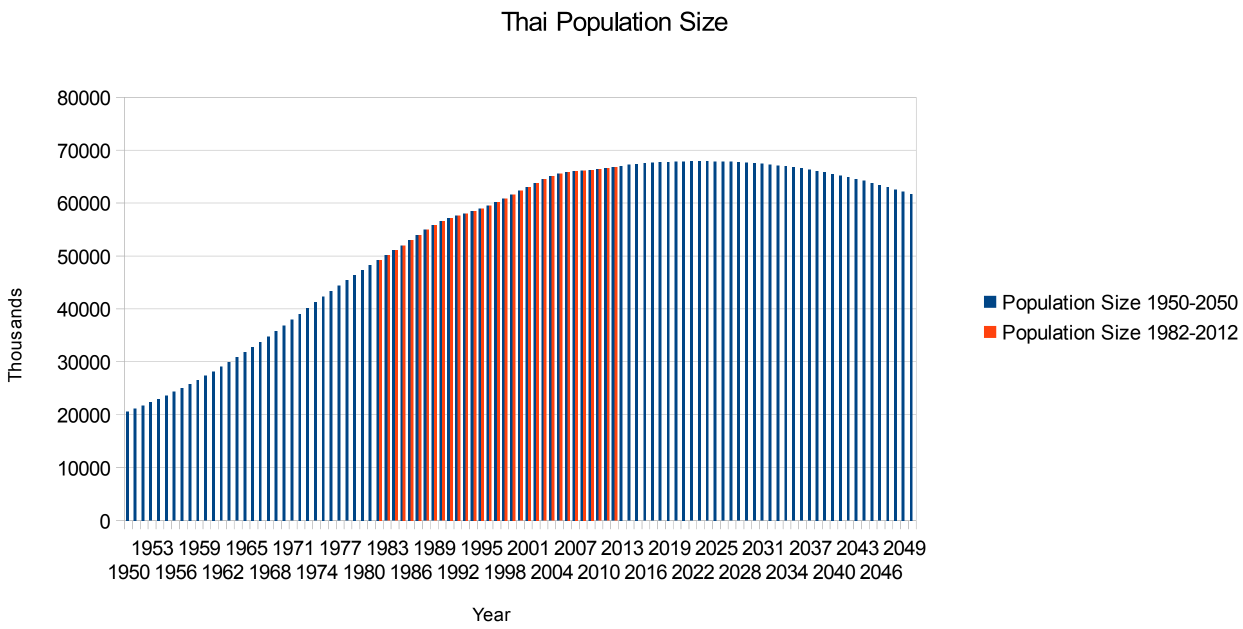

Figure 14: Thai Population Size from 1950 to 2050. The data and the predicted data were obtained from the UNESCAP online database.

The Demographic Transition Model

The period covered by the present study presents features characteristic to the stages 3 and 4 from the Demographic Transition Model as proposed by Warren Thompson in 1929. In order to obtain a proper visual image of the model, the process should be discussed as a result of contrasting the population growth to the birth and the death rate, and the natural increase rate, achieved as combining both latter indices. The exercise was undertaken to visualize the change in the trends behaviour, contrast them and consequently identify the Demographic Transition stage or stages that Thailand had passed through during the period of thirty years studied in the thesis. The first stage of the demographic transition is characterized by high levels of both birth and death rate (Lee, Mason, and Miller 1997). Subsequently, due to hygiene, health, and socio-economic development, the mortality rate begins to decrease which has an impact on a steady population growth. The rise in the population size accelerates and eventually turns into a phenomenon known as a 'population explosion' (Montgomery, 2013).

The third stage of the demographic transition is related to the decrease in the birth rate, which slowly moves the tendencies towards a balance lost in the Stage 2, as a consequence of the population explosion due to the death rate decrease. The drop in the birth rate tends to be attributed

to socio-economic changes, such as the improvement of the life quality and decreasing need for children as a workforce, the family planning, an improvement of the woman's status, an increasing tendency to later marriages.
The fourth stage of the demographic transition takes place when both the birth and the death rate are low, the population size remains high and stable. As the birth rate decreases, the natural increases does so as well and eventually approaches 0 rate, which leads to no population growth.
The keep-declining birth rate may lead to the natural decrease which makes the country's population size shrink. This stage in the actualized Demographic Transition Model is being referred to as the stage 5.
After the analysis of the Thailand's demographic variables for the period from 1982 to 2012 and contrasting them with the characteristics of the stages proposed in the Model, the assumption arises that Thai population passed through the stages 3 and 4 during the period 31 years studied. Figure 15 compares three clue for the demographic transition trends, in other words, the evolution of the birth and the death rate and the natural increase rate, obtained as an outcome of subtraction of the death rate value from the birth rate value.
When it comes to the death rate value, it kept stable throughout the whole period. Surprisingly, it even slightly rose, which might be attributed to the shift towards greater burden of the chronic diseases characteristic for the developing and developed countries. The leading causes of death in Thailand are stroke, (10.7%), followed by ischemic heart disease (7.8%) and HIV/AIDS (7.4%). Other leading causes are road traffic accidents (males) and diabetes mellitus (females) (Porapakkham et al. 2010). The rise in the death rate might be as well related to, among others, socio-economical changes, a transition towards more sedentary life style, change in the diet related to the process of globalization, and environmental changes.
As far as the birth rate is concerned, a dramatical change can be observed in the chart. In 1982 the Thai demographic transition must have already been during the Stage 3 of the Model as it is characterized by a sharp fall in the birth rate. From 1982 to 2012 the crude birth rate in Thailand decreased from 24.7 to 10.4 births per 1,000 people. The outcome of the calculations shows that the rate fell ~58% from its value in 1982 to 2012, proving that the Thai population entered meanwhile the 4^{th} stage of the Demographic Transition Model, characterised by a low birth rate.
The subtraction of the death rate from the birth rate gives the value of the natural increase which may be converted to a percentage value if divided by 10. As applied to the Thai demography in the target period, the natural increase rate dropped from ~1,78% to ~0,29% and continues falling which means that in few years it may be negative, according to the UNESCAP data based on its

predictions, the estimations could be elaborated, a rough analysis for this paper leading to the conclusion that the natural increase would definitely evolve into a natural decrease in 2022.

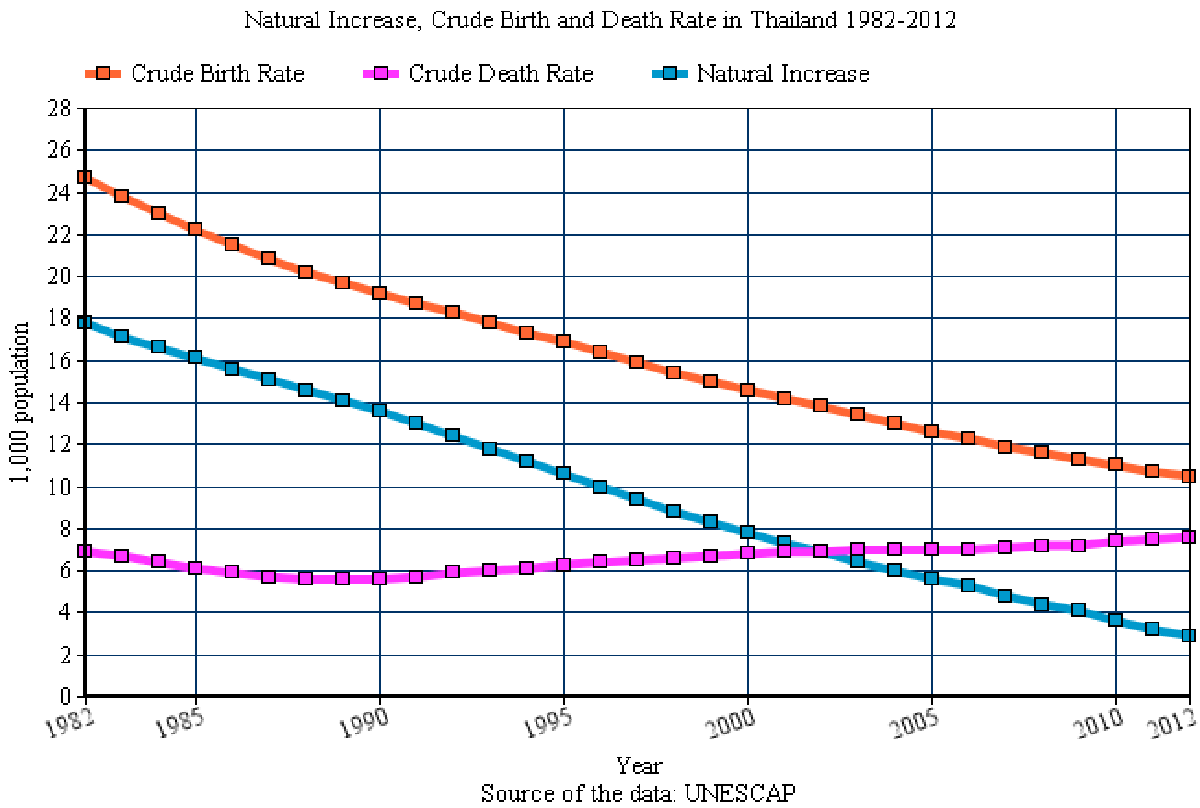

Figure 15: Crude Birth and Death Rate versus Natural Increase in Thailand 1982 - 2012. Source of data: the UNESCAP online database.

Based on the Demographic Transition Model analysis applied to the Thailand in 1982-2012, several important conclusions can be withdrawn which might have a considerable impact on the dengue epidemiology evolution in the recent decades. First, the country's population passed through the stages 3 and 4 as proposed by the Model. Second, four important trends have been observed. The so-far increasing at a fast pace size of the Thai population has recently slowed down and nearly stabilized. The death rate maintained approximately the same level throughout the 30 years and even rose slightly. The birth rate decreased dramatically and in 2012 as well as for few previous years remained considerably slow. The natural increase trend experienced as well a dramatic, more than 6-fold fall during the period from1982 to 2012. Obviously, the demographic transition had an important impact and was accompanied by other other extremely relevant demographic trends such as the evolution in the age structure of the Thai population, the process of urbanization, the internal and external migrations which will be analysed in the following sub-sections.

The evolution of the age structure of the population in Thailand 1982-2012

Closely related to the birth and death rates, the age structure of the Thai population has undergone dramatic changes throughout the period 1982-2012. These changes have exercised an important impact on the society therefore have to be taken into account while analysing the changing dengue epidemiology in Thailand. The lowering birth rate and a stable death rate have contributed to the ageing of the Thai population.

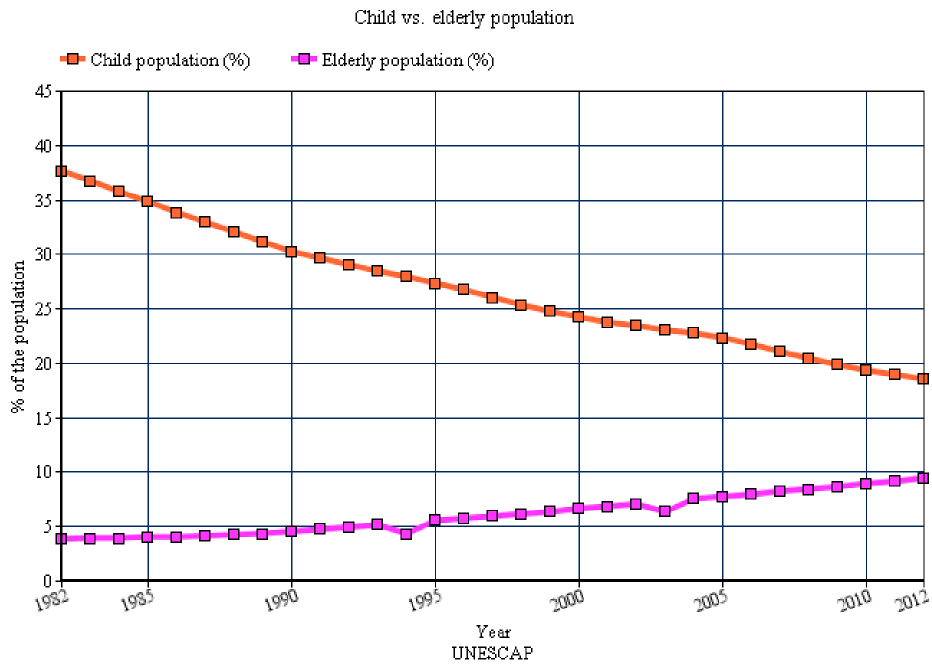

Figure 16: Child versus elderly population in Thailand 1982 – 2012. Source of data: the UNESCAP online database.

Figure 16 presents changing trends in the age distribution for the population of Thailand. The chart covers the study´s target period, from 1982 to 2012 and reflects the changing proportion of child and elderly population as contrasted with the total country´s population. The elderly population is defined here as people aged 65 or more and the child population corresponds to the less than 15 years aged-group. As far as the proportion of the aged-people as contrasted with the total population is concerned, the trend experienced a steady growth from 1982 to 2012. The proportion increased from 3.8% to 9.4%, so nearly tripled. When it comes to the proportion of the child population, its share decreased dramatically from 37.6% in 1982 to 18.5% in 2012. It means that this age-specific fraction of the Thai population more than halved throughout the studied period.

Figure 17 visualizes the changing age-structure of the Thai population. The age pyramids show the age distribution for the country's population in 1980, 1990, 2000, 2010. The charts display the evolution of the age structure as undergoing dramatic changes in its structure and steadily heading towards older models.

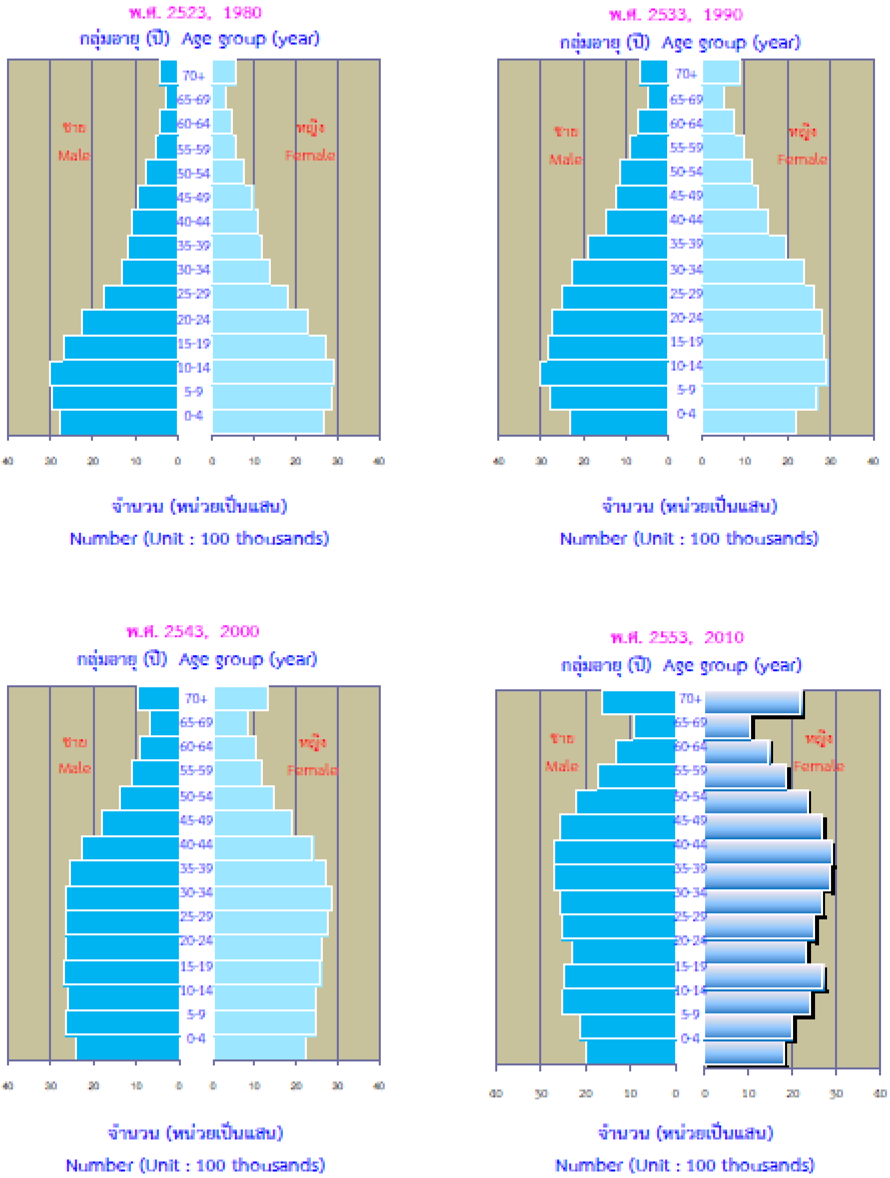

Figure 17: Thai Population Pyramids for 1980, 1990, 2000, and 2010. Source: Thai Census

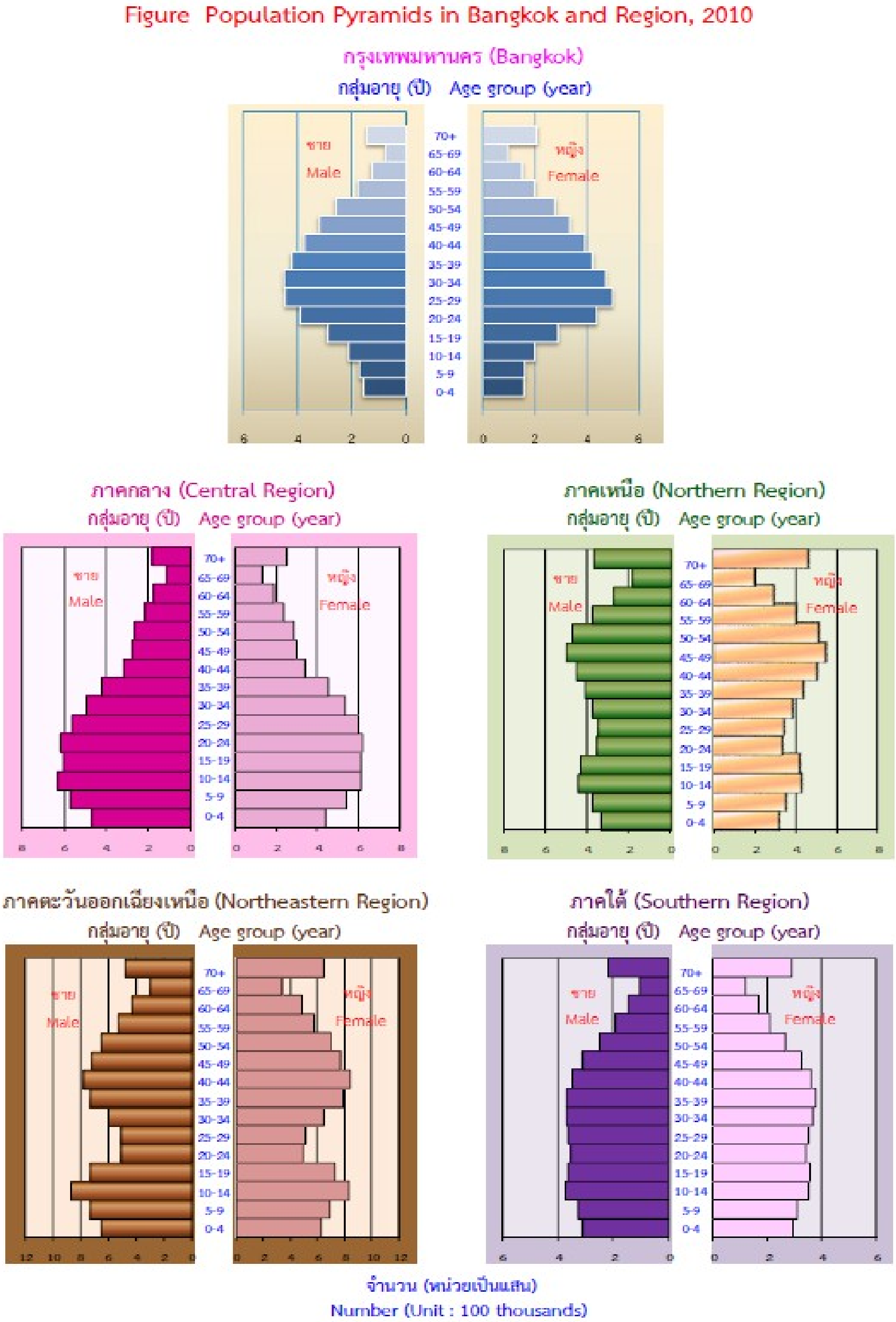

Figure 18: Population Pyramids for Bangkok, Central, North, Northeast and South Regions in Thailand, 2010. Source: Thai Census.

Thai population structure presents interesting differences depending on the region. Figure 18 provides a visual comparison of the age structure of the population in five Thai regions: Bangkok, Central, Northern, North-eastern and Southern Regions for 2010. The Bangkok Region pyramids strongly attracts attention as it presents most advanced population-ageing characteristics and differentiates in the structure from other regions. The difference in the region's pyramid might be motivated by several factors, among them, by such as the labour-immigration tendency, less traditional patterns related to the family planning, recent urban-rural back-migration tendencies, which might explain lower rates of the young population.

4.2.3 Urbanisation process

Traditionally considered as mostly present in urban and peri-urban settings, dengue incidence has been observed to increasingly spread to rural areas. The former assumption that dengue was predominantly an urban and peri-urban disease was based on the role of the population density as a factor contributing to the greater impact of dengue. However, the recently published studies suggest that although the urban centres do contribute to the spread of dengue as they display high absolute numbers of the incidence, the low-to-moderate population density areas are best-suitable for an intense virus transmission, especially if combined with the absence of the tap water supply (Schmidt et al. 2011). In fact, the steady increase in the rural cases might be related to the lack of control and reporting of dengue in the rural areas in the past, the steady rise in the incidence evidence would be therefore the outcome of the improvements in the reporting systems rather than of an actual shift from the urban to rural settings.

According to some recent studies undertaken for dengue outbreaks in Vietnam, the highest risk of incidence was typically related to the settings of villages and some peri-urban areas, the mean population density being of around 3,550 people/km^2 and 61% of cases accounting for population densities below 6,360 people/km^2 (Schmidt et al. 2011). The pattern was associated and contrasted with factors such as water supply, wealth, education, distance to hospital, house composition, and presence of animals, which differentiate rural and urban settings.

Urbanisation process in Thailand

Although Thailand has undergone a process of urbanisation throughout last decades due to the industrialisation (Krainara 2012), the country's characteristics in terms of the population and geography remain mainly rural. Figure 19 presents the evolution of the rural-urban population proportions from 1982 to 2012. In 1982, the urban population constituted 27% of the total Thai population ad its share grew gradually, in 2012, its value corresponding to 36% of the total population.

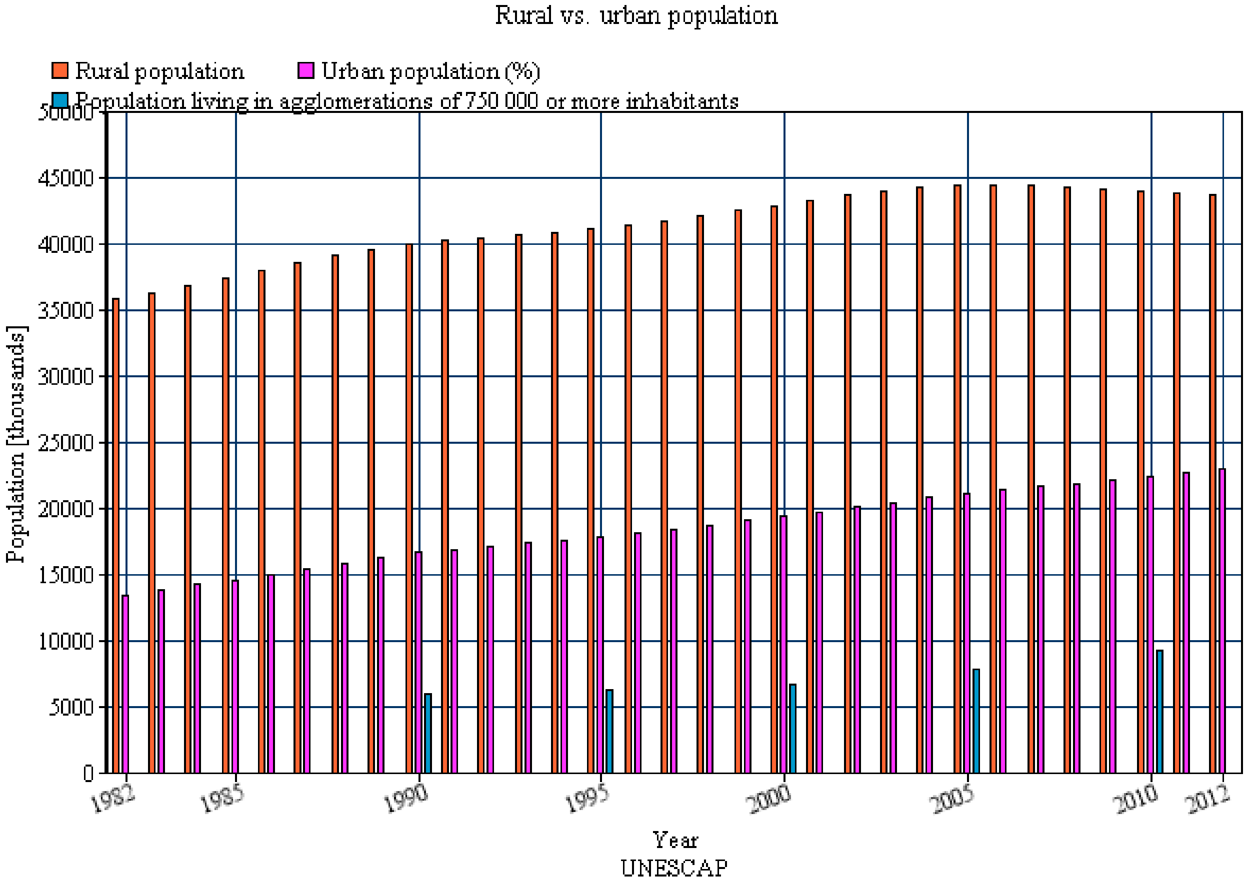

Figure 19: Rural versus Urban Population in Thailand 1982-2012. Source of data: the UNESCAP online database.

4.2.4 Summary

In dengue epidemiology, an important shift in the incidence modal age has been observed. The shift in the age distribution of dengue cases was produced towards older age-groups. Furthermore, a continually increasing number of dengue haemorrhagic fever cases among the fraction of population older than 65 years old has been noticed. It is a very importing fact, considering that all the prevention and treatment treatment guidelines are elaborated for younger age-groups, as until now dengue was considered almost exclusively a childhood disease.

Age trends in Thailand have been studied. Important changes in Thailand's demography have been produced as Thailand had been undergoing a demographic transition from 1982 to 2012. After a demographic explosion, the natural increase lowered significantly, the age structure evolved towards the ageing-society model, the proportion of children to elderly having changed significantly. In 1982 the proportion of the population aged over 65 to the population less than 15 was 1:10, in 2012 this proportion equalled 1:2.

In dengue epidemiology a spread towards rural areas was observed. However, the previous tendency to consider dengue an urban-and peri-urban disease could be as well explained by dengue under-reporting in rural settings. In Thailand, from 1982-2012, a gradual and slow urbanization process took place. Nevertheless, the Thai population in 2012 was still 66% rural, as compared to constituting 73% of population in 1982. Some conclusions could be drawn on the need for further rural distribution of health service, reporting, prevention and control programmes.

4.3 Migration and International Trade

4.3.1 Introduction

Migration and international trade flows are claimed to be one of the most important factors at the origin of the global dengue spread and the evolution of the dengue epidemiology into one of the most important public threats (Gubler 2002; Hales et al. 2002).

International travel

The international movement of human cases, vectors transmitting infections and contaminated goods, has resulted and is still resulting in international disease diffusion (WHO 2009). Dengue expanded from Africa into Asia and Americas, and recently, into the Middle East, the US states of Texas and Hawaii (Wichmann et al. 2007), and some areas of the Mediterranean coasts (Randolph and Rogers 2010), where the climate changes made possible the mosquito's *Aedes albopictus* adaptation. The dissemination of dengue and/or the vector has effectively taken place through three modes of transportation, namely, water, land and air (Kuno 1995). As it was previously mentioned (See: 2.2.4 Geographical spread and distribution of dengue), it was the shipping industry that initiated the global spread of dengue, infesting the towns along the coasts and rivers with the *Aedes aegypti* mosquito. Another factor contributing to the spread of dengue was the development of the railways and highways. Some scientific investigations were conducted, proving the importance of the land transport's role in the dengue infestation, such as the research and analysis showing the spread of dengue haemorrhagic fever along the railways and roads in Thailand (Wellmer 1983). Finally, the increased air travel provided a perfect mechanism for the *Aedes* mosquito transport, provoking the exchange of the virus among endemic countries, introducing the vector at a large scale to the places which were previously vector-free and to receptive areas (Wellmer 1983). Air travel being one of most important way of the vector diffusion, the WHO introduced air-craft regulation aiming at the prevention of the *Aedes* mosquito spread. However, in opinion of some researchers, the measures might appear ineffective since other important mechanisms of vector spread at both internal and international scale, such as the land and water transport, seem lacking an adequate regulation (Kuno 1995).

International trade

International trade is one of the most important, and, actually, was the first reason for dengue diffusion (Gubler 2002; Kuno 1995; Randolph and Rogers 2010). Dengue became distributed worldwide in the tropics due to the developing shipping industry and commerce in the 18th and 19th centuries (Gubler 2002). In recent decades, the movement of man-made containers and, particularly, the international trade in used tyres in which mosquito eggs are deposited when they contain rainwater, contributed to the *Aedes albopictus* mosquito spread from Asia to Africa, the Americas and Europe (WHO 2009).

4.3.2 Internal and International Migration in Thailand

Internal migration

Due to the process of industrialisation, the rates of internal migration in Thailand grew significantly in the mid of the 20th century, attracting the attention of investigators (Chamratrithirong 2007). However, since the 1960s, the internal migration rates steadily descended and the tendency continued throughout the first decade of the 21st century (See: Figure 20). Most of the internal migration tendency was of return kind, the migration flow from urban to rural areas maintaining high rate values (Punpuing and Richter 2011). In spite of the decreasing migration tendency, it is important to draw attention to a significant for dengue epidemiology rate of short-term and seasonal moves. Temporary moves, which include both seasonal movement and other forms of short-term moves, have been estimated to represent one-third part of all migration with durations of one month or more (Deshingkar and Grimm 2004).

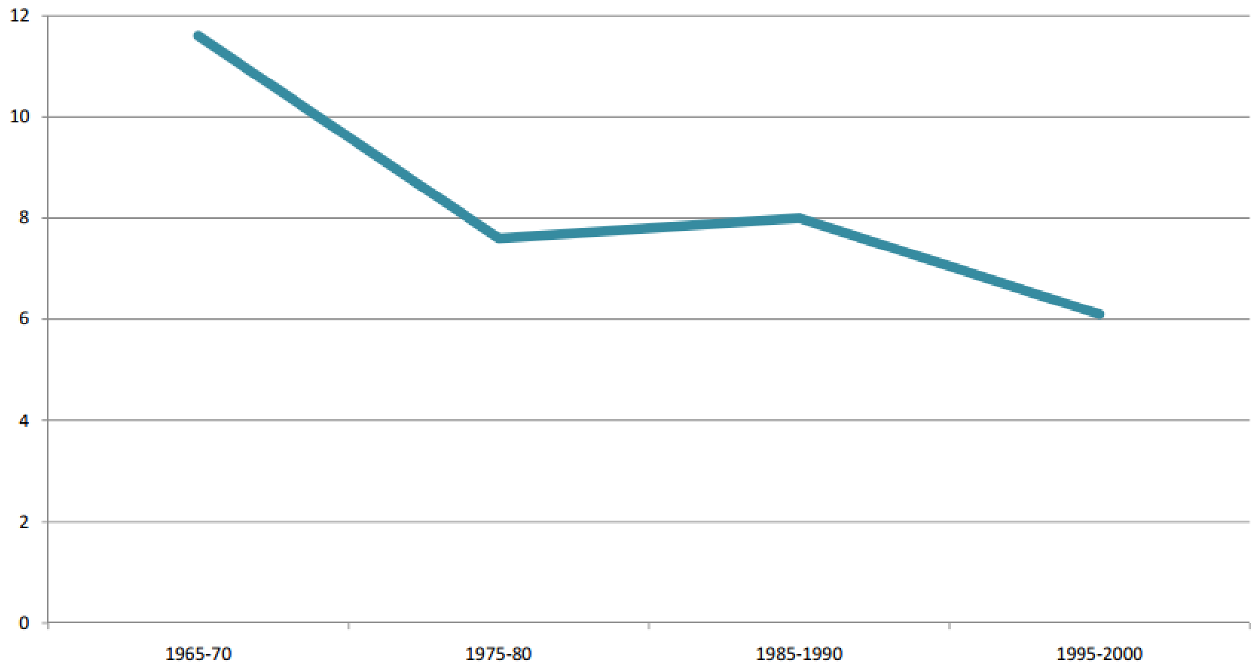

Figure 20: Percentage of the Thai Population who moved in last 5 years. Source: Thai Census in (Punpuing and Richter 2011)

Railway travel and transport of goods in Thailand

Provided that investigators consider land transport an important factor of the mosquito-vector spread, it is important to observe a changing pattern in the railway passengers and freight flow in Thailand throughout the 30 years covered by the study. Figure 21 shows the evolution of the passengers and freight volumes in Thailand from 1982 to 2011.

According to the data available at the UNESCAP Online Statistical Database, in 1982 there have been 9 231 million passengers per kilometre of railway. The tendency rose throughout the 1980' and achieved its peak in 1993, with the record of 14 718 million passengers. Since then, the rates have been continually decreasing, and in 2011 equalled 7 504 million passengers per kilometre.

Although the railway passengers ratios decreased, the increase in seasonal and short-term internal migration could be explained by the increase of road density, which was 2.5 bigger in 2006 than in 1990, and increased ratio of passenger cars to 1000 population, which from 2003 to 2010 increased from 54 to 67 (See the database in the Appendix B).

The railway freight volumes' evolution presents different trends. The transport of goods by railway had been gradually increasing from 1982 until achieving the peak of goods transported in 2004, with the value of 4085 million tons of goods per one kilometre. Since then, the volume of good transported experienced an important decrease, with the value of 2455 million tons per km in 2011.

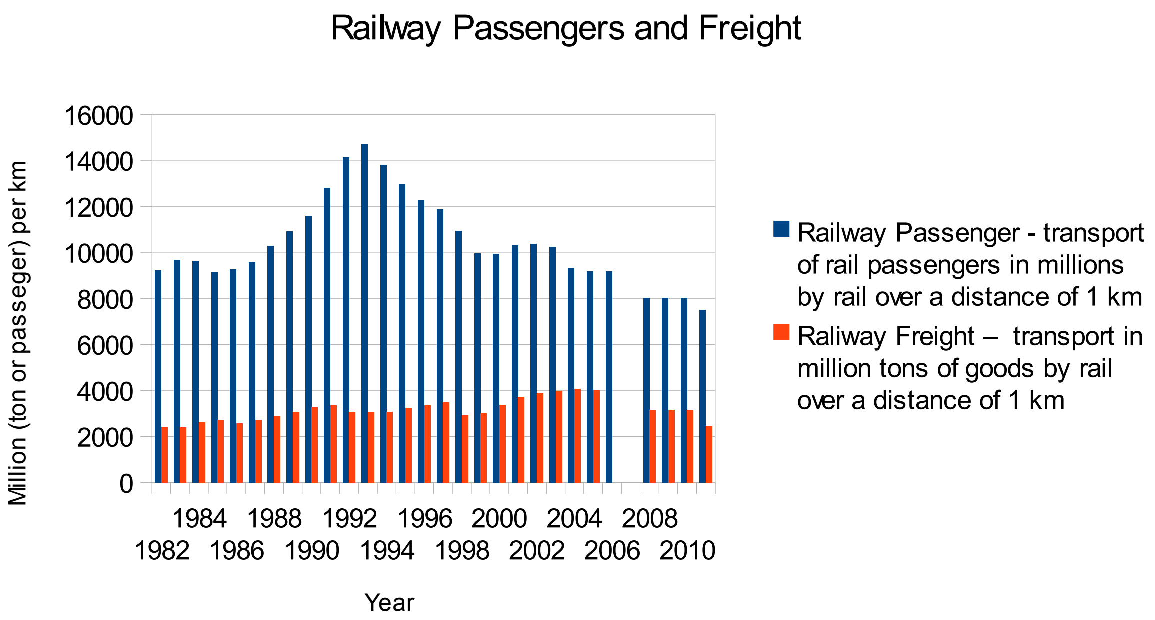

Figure 21: Railway Passengers and Freight in Thailand, 1982-2011. Data obtained from the UNESCAP database.

International migration

Due to globalization, and the development and industrialisation process undergone in Thailand, transborder migration has increased significantly throughout the past 30 years. The international migration in Thailand has manifested through three trends (Chalamwong in: Sciortino and Punpuing 2009).

The first trend refers to the outward migration from disadvantaged Thailand regions to higher income countries. Since the late 1970s an important tendency for abroad migration in search for a work as contract or independent labour has been initiated. The tendency concerned mostly low-skilled rural residents. From the late 70s until the mid of 80s the top destination of labour migrants from Thailand were the Arab states of the Gulf due to the rise in the oil revenues. With the oil market crisis and the governmental relationship deterioration, in the mid of the 1980s, Thai workers abandoned almost totally all the Middle East, apart from Israel, and migrated to newly industrialised East and South-East Asian countries, and, in parallel, to Europe, Australia, and other Western countries.

The second trend, initiated as well in the late 1970s, consisted in the immigration of mainly high-skilled workers from countries with high investments in Thailand, such as Japan, the European Union countries, the USA, China. This phenomenon was motivated by the fast industrialisation of Thailand and lack of the expertise capacity among the national workforce.

In the 1990s Thailand has eventually converted from a labour-exporting into a labour-importing country. This third trend was motivated by a faster development and industrialisation in Thailand, as compared to its neighbour countries, which has attracted low-skilled workers to find job and settle in Thailand. Those workers joined the high-skilled workers arrived in the late 70s and the migrants from coutries such as China, Viet Nam, the Lao People's Democratic Republic, Cambodia, and, especially, Myanmar, who would abandon their countries and seek refuge in Thailand because of war, internal conflict, or national instability. The refugees settled mainly along the borders (Sciortino and Punpuing 2009). Figure 22 presents the evolution of net international migration rates in Thailand from 1980 to 2010.

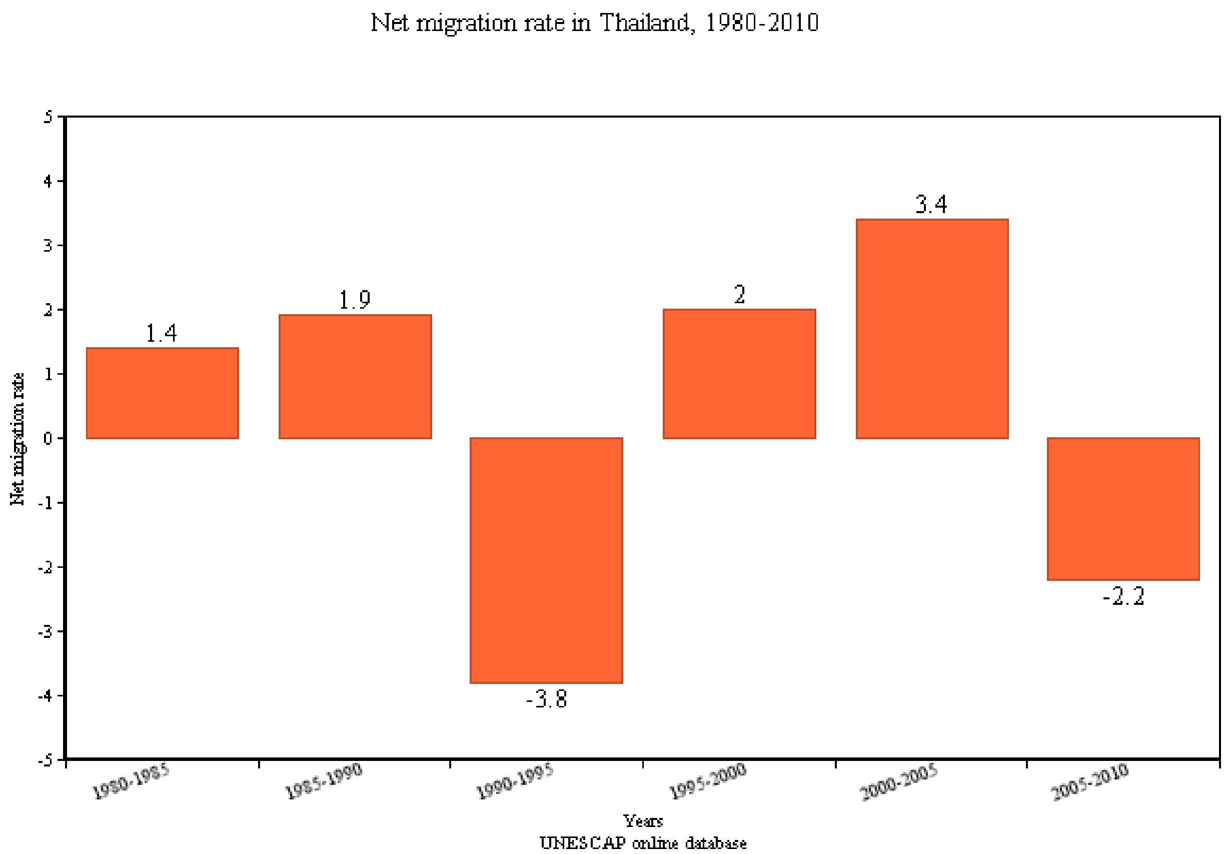

Figure 22: Net International Migration in Thailand 1980-2010. Source of data: the UNESCAP online database.

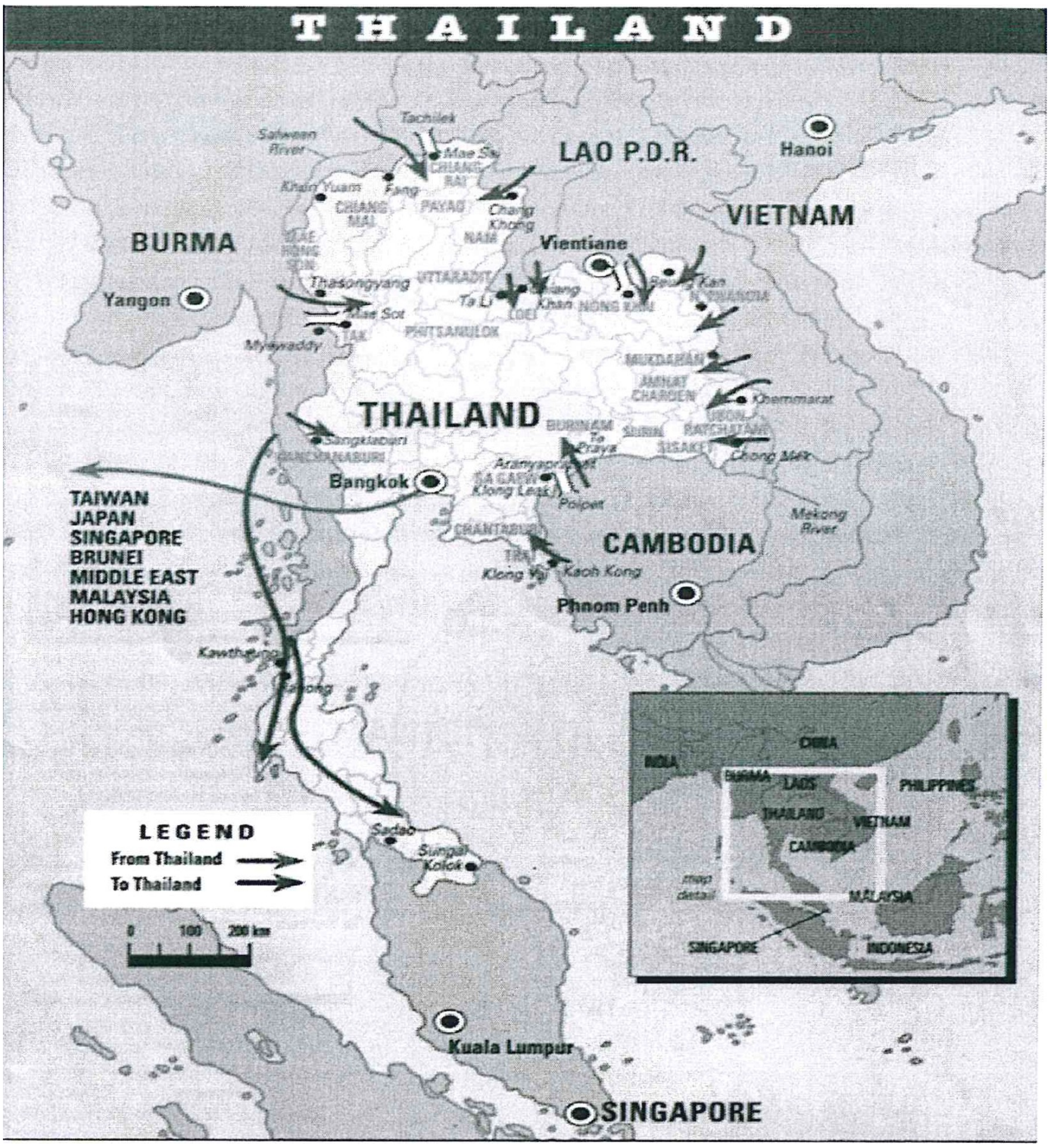

Figure 23: Inflow and Outflow Migration to/from Thailand. Source: Asian Migrant Center, 2005, in: (Krainara 2012)

Figure 23 shows the inflow and outflow migration destinations. Thailand hosts 1,5-2 million immigrants from Greater Mekong Sub-region. On the other hand, it is estimated that about 200,000 Thai workers emigrated to Malaysia, mostly employed by Tom Yum Kung restaurants (Krainara 2012).

Immigrants to Thailand

In view of large international migration flows from and to Thailand, it is important to discuss the role of the international migrants to Thailand on the dengue epidemiology.

The Kingdom of Thailand is signatory to most major international treaties, including treaties on human rights, rights of migrants and their right to be provided basic services. Unfortunately, reports on Thailand's performance in these matters are alarming considering the situation of low-skilled workers and illegal migrants to Thailand (Huguet and Chamratrithirong 2011). The situation of the international migrants affects both the migrants as well as nationals in terms of the risk of dengue transmission and introduction.

A vast group of unregistered illegal migrants are settled in Thailand. Those migrants are denied access to health care, sanitary housing and social security. What is more, as well legal or regularized low-skilled workers tend to be denied an effective access to such schemes as the migrant employers are not likely to pay into the system (Huguet and Chamratrithirong 2011). In absence of clear governmental policy aiming at ensuring sanitary housing and living conditions, the migrants tend to live without access to clean water, ventilation, waste disposals systems and adequate toilet facilities, in temporary shelters and housing in high concentrations in small areas. Such conditions increase much the hazard of the transmission or introduction of dengue as well as other serious diseases (WHO 2009).

4.3.3 Air travel

In Thailand there are 34 airports managed by two companies, the Department of Civil Aviation of Kingdom of Thailand, operating Suvarnabhumi Airport, Phuket Airport, Chiang Mai Airport, Don Mueang Airport, Hat Yai Airport and Chiang Rai Airport, and the Airports of Thailand Public Company Limited (AOT), which operates the rest of the Thai airports. The Suvarnabhumi Airport, Don Mueang Airport, (both serving the city of Bangkok), Phuket Airport in Phuket (Southern Region), Chiang Mai Airport (Northern Region), Hat Yai (Southern Region, near the Malaysian boarder) are five Thai regions with the highest records of air traffic, listed here starting from the airport with the highest record.

International commercial air travel

The Suvarnabhumi Airport is currently the most important international airport in Thailand. Opened in 2006, it was designed to replace the Don Mueang Airport in its function of serving the city of Bangkok's international commercial flights. The Suvarnabhumi Airport has operational capacity of handling 76 flight operations per hour. It was designed to manage 45 million passengers per year. However, its capacity has turned out to be bigger. With the raising number of air movements and passengers, the Don Mueang Airport was re-opened for the international movements services as for to support the Suvarhabhumi Airport's capacity. The Don Mueang Airport is one of the world's oldest international airports, with its opening for the Royal Thai Air force use in 1914, and for the commercial use, in 1924. Prior to its closure in 2006, it was one of the most important airports in the whole continent, serving most of the Asian air traffic. After its closure in 2006, it was first abandoned, but then re-opened for domestic flights in 2007. In 2012, due to the congestion of the Suvarnabhumi Airport and its high prices, the public authorities pressured by airline companies, and the low-cost ones in particular, ordered the re-opening of the Don Mueang Airport for the international movements.

Figure 24 provides the statistics for the international commercial air traffic in Bangkok from 1996 to 2012. Till 2006 all the international commercial air traffic serving the city of Bangkok was managed by the Don Mueang Airport. The values of the arrivals and departures in this airport would steadily rise until the closure of the airport in 2006, and the trend-lines reappear in 2012, with the re-opening of the airport for the international movements and their values are predicted to sharply increase with the return of the low-fare airlines to the airport. The Suvarnabhumi Airport was opened in 2006 and in 2007 the whole value of the international commercial air traffic in Bangkok corresponded to this airport. The decrease in the total air traffic might be related to the political crisis in Thailand which included a protest at the Suvarnabhumi Airport and led to its closure and business and tourist movements alteration and decrease (Deutsche Welle 2008). Furthermore, the global economic crisis might be another reason for the sudden and dramatic decrease in the commercial air movements records for in 2009 since the Thai exports were severely cut (Index Mundi 2013). The values for 2010 show the return to the increasing air movement tendencies, and the ones for 2011 and 2012 constitute records confirming the steadily rising trends.

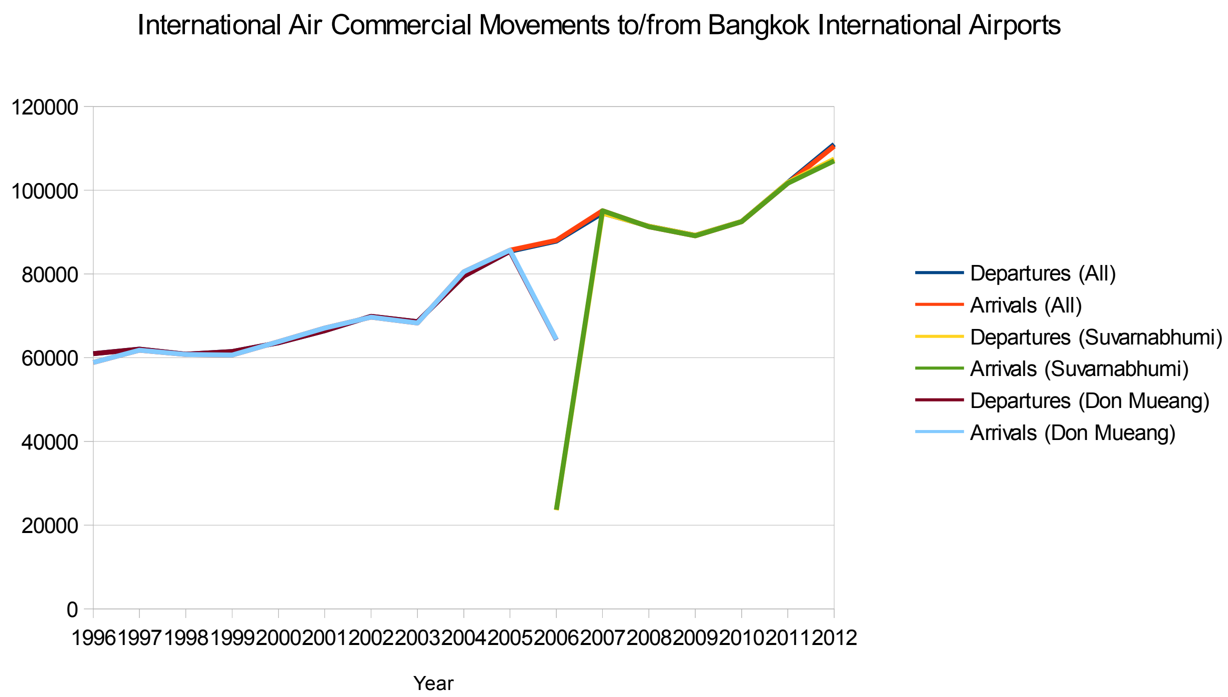

Figure 24: International Commercial Air Traffic, number of departures and arrivals from/to Don Mueang (DMK) and Suvarnabhumi (BKK) Airports, 1996-2012. Chart elaborated with the self edited data obtained thanks to the kindness of the Department of Civil Aviation of Kingdom of Thailand.

International air movements destinations

Data obtained from the Department of Civil Aviation of Kingdom of Thailand has been revised and edited in order to compare international destinations from/to Bangkok International Airports, Don Mueang International Airport (DMK) or/and Suvarnabhumi International Airport (BKK) (See: p.43). After calculations, the top five international destinations from/to Bangkok have been obtained. The graph below contrasts the evolution of the number of annual movements (conceived here as both arrivals and departures) for the top five international destinations from/to Bangkok. The airports which exchanged most international movements with Bangkok were: Hong Kong International Airport (HKG), Singapore Changi Airport (SIN), Taiwan Taoyuan International Airport (TPE), Narita International Airport (NRT) serving Greater Tokyo Area in Japan, Incheon International Airport (ICN) serving Seoul National Capital Area in South Korea, Kuala Lumpur International Airport (KUL) serving Greater Klang Valley conurbation in Malaysia.

Top 5 International Destinations from/to Bangkok International Airports. Self-edited data obtained thanks to the kindness of the Department of Civil Aviation of Kingdom of Thailand.										
	1996		2000		2004		2008		2012	
	Code	Movements	Code	Movements	Code	Movements	Code	Movements	Code	Movements
1	HKG	11999	SIN	12736	SIN	17330	SIN	14458	SIN	18621
2	SIN	11434	HKG	11352	HKG	14547	HKG	11784	HKG	14992
3	TPE	7425	TPE	8550	TPE	8620	KUL	10412	KUL	12731
4	NRT	5209	NRT	5782	NRT	6882	NRT	7688	ICN	10681
5	ICN	4665	ICN	4995	ICN	6189	TPE	7685	NRT	6609

The results of the records' analysis draw attention to an overall increase in the international annual movements from/to Bangkok, changes in the ranking of the top destinations, and an alteration of the increasing tendency of the international movements in 2008.

The number of all international movements from/to BKK and DMK increased by 101746, from 119795 in 1996 to 221541 in 2012. Its growth rate was therefore of ~84,93% in 16 years, and the annual growth rate was of ~5,31%. The number of the movements between the Bangkok International Airports and the first most frequented destination increased by 662 movements from 11999 in 1996 (HKG) to 18661 in 2012 (SIN).

Secondly, there might be observed an interesting disparity among the growth rates of the international movements' numbers according to the destination. The Singapore Changi Airport overtook the Hong Kong International Airport in the number of movements from to/Bangkok, and in 2012 exchanged 3629 more movements with the Bangkok International Airports. The growth rate of the movements for BKK/DMK and HKG airports was in 16 years of ~25%, with an annual growth rate of ~1,56%, whereas the movements exchanged between BKK/DMK and SIN rose in 16 years with a rate of ~63% , ~3,93% annually. Even more important increase may be observed for the BKK/DMK-KUL movements, in 16 years its growth rate being of ~289,2%, and the annual growth rate of ~18,08%. On the contrary, there might be observed a significant decrease in the BKK/DMK-TPE movements, with a growth rate of ~ -33,02% in 16 years and ~ -2,05% annually.

As it was previously discussed (See: p. 43), in 2008 an anti-governmental protest started in Thailand, one of the protests' resulted in a temporal closure of the Suvarnabhumi International Airport. The closure of the airport and the political and social unrest are probably the main reasons of the significant decrease in the international air movements from and to Bangkok.

Figure 25 illustrates the evolution of the international movements to and from BKK/DMK records for all the airports which, considering the data for 1996, 2000, 2004, 2008, or 2012, classified as one of the 5 top destinations to/from BKK/DMK for the year given. The chart presents number of movements to and from BKK/DMK for 6 airports (HKG, SIN, TPE, NRT, ICN, KUL) for the period 1996-2012, calculated on the basis of the data obtained from the Department of Civil Aviation.

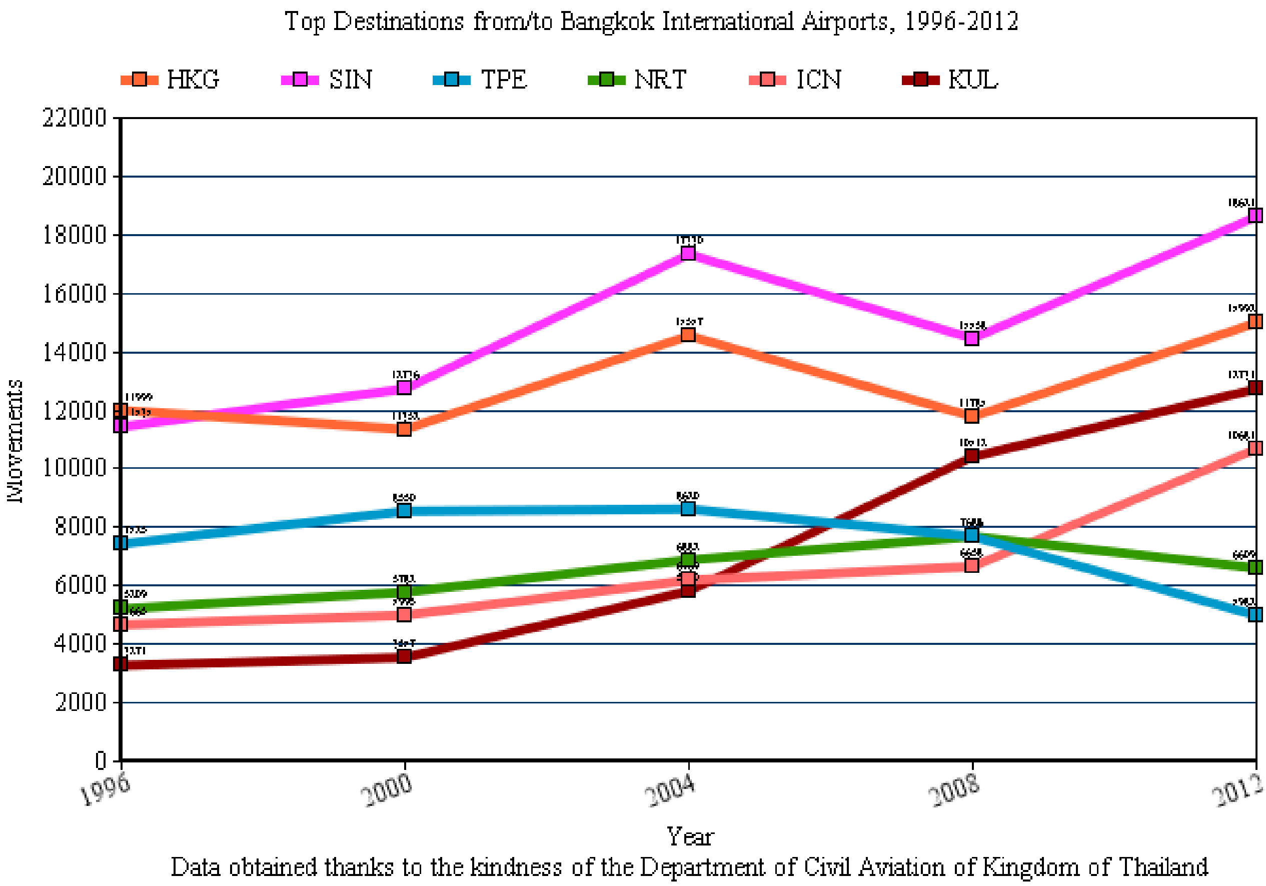

Figure 25: Top Destinations from/to Bangkok International Airports, 1996-2012. Chart based on the self-edited data, obtained thanks to the kindness of the Department of Civil Aviation of Kingdom of Thailand.

The increasing trends of air traffic between BKK, DMK and the airports included in figure turn out to be extremely significant if contrasted with alarming reports of important dengue incidence increases in these countries. All of these countries reported in last years increasing dengue incidence. While some of the airports are located in areas where the vector and dengue incidence are high, others are located in the countries where dengue morbidity is mainly observed in travellers to Southeast Asia, as it is the case for Japan, Hong Kong, and South Korea. It is important to underline that these countries reported during last years an alarming increase in dengue morbidity, concerning both the number of imported and locally-contracted infections.

4.3.4 International Trade

Thailand's economy is strongly export-oriented, and its steady economic growth is largely based on industrial and agriculture exports (Index Mundi 2013). Thailand exports principally industrial and agricultural goods (such as rice, natural rubber, sugar cane, cassava), mainly electronics, automobiles and parts, agriculture commodities, and processed foods. Throughout recent years, the Thai economy has suffered both internal and external shocks, caused by events such as Asian financial crisis in 1997, already discussed global economic crisis, or extremely severe flooding in Bangkok industrial area and surrounding provinces in 2011, which have significantly affected the Thai manufacture industry.

Natural rubber production and international trade

Thailand is the world leading natural rubber producing country. For the present study, this information is crucial having considered that, first, the international trade was the cause of the global spread of dengue and dengue vector, and, second, that the natural rubber is an intermediate good used in producing final consumer goods, and notably, tires. Therefore, Thailand's international trade in natural rubber contributes to the global dengue spread in two ways. On one hand, its exports of the resource account for the international trade movements, increasing the international travel records, and provide tires producers with the material which is consequently distributed internationally. On the other hand, Thailand, apart from distributing worldwide the crude natural rubber, produces and exports rubber products, and products which include rubber elements. Added-value goods such as tires and tubes for motorcycles, airplanes, cars and bicycles, gloves, rubber bands, and elastic could be listed as most important processed-rubber products.

International trade in tyres and vehicles

Particularly relevant, from the point of view of scientific research, is the international trade of tyres, and especially, of used tyres (Randolph and Rogers 2010). International trade in, and an inadequate disposal of, tyres provides a perfect vector-spread mechanism as tyres recreate larval habitats and air movements provide diffusion of vector over long distances (WHO 2009).

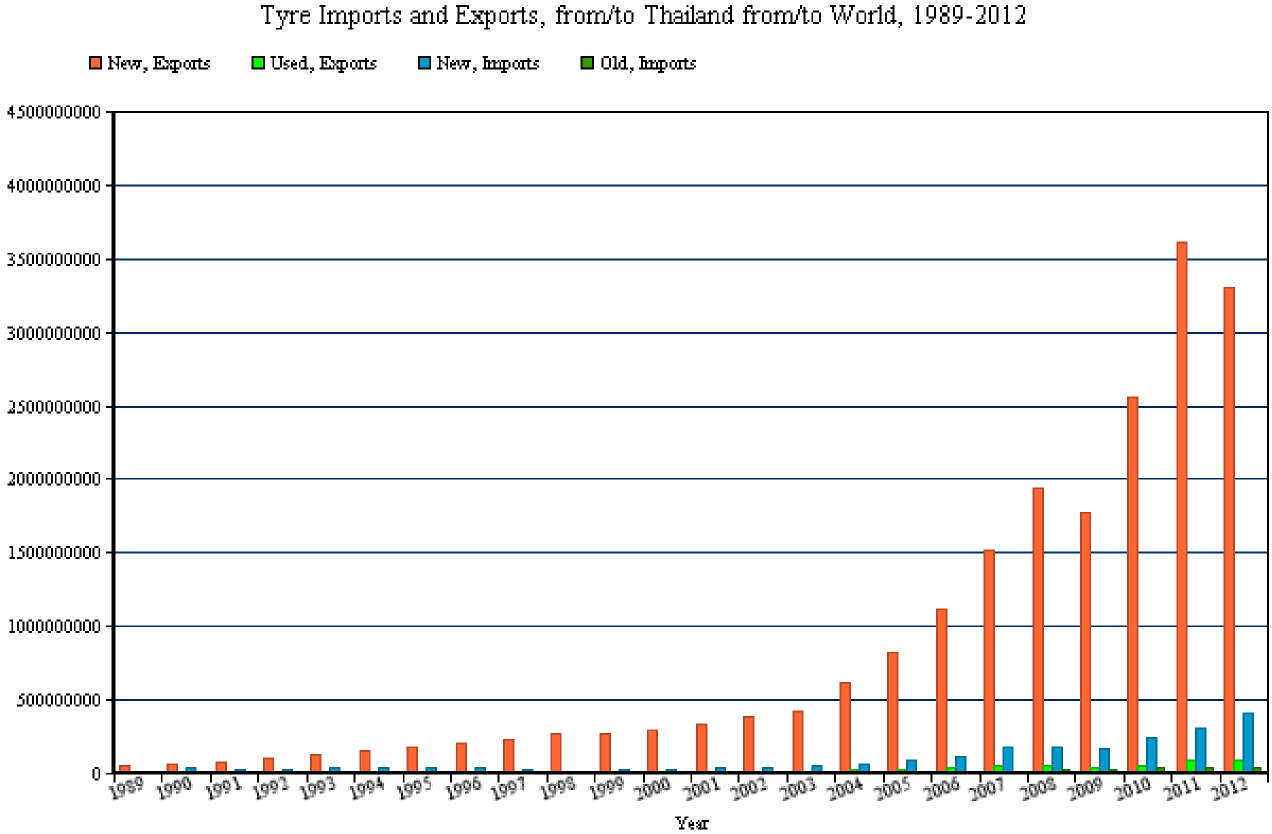

Figure 26: The Value of Imports and Exports of New and Used Tyres from/to Thailand/World in U.S. Dollars, 1989-2012, data self-edited and presented, obtained from the United Nations Commodity Trade Statistics Database.

Figure 26 plots the evolution of the Thai international trade in tyres, presenting the value in U.S. dollars of the imports and exports of both used and new tyres from/to Thailand from 1989 to 2012. The chart demonstrates a rapid growth of mainly new tyres exports, which is here attributed to the strong, and export-oriented economic growth. The figure displays as well an important decrease in the tyre exports in 2009, which may be attributed to the impact of the global economic crisis, and to the internal socio-political crisis.

Figure 27 plots an interesting evolution of the export and imports in vehicles other than railway or tramway. It demonstrates that until 1998, Thailand was rather imports-dependent as far as vehicles are concerned, the value of the imports being several times higher than that of exports. In 1998 Thailand became a net exporter of vehicles, the value of the exports increasing each year, excluding the already discussed records for 2009, and in 2012 the value of exports were twice as big than the values of imports, $24,290,549,656 to $12,413,394,032, as compared.

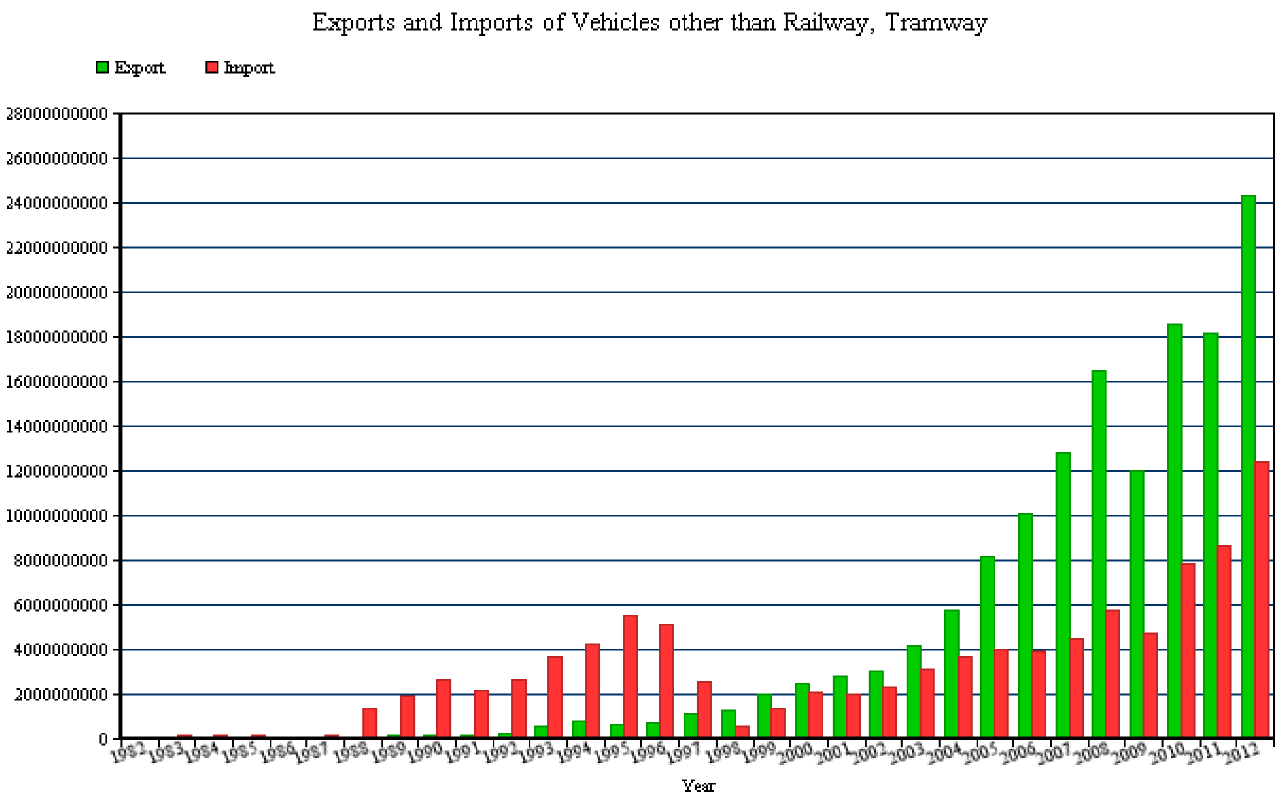

Figure 27: The Value of the Imports and Exports in Vehicles other than Railway and Tramway from/to Thailand/World in U.S. Dollars, 1982-2012, data self-edited and presented, obtained from the United Nations Commodity Trade Statistics Database. The green bars correspond to the export values, the red bars correspond to the import values.

4.3.5 Summary

Section 4.3 discusses international migration and trade from/to Thailand as both issues are considered to be one of the most important causes of dengue global spread. The internal and international migration have been analysed. It was found that the long-term internal migration in Thailand from 1982 to 2012 was mainly of return kind, from urban to rural areas. The railway travel was found to diminish significantly, and the rail freight remained stable from 1982 to 2012. The high seasonal and short term migration could be therefore explained by increased road density and ratio of passenger cars to 1000 population. As far as the international long-term migration is concerned, three trends were observed for the last decades in Thailand. First, the outward migration from unprivileged areas to higher-income countries. Second, the immigration the high-skilled workers due to the process of industrialisation. Third, Thailand became a labour-importing country. Many of the immigrants are not guaranteed in Thailand basic rights such as those to health care, sanitary housing, or social security, their situation being a potential factor of increasing hazard of dengue transmission or introduction. There was observed an important increase in the commercial air transport, the international Bangkok airports being, furthermore, one of the most important hub in Asia and in the world. The values and the destinations of the international movements from/to international Bangkok airports were analysed in order to provide patterns and draw conclusions contributing to a possible international spread of dengue. International trade is another crucial factor of global dengue spread, and particularly, the trade in used tyres. Thailand is exports-oriented country, is important vehicle-exporter, and is the world top-producer of natural rubber, which is mainly used in tyres production.

4.4 Economics and Infrastructure

4.4.1 Introduction

The relationship between the poverty or welfare and dengue seem to be ambiguous (Guha-Sapir and Schimmer 2005). On one hand, the poverty contributes to dengue spread as far as it is decisive for the human and financial resources which government and population may dedicate for the health needs. It determines as well the quality and accessibility of infrastructures such as housing, water supply, sewerage and waste management systems (Lowe et al. 2011; Gubler 2002). In this sense, lower income countries seem to be more vulnerable to the impact of the economic factors on dengue spread and distribution. On the other hand, it was discussed in some studies that at a micro-economics level, a greater susceptibility for contracting dengue was found among well-nourished middle classes rather than among poor, malnourished population (Guha-Sapir and Schimmer 2005). In view of this ambiguity, and as it was already suggested in the present study (See: p. 35), some beliefs concerning dengue disease are being revised, or still need revising due to mistakes in the reporting systems or missing indicators which should be taken into account when the relationship of the economic status and dengue is examined.

As far as the economic issues are considered, apart from the economic factors determining the distribution and spread of dengue, it is as well extremely important to take into account the economic burden of the disease. The results concerning the burden of the disease may result crucial as far as they determine the scope and scale of the action undertaken by decision-making actors and their engagement in coping with dengue as one of the most important public health threat in endemic countries.

4.4.2 National Health Infrastructure

Throughout the 20th century, thanks to the democratic changes and economic growth, the Thai health care infrastructure slowly expanded from a practically non-existent structure to a system which currently aims at providing a universal health care. In the mid of the 20th century there was established a coverage planning for health care infrastructure. Gradually, the still-existing problems of low accessibility and maldistribution of health care services, have been reduced. Until 2002, six major schemes as follows had been gradually established: the Medical Service Welfare for the People Project (MSWP) providing medical services to poor and underprivileged, the Voluntary Health Insurance with Government Subsidies Project (VHIP) for the people in the non-formal employment sector, the Civil Servants Medical Benefits Scheme (CSMBS) for civil servants and state enterprise employees, compulsory health insurance schemes required by the government for employees in the private sector, including the Workmen's Compensation Fund and the Social Security Fund (SSF), and the Private Voluntary Health Insurance (PVHI).

In 2001, the Thai government announced the universal coverage health care policy which included two funds are two funds under the health security scheme: for the employment sector, expanding the social security fund to cover medical service welfare for civil servants and state enterprise employees including their families, and for the non-employment sector, using the universal health security scheme. The universal health care scheme provides a comprehensive benefits package covering inpatient and outpatient services, childbirth service and some dental care services, annual check-ups, disease prevention and health promotion. Initially, there was established a co-payment system which imposed on the patients, except for the underprivileged, a payment of 30 Baht per visit. The payment was later-on abolished and the the Universal Coverage scheme has become free.

Health insurance coverage

Figure 28 presents the evolution of the health insurance coverage in Thailand from 1991 to 2009. Certain important conclusions for the dengue epidemiology in Thailand can be withdrawn. Thailand has undergone a striking evolution of the health insurance coverage. In 1991, 66.5% of the Thai population were not covered by any health insurance. In 2009, 97.4% of Thai citizens were covered by a health insurance, and 76.1% of them were under the universal coverage scheme. It is an important fact to observe that, distinguishing among the 2.6% of Thai population who in 2009 were not covered by any insurance, 1.4% of non-municipal population experienced lack of it, as compared to 5.3% of municipal population in the same situation (See: the database in the Appendix B). Another difference between non- and municipal population, is that most of the population subscribed in 2009 to a private insurance were from municipal areas (See: Figure 29).

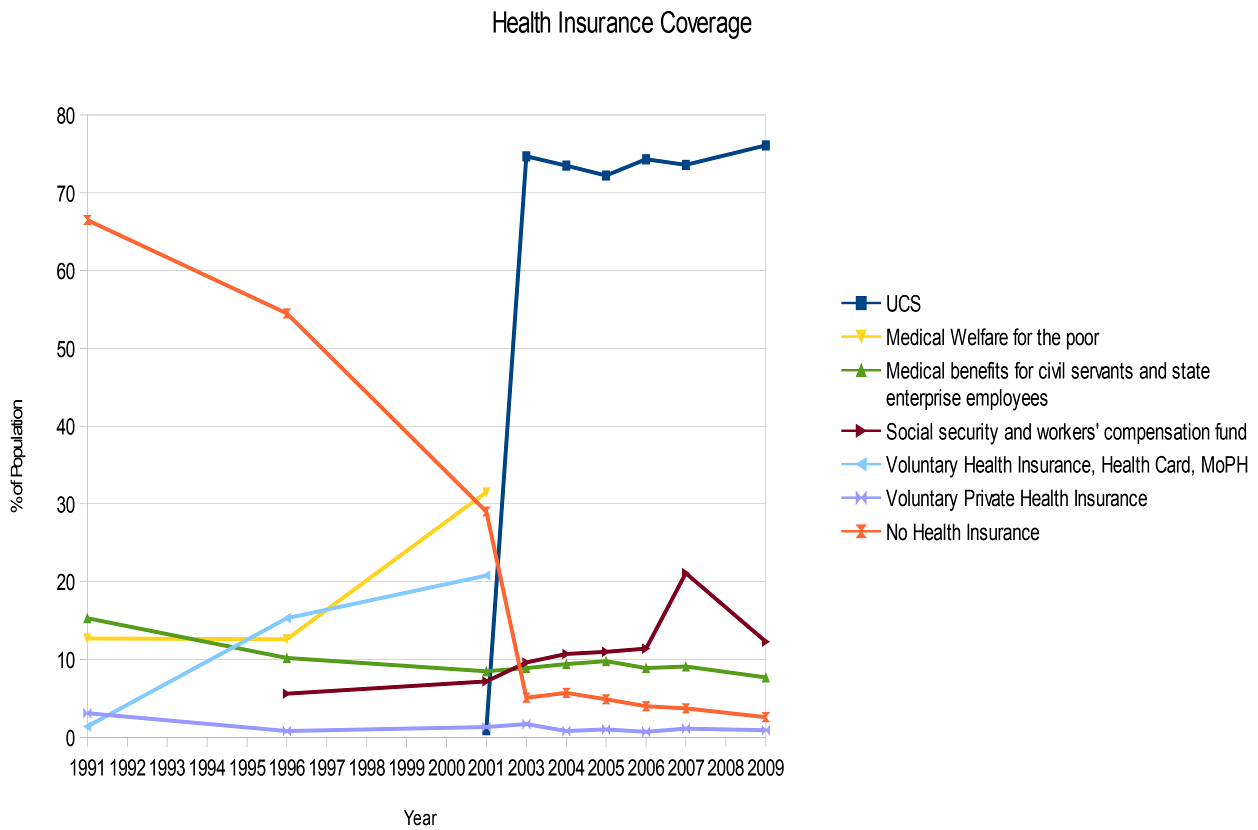

Figure 28: Health Insurance Coverage in Thailand, 1991-2009. Data obtained from the Thailand Health Profile Report 2008-2010.

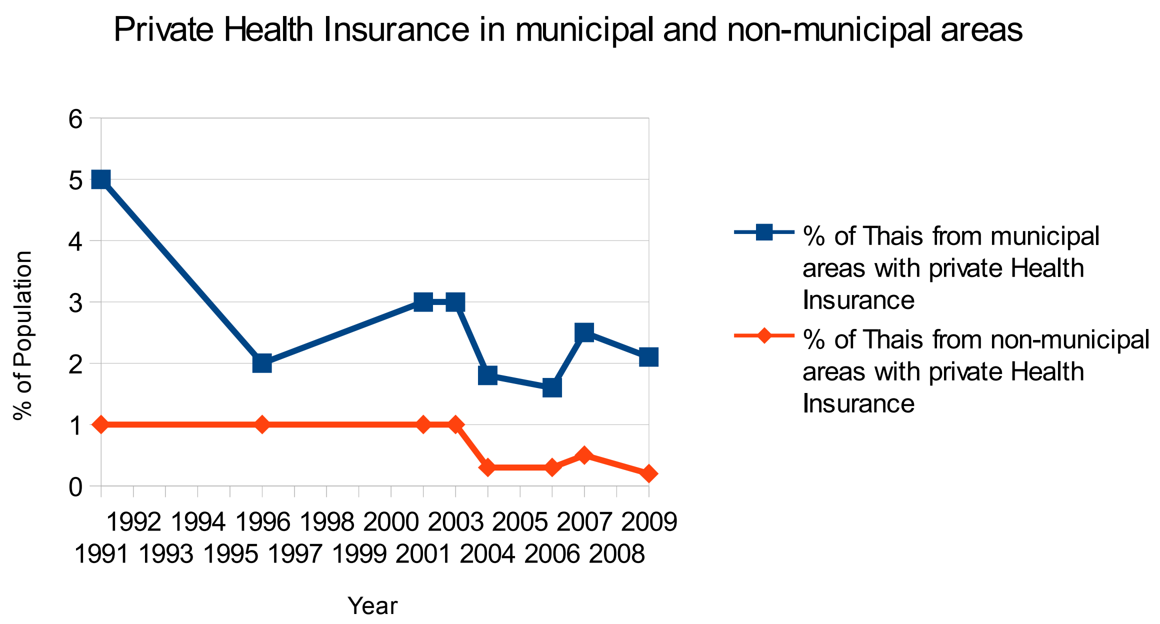

Figure 29: Private Health Insurance by Population from Municipal and Non-Municipal Areas. Source: Thailand Health Profile Report 2008-2010, MoPH.

Health expenditure in Thailand

The health expenditure structure and value has as well undergone a significant evolution throughout last decades. As it can be observed in Figure 30, in 1995 the total health expenditure's per Capita value was of 164 PPP U.S. dollars, out of which 53% was assumed privately (See: Figure 31). From 1995 to 2011 the total health expenditure experienced a ~2.15-fold rise, from 164 PPP U.S. dollars in 1995, to 353 in 2011. The share of the private and general government in the total health expenditure also changed significantly. Meanwhile the annual private expenditure per capita was quite constant, its value in 1995 being of 87 U.S. PPP dollars, and in 2011 of 86, the value of the public expenditure steadily rose, from 77 in 1995 to 267 U.S. PPP dollars in 2011, constituting 75.5% of the total health expenditure (See: the database in the Appendix B). The constant private expenditure might arise some hypothesis about the health cost-demand elasticity and the price that the population is ready/capable to assume privately. Regarding the private expenditure evolution, the out-of-pocket expenditure's share in it diminished, as it constituted 80.4% of the private health expenses and gradually diminished to 55.8% in 2011.

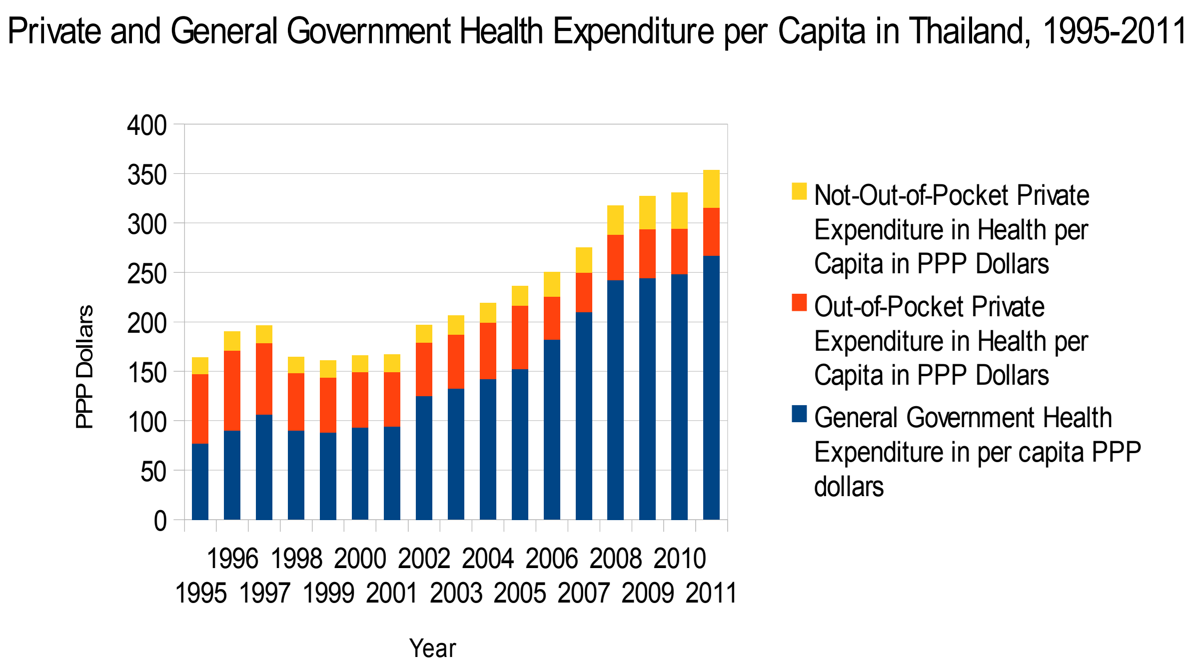

Figure 30: Government and Private Health Expenditure in Thailand, 1995-2011. Source of data: UNESCAP database.

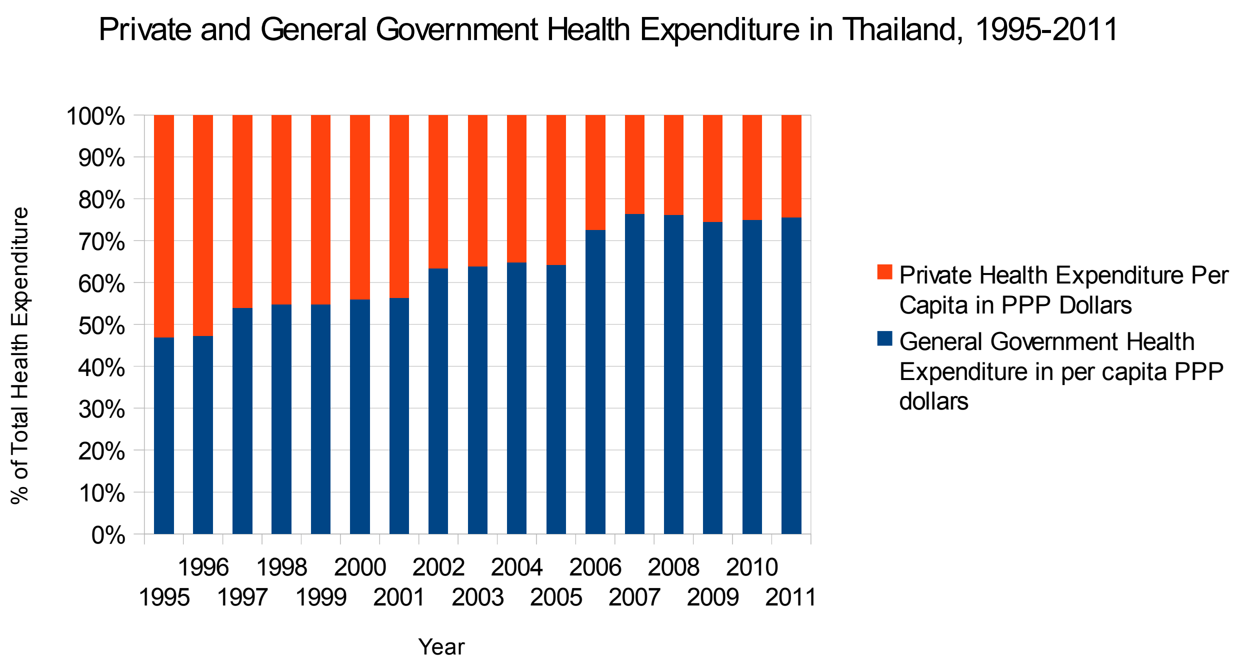

Figure 31: The Share of Private and General Government Financing in the Total Health Expenditure in Thailand, 1995-2011. Source of data: UNESCAP Online Database.

Health infrastructure in Thai regions

Although the health service coverage has significantly improved in last years, strong disparity in the distribution, accessibility, and consumption of health services and resources still persists among the regions. The Northeast region remained throughout last decades the region with the lowest service utilization rates (See: Figures 32 and 33), and with the highest rates of the population to bed, health worker at sub-district health centres, and doctor (See, respectively: Figures 34, 35, and 36).

The rates of inpatient service utilization experienced a slight and gradual increase, except of the rate for the Bangkok region, as it is visible in Figure 32. Bangkok had in 1995 a slightly lower inpatient service utilization rate than the Central region, with the highest rate, but in subsequent years its rate increased drastically until 2008, when it experienced a strong decrease, from 2007 to 2009 having reduced by half.

The rate of inpatient service utilization is related to the population/hospital bed ratio (See: Figure 34). In 1979 there was one bed for 1511 people in the Northeast region, as compared to one bed for 337 people in Bangkok, respectively. The disparity between the two, the region with the highest and the lowest ratio, was ~4.5-fold, and ~2.78, ~2.27, and ~1.54-fold with the following respectively regions. Until 2007, the ratio for all the regions had a decreasing tendency, the ratio for the Northeast region being of 1:723, for the North region of 1:497, for the South 1:490, the Central of 1:386, and Bangkok of 1:196. The disparity between the North region, with the highest ratio, and the following ones, was, respectively, ~1.45, ~1.48, ~1.87, and ~3.69-fold.

The ratio of the outpatient service utilization is related to the population/doctor ratio. With accordance to the general trend, the both ratios' evolution reflect an improvement in the health care accessibility, as it can be seen on the basis of Figures 33, and 36. However, just as in the case of the already discussed ratios, differences among the regions persisted and still persist, even though they might seem smaller in the case of the outpatient service utilization and population/doctor indicators. The data for the outpatient service utilization in 2011 attracts attention to a strong disparity between Bangkok, with the ratio of 4 annual visits per person, and the rest of the regions, with the following ratios: 2 for the Central, 1.7 for the South, 1.6 for the North, and 1.2 for the Northeast region. In 2009 the ratios the ratios were better and much more similar, the South region having the highest ratio (4.2), then Bangkok (3.7), the South (3.2), North and Northeast Regions (3.1, both). From 2001 to 2009 the ratio tendency was almost exclusively increasing, except for the ratios for Bangkok, which after reaching in 2007 a peak of 6.4 annual visits per person, later on dropped significantly. Similar trends may be observed as regarding the population/doctor ratio. The strong disparities in 1983 (with ratios of 1404 for Bangkok, 7179 for the Central, 10879 for the North, 10061 for the South, and 19675 for the Northeast regions), gradually diminished, the ratios showing an improvement in the health care accessibility.

Interesting trends may be observed for the population/health personnel ratio (See: Figure 35), which in the beginnings of the 90s decreased significantly but rose in the beginnings of the 21st century, to finally reach an decreasing tendency from 2007 to 2009.

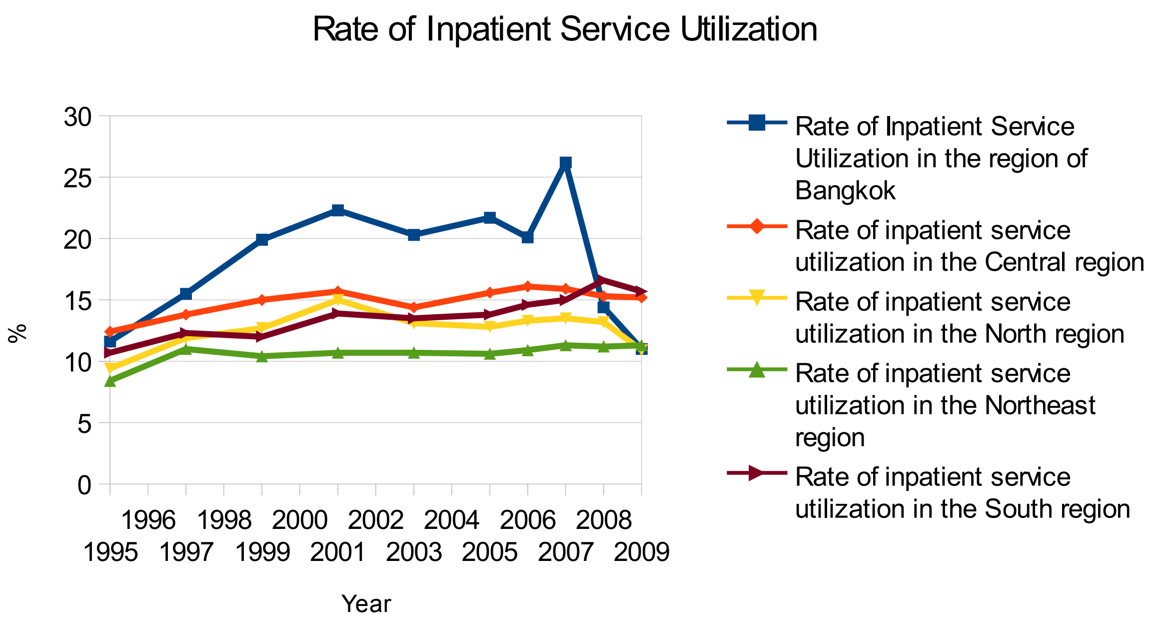

Figure 32: Rate of Inpatient Service Utilization in Thailand by Region, 1995-2009. Data obtained from the Thailand Health Profile 2008-2010.

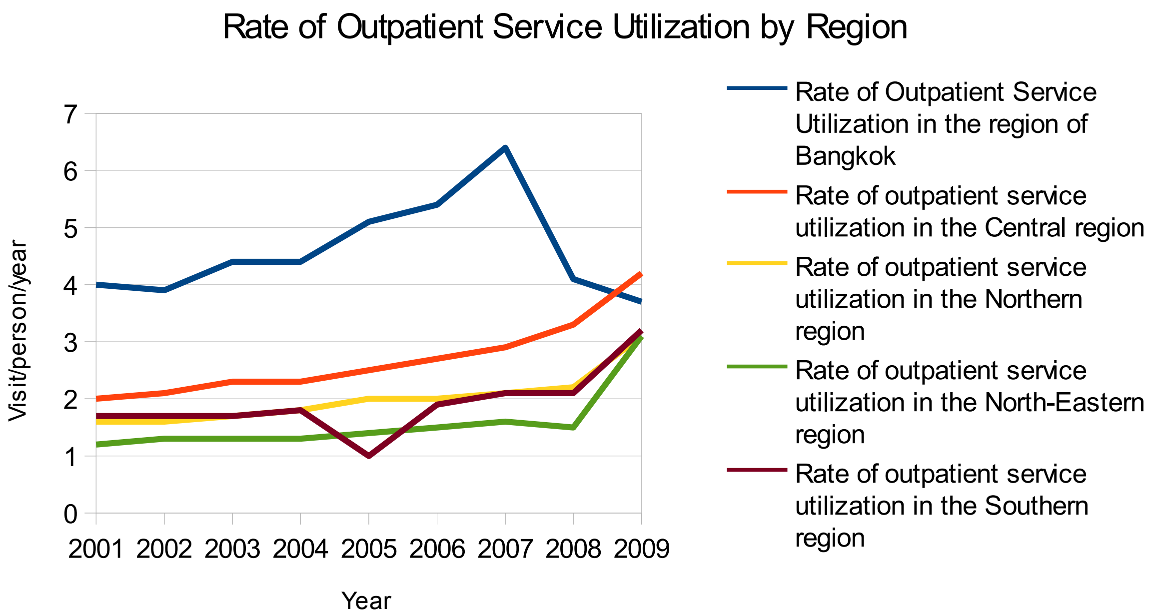

Figure 33: Rate of Outpatient Service Utilization in Thailand by Region, 2001-2009. Data obtained from the Thailand Health Profile 2008-2010.

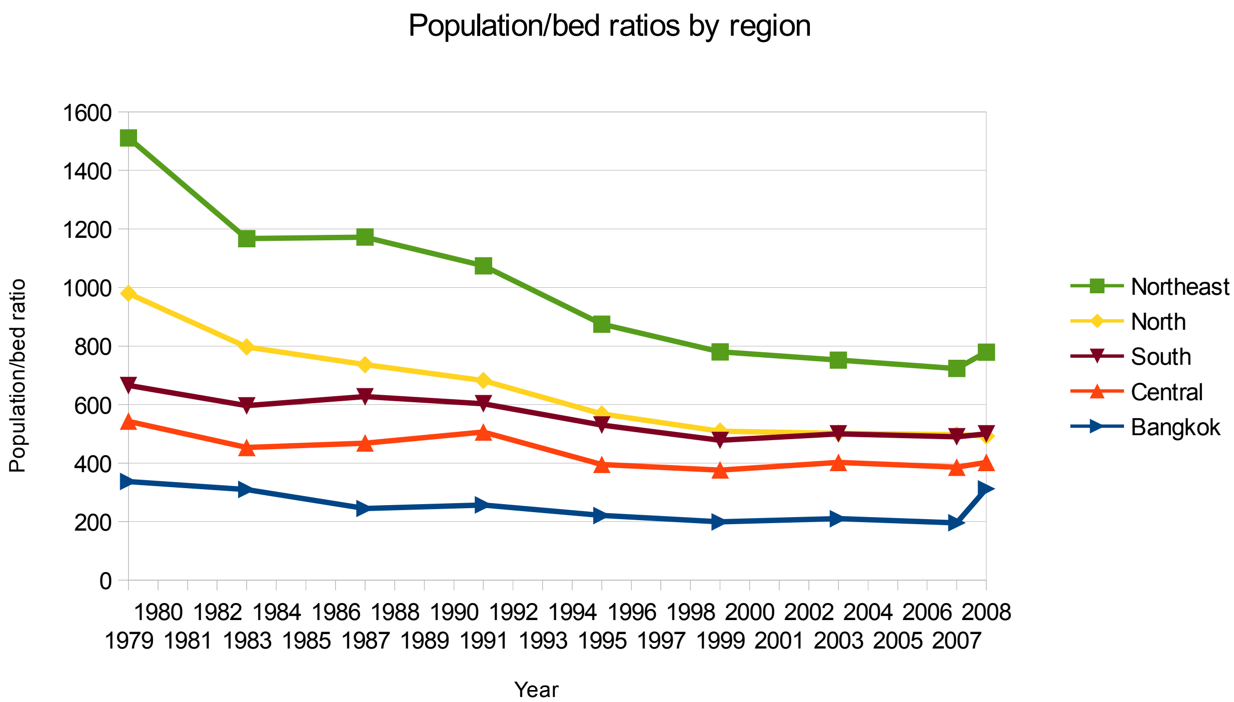

Figure 34: Population/Bed Ratio in Thailand by Region, from 1979 to 2008. Data obtained from the Thailand Health Report 2008-2010.

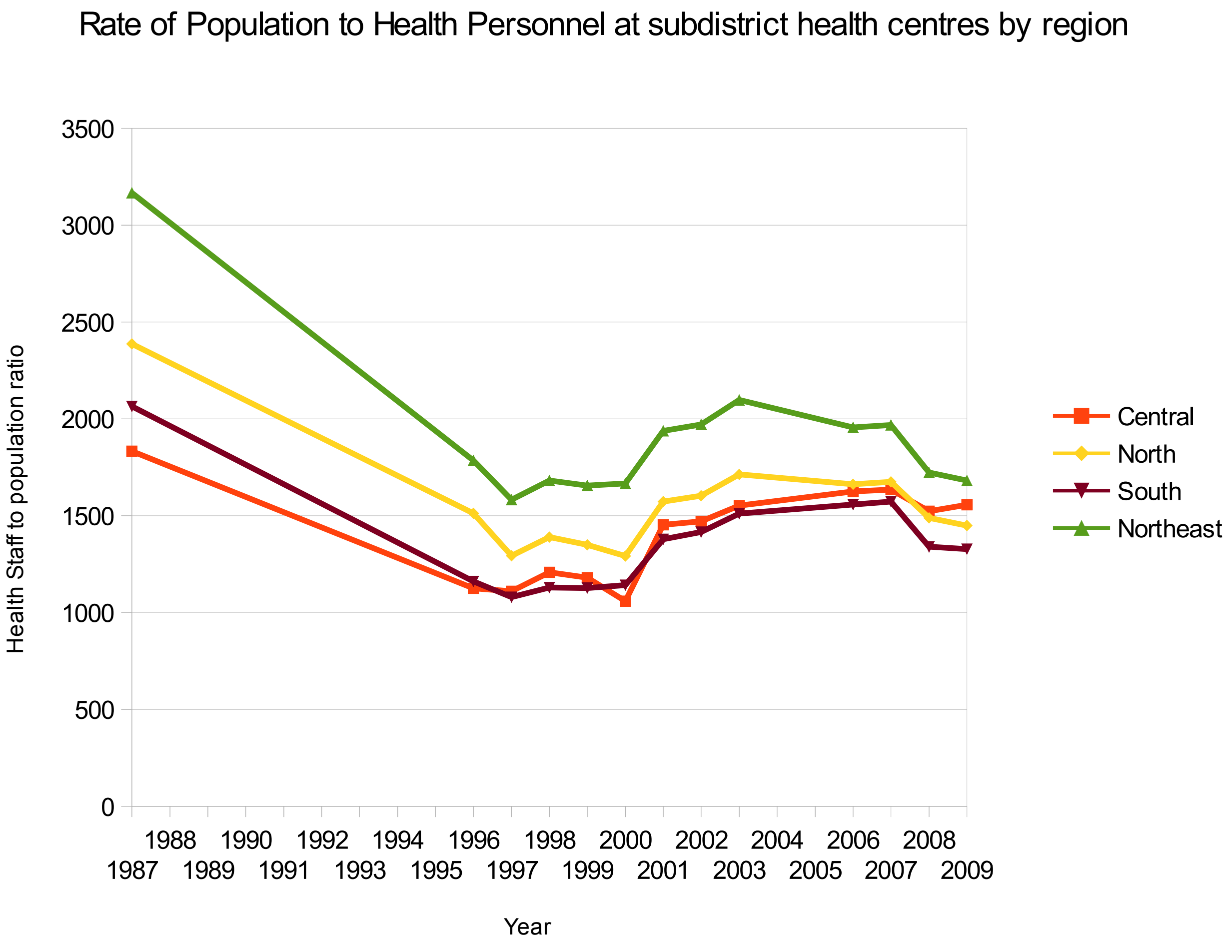

Figure 35: Rate of Population to Health Personnel at subdistrict health centres in Thailand, by region, from 1987 to 2009. Data obtained from the Thailand Health Profile 2008-2010, MoPH.

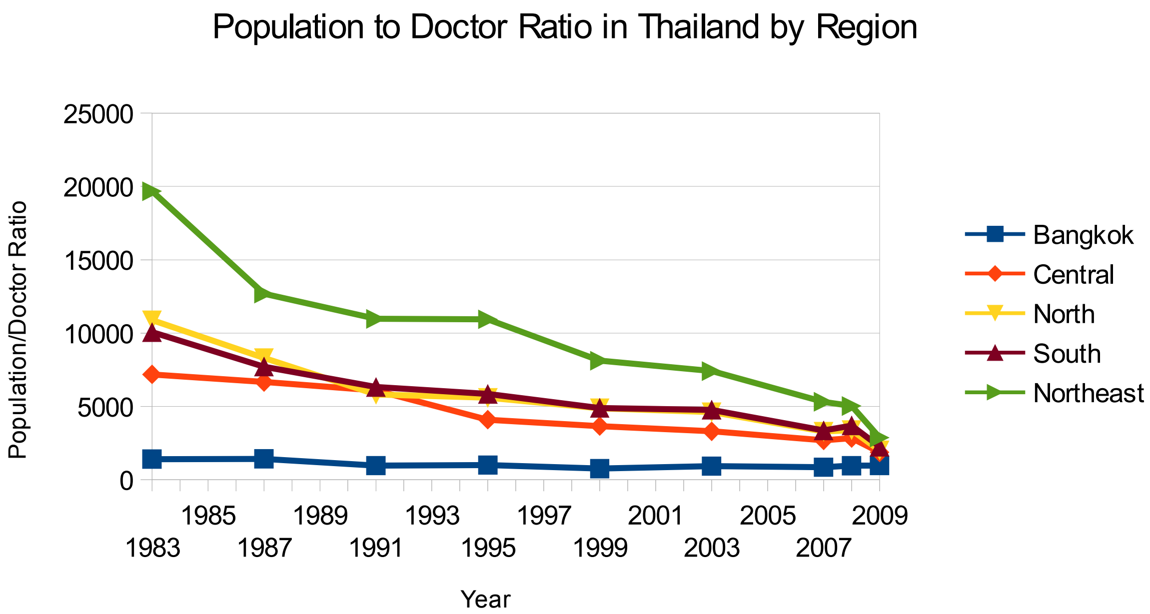

Figure 36: Population/Doctor Ratio in Thailand by Region, from 1983 to 2009. Data obtained from the Thailand Health Profile 2008-2010.

4.4.3 Hard Infrastructure

The infrastructure such as water supply, sewerage and management system, housing components in construction, air-conditioning and the use of door and window screens, play an important role in dengue transmission, greatly contributing to the vector control. The main reason for this relationship is the mosquito habitat which may be recreated in certain conditions. The standing water stored in human-made containers constitutes in this matter the key factor given that it recreates for the mosquito the breeding site conditions, and, consequently, serves for the reproduction of the vector (Schmidt et al. 2011).

Water Supply and Drinking Water

The quality of the water supply infrastructure may be decisive for the vector control. The piped water is considered to increase the vector control, whereas the water drawn from wells, communal standpipes, rooftop catchments and other water-storage systems are considered to increase dengue transmission (WHO 2009). Furthermore, the potable water must by supplied in a reliable way in order to prevent storage of water for alimentary use in containers such as drums, overhead or ground tanks and concrete jars.

Figure 38 presents the percentage of Thai households by water supply type in 2007. In overall, 87.7% of the water supply comes from inside piped water, whereas the resting 12.3% of the water supply is taken from outside sources such as public wells or taps, rivers, etc. Figure 37 shows the percentage of Thai households by source of drinking water in 2007. 57% of drinking water came from bottle or was piped inside the household, but 37% was rain water, which might have been stored in a way contributing to the mosquito breeding, the resting 6% of water was taken from sources such as public wells or taps, river and streams, etc.

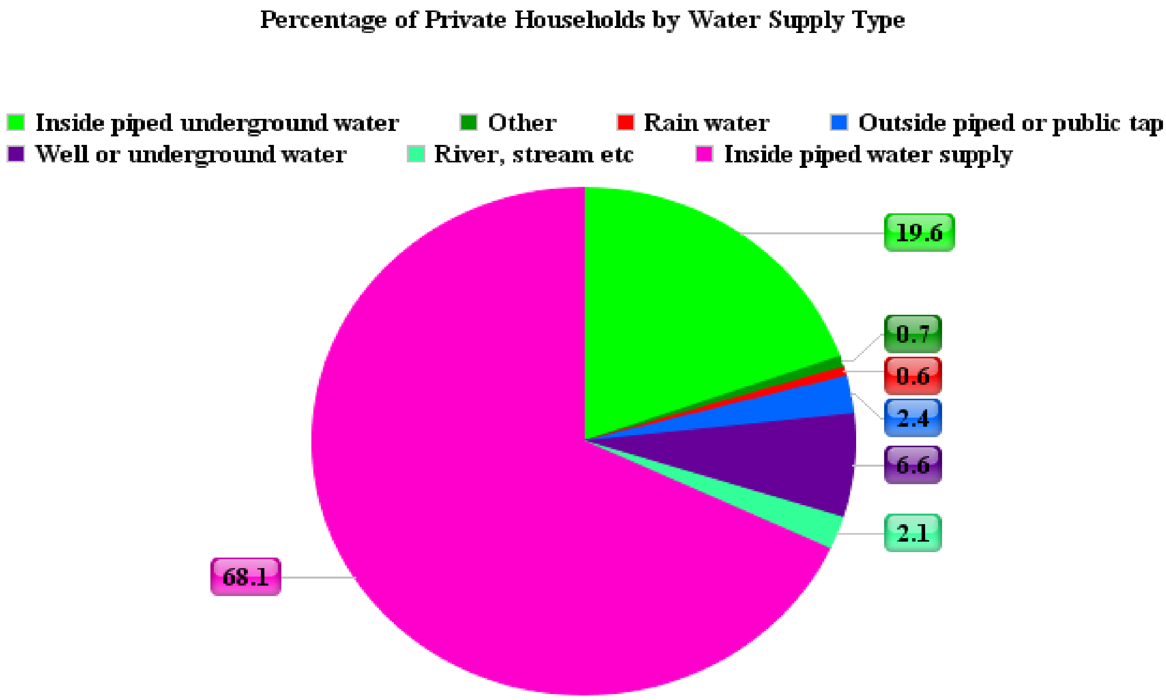

Figure 37: Percentage of Private Households by Water Supply Type in Thailand, 2007. Data self-edited and presented in form of a graph, obtained from the Thai National Statistical Office Database.

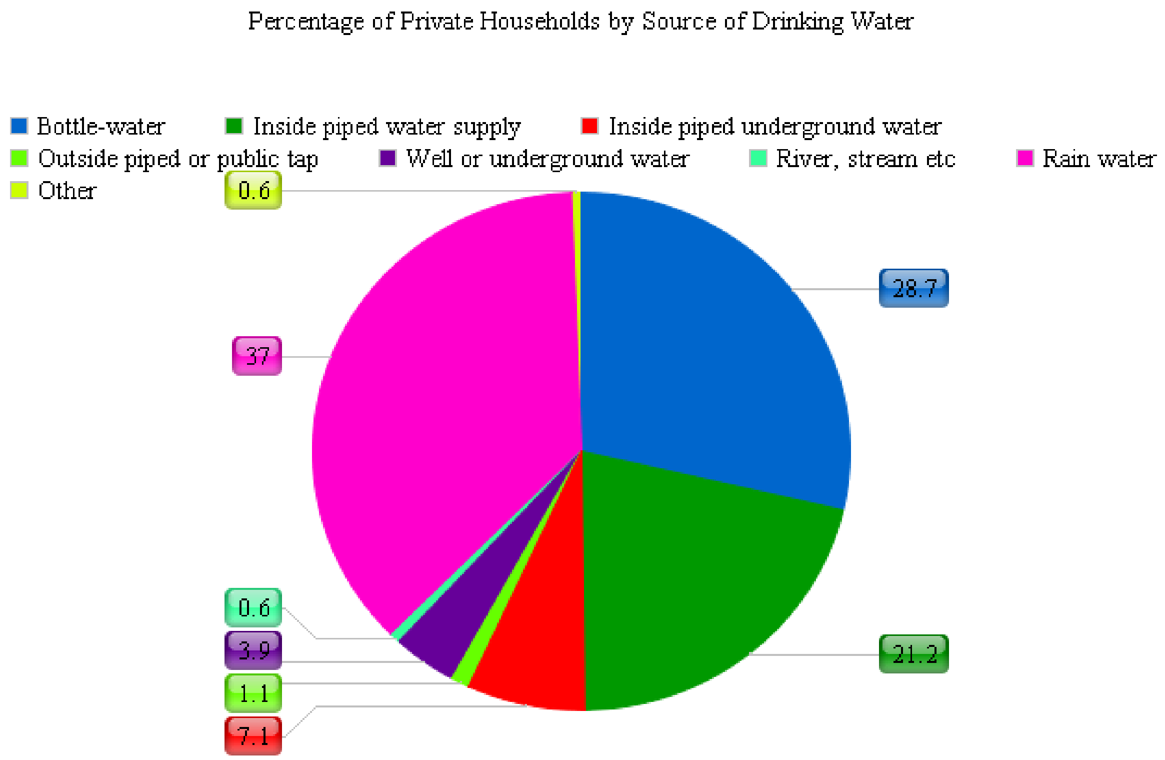

Figure 38: Percentage of Private Households by Source of Drinking Water, Thailand, 2007. Self-edited and presented in a graph data obtained from the Thai National Statistical Office Database.

Sewage and waste management

Larvae of the mosquito can be usually found in containers with water-holding capacity, such as discarded tyres, buckets, flowerpots, wading pools, and blocked rain gutters (Rigau-Pérez et al. 1998). For this reason, proper solid waste and sewage management systems are crucial in terms of the vector control. The management of the solid waste, in the context of dengue vector control, mainly refers to the non-biodegradable items of household, community, and industrial waste (WHO 2009). When it comes to the wastewater, in order to avoid creation of the mosquito larvae habitats, there should be ensured a proper and secure water run-off drainage system and manholes.

4.4.4 Economic and disease burden of dengue in Thailand

It is extremely difficult to estimate the cost of dengue and the studies aiming at measuring this cost tend to underestimate it. The reason for the errors may lie in a big variety of indicators and factors which may be difficult to be quantified, or not taken into account. For instance, it is probably impossible to quantify personal and societal loss issued from the school absence due to dengue incidence. In spite of its difficulty, several studies have been undertaken to measure the economic burden of dengue and many of them have been identified and selected for the analysis for the present study purposes (Suaya et al. 2009; Shepard et al. 2011; Shepard, Undurraga, and Halasa 2013; Undurraga, Halasa, and Shepard 2013; Kongsin et al. 2010; Okanurak, Sornmani, and Indaratna 1997; Duane J Gubler 2012; Clark et al. 2005).

The table below presents and contrasts the results of three studies aiming at estimating the dengue annual economic and disease burden in Thailand (Shepard, Undurraga, and Halasa 2013; Kongsin et al. 2010; Suaya et al. 2009). The study undertaken and published by Shepard, Undurraga, and Halasa 2013 seems to be the most complete so-far published estimation of the economic and disease burden in Southeast Asia. Its results for Thailand are mainly based on the results and data published in the study by Kongsin et al. 2010. It takes as well from the study by Suaya et al. 2009, its analytic framework description being based on this study. The structure of the table elaborated for the present study and presented below was created partly according to this framework. The table presents the dengue annual economic and disease burden in Thailand including as well the results for the Thai national vector control cost (Kongsin et al. 2010). It presents the type of costs estimated, the description of the expenses included in the cost types, its total annual values and the annual values per capita, and the Disability-Adjusted Life Years (DALYs) value. The DALYs concept was established as a method of estimating and comparing the burden of morbidity and premature mortality caused by widely varying conditions and states within and among countries (Larson 2013). The value of DALYs reflects the discounted value of future years of healthy life lost to morbidity or/and disability and future years of life lost to premature mortality.

The dengue annual economic cost in Thailand was estimated as 290 028 028 U.S. $ (Shepard, Undurraga, and Halasa 2013; Kongsin et al. 2010) , the national cost of vector control as 62 000 000 U.S. $, per capita values were calculated respectively as 4,28 U.S. $ and 1 U.S. $. Contrasted with the Thai GDP per capita in 2005, amounting for 4 850 U.S. $ according to the International Monetary Found estimations, the dengue economic burden constitutes ~0,001 of the Thai GDP per capita, excluding the vector control costs.

<table>
<tr><td colspan="5">Dengue Annual Economic and Disease Burden in Thailand</td></tr>
<tr><td></td><td colspan="3">Annual Dengue Economic and Disease Burden (average, 2001-2010)</td><td>Vector Control Cost (average, 2001-2005)</td></tr>
<tr><td rowspan="2">Type of cost</td><td colspan="2">Direct Cost</td><td rowspan="2">Indirect Cost</td><td rowspan="2"></td></tr>
<tr><td>Medical</td><td>Non-Medical</td></tr>
<tr><td>Description of the coverage of the expense estimated.</td><td>Sum of quantity of services used (ambulatory or inpatient) by sector (public or private) times their respective average unit costs</td><td>Patients' out-of-pocket payments for:
- Transportation
- Food
- Lodging
-Activities aimed at medical care seeking;

Household members visits</td><td>- Lost days of school

- Lost days of work for pay

- Other days lost by the patent or their household caregivers;</td><td>Expenses on households-educating vector control programmes. Assumed at administrative levels:
- National (Strategic management)
- Regional (Train, supply, supervision)
- Provincial and Local (Implementation)</td></tr>
<tr><td rowspan="2">Aggregate Cost (US$)</td><td colspan="2">215 772 000</td><td>74 303 000</td><td rowspan="2">62 000 000</td></tr>
<tr><td colspan="3">290 028 028</td></tr>
<tr><td>Cost per capita (US$)</td><td colspan="3">4,28</td><td>1</td></tr>
<tr><td>DALYs</td><td colspan="3">28 475</td><td></td></tr>
</table>

Poverty in Thailand

As it can be observed from the analysis of the economic and disease burden, the cost of dengue is high, and may result unbearable for the population with less economic resources, and/or may result in the loss in the economic and social status of the patients and their care-providers. It might be particularly relevant for the years preceding the universal coverage scheme, as many patient had to face the costs individually and privately.

As Figure 39 shows, the poverty lines had an strongly decreasing tendency in the period from 1988 to 2010. In 1988, 65.3% of the Thai population were below the national poverty line, the line being defined by the same country, and 41% of the population lived on less than $2, as revised in accordance to 2005 PPP. From 1988 to 2006 the poverty lines had a clearly descending tendencies, experienced a significant increase in 2000 and from then to 2010 decreased gradually. In 2010 13.2% of the population lived below the national poverty line and 4% lived on less than $2.

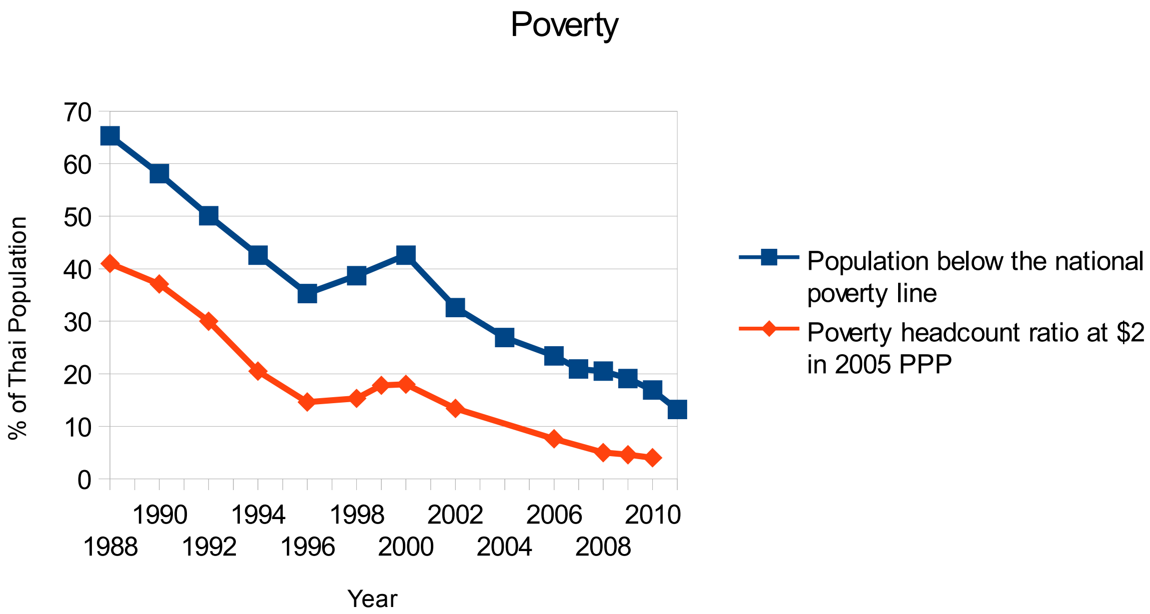

Figure 39: Percentage of Population below the National Poverty Line and of the Poverty Headcount Ratio at $2 in 2005 PPP. Data obtained from the UNESCAP database.

4.4.5 Summary

Section 4.4 studies the relationship of economics and infrastructure with dengue disease. It analyses the issues of Thai national health infrastructure, of dengue-related 'hard' infrastructure, and the economic and disease burden in Thailand. It was found that the Thai national health infrastructure and the accessibility of health care greatly improved from 1982-2012, although some important disparities persist among Thai regions. As far as the 'hard' infrastructure is concerned, the data on water source was provided, stating, among others, that in 2007 37% of households used rainwater as source of drinking water, depending on the way of storage, this fact might be crucial for dengue epidemiology. The results of other researches were contrasted in order to present as comprehensive as possible annual dengue economic and disease burden, which turned out to be very high, estimated for 5,28 U.S. dollars per capita and 28 475 DALYs. In the view of important out-of-pocket and indirect costs assumed individually and of the low health insurance coverage in the period preceding the year 2003, the poverty ratios were studied. It was found that although the poverty from 1982 to 2010 greatly diminished, in 2010 13.2% of the Thai population still lived below the national poverty line.

4.5 Dengue-related Knowledge, Attitude and Practice

The social and cultural factors determine dengue spread and the evolution of dengue epidemiology in many ways. This kind of aspects play an important role in terms of dengue control, treatment and the vector control. Scientists and investigators tend to consider the knowledge, attitude and practice (KAP) of dengue in the population as a crucial factor, determining the scale of dengue spread and the successfulness of dengue vector control and disease prevention and treatment. The traditional practices related to water may play a crucial role in the mosquito vector spread.

4.5.1 Dengue-related Knowledge, attitude and practice, and the Health-Belief Model

The health education and communication for dengue haemorrhagic fever prevention and control is being managed and provided for Thai population by involved actors on the basis of the Health Belief Model (HBM) (Phuanukoonnon, Brough, and Bryan 2006; Lennon 2005). The model was developed by Godfrey Hochbaum in the early 1950s in order to study the perception of the population of their vulnerability, susceptibility in relation to a particular health threat and their perception of the benefits of undertaking measures against the problem in households (Phuanukoonnon, Brough, and Bryan 2006). The aim of the application of the model is, on the ground of the study, to inform and convince the population about their actual vulnerability and susceptibility, and empower them for undertaking individually dengue prevention and control measures. The HBM consists of five components, namely, perceived: susceptibility, severity, benefit, barriers, and self-efficacy. The HBM components reflect the knowledge of, and attitude towards dengue and determine the practice related to the disease control and/or prevention.

The knowledge of dengue as arboviral disease is crucial so as to adopt right attitudes and measures. In order to evaluate the knowledge of the Thai population and contrast it with the control and prevention measures individually applied, several studies have been conducted, some of them have been reviewed for the present study's purposes (Swaddiwudhipong et al. 1992; Phuanukoonnon, Brough, and Bryan 2006; Phuanukoonnon, Bough, and Bryan 2006; Wong and AbuBakar 2013; Van Benthem et al. 2002; Kittigul et al. 2003). Studies find that most of the population interviewed had increasingly good, but still unsatisfactory knowledge of dengue symptoms, infection, transmission, prevention and control, and some mistaken beliefs led to adoption of wrong attitudes and practice. Most people would recognize mosquitoes as vector transmitting dengue and can distinguish dengue haemorrhagic fever from other diseases. However, the knowledge of dengue was often not reflected in the prevention measures applied, the selection of the measures or the frequency of application being inadequate (Swaddiwudhipong et al. 1992; Kittigul et al. 2003; Van Benthem et al. 2002; Phuanukoonnon, Brough, and Bryan 2006). Some studies' results point to differences in the population's knowledge of dengue according to the profile of the population groups (Van Benthem et al. 2002). The groups presenting significantly less knowledge were old persons, housewives and unemployed. The lack of knowledge of dengue and mistaken beliefs often manifest in perceptions from the HBM.

The perceived susceptibility in the context of dengue refers to the subjective perception of the risk of contracting the disease. Studies show that the perception of susceptibility was particularly low among young adults and elderly people (Wong and AbuBakar 2013). Both groups would rather point to children as most vulnerable to dengue infections. The low perceived susceptibility of the teenagers and young adults was based on the conviction that dengue resulted from a poor body immune system, and, consequently, a young and strong immune system would protect them from the dengue infection. The second group's misperception of self-susceptibility was partly motivated by the belief that a thickened and hardened skin prevented the elderly from being bitten by the mosquito. Furthermore, the perception of susceptibility was often weakened by experience of being bitten several times by mosquitoes with no further infections.

Some studies provide evidence of reduced perception of severity of dengue infections due to the popular in Thailand generalised conviction that dengue is curable and the health services are reliable, increasing the perception of control over a possible dengue infection (Phuanukoonnon, Brough, and Bryan 2006). Other literature finds that the fatal cases reported and alarming mass media campaigns increased the perception of dengue severity among Thai population (Kittigul et al. 2003).

Studies show that the Thai population perceived the presence of mosquitoes as annoying, therefore the main benefit perceived from control activities was reducing these annoying aspects (Phuanukoonnon, Brough, and Bryan 2006). Furthermore, the population interviewed tended to consider the risk of having breeding sites at home as significantly minor than outside, therefore they would estimate the individual undertaking of control and prevention activities as not worth the effort implied and would tend to consider the mosquito control as best left in hands of the public authorities. The perception of self-efficacy was therefore low and the dengue control and prevention was perceived as beyond them.

In fact, as far as the perceived barriers are concerned, many among the interviewed in the study considered mosquitoes control an unrealistic goal as the promoted control activities were found by population to be incompatible with household water practices (Phuanukoonnon, Brough, and Bryan 2006).

4.5.2 Education

The education is one of the key factors determining the disease prevention and control. Firstly, most of the prevention and control programmes are disseminated through the school and health centres programmes. Secondly, the capacity to understand and analyse information, such as the information on dengue control and prevention, decides on the attitudes and practice adopted by the population.

Figure 40 presents the learning rate of Thai population, defined as the level of literacy and basic computation required for using such skills in resolving daily-life problems among the people aged 15 years and over completing Mathayomsueksa 3 (grade 9) or equivalent in proportion to the total population of the same age group. The learning rate of Thai population is low and exhibits strong disparities between the urban and rural residents groups. From 2001 to 2009, the values of learning rate for both urban and rural residents rose, but the increase was not big, with the learning rate of 53.2 in 2001, and of 58.1 in 2009 for urban residents, and of 27.2 in 2001, and of 37.9 in 2009 for urban residents. The disparities have diminished only a little.

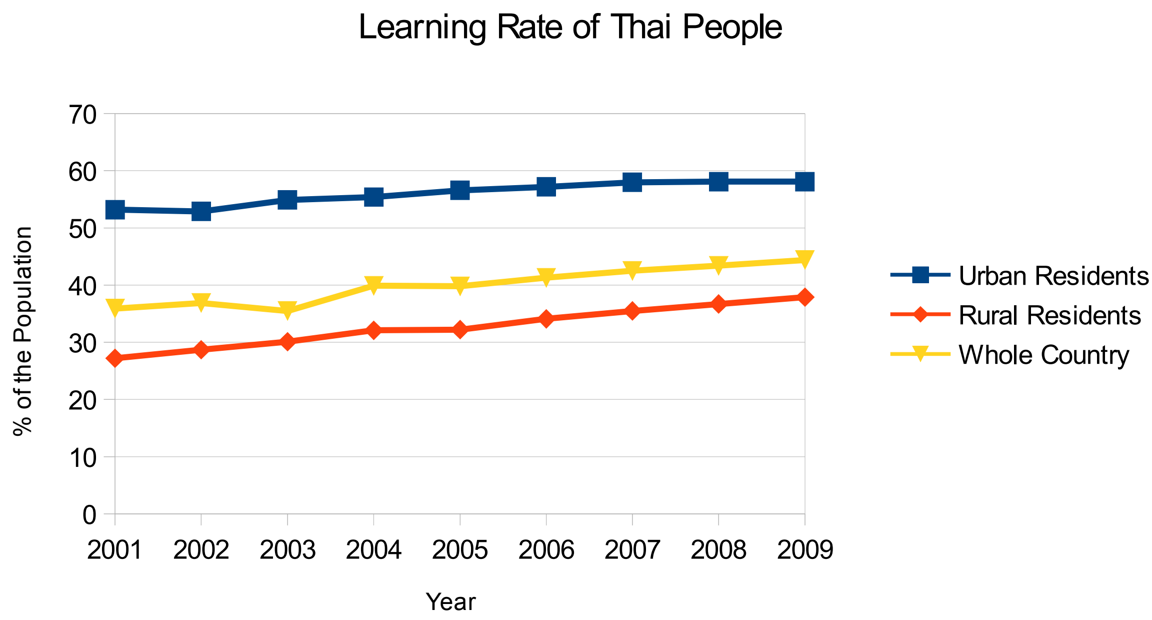

Figure 40: Learning Rate of Thai Population, Rural and Urban Residents, 2001-2009. Data obtained from the Thailand Health Report 2008-2010.

4.5.3 Water-related practices

Due to the scarcity of water in dry seasons and its abundance during wet seasons, the rainwater harvesting in Thailand is and old and traditional practice. In view of the water sustainability and security, for several years Thai citizens were encouraged by the public authorities to cultivate the rainwater-storage practices. One of the most important governmental initiatives was the launch of the Rainwater Jar Programme in the 1980s, which resulted, according to the UNICEF data, in the construction of some 300 million wire-reinforced cement rainwater storage jars and tanks from 1980 to 1991. Essential from the point of view of the water security, the rainwater-storage practices may have severe implications for dengue epidemiology, as wrong conservation of jars and scarce use of temephos may contribute to the increase of the *Aedes* mosquito-breeding.

Paddy production

The paddy rice production is essential in Thailand for both food security and economic reasons. According to the data published in the Thai National Statistical Office, from 2007 to 2009 rice was the forth principal export item in Thailand. However, from the point of view of dengue epidemiology, paddy appears to be a favourable habitat for dengue vector propagation, as the paddy crop requires utilization of vast areas of standing water (Sarfraz et al. 2012). Figure 42 presents the evolution of the paddy crop planted and harvest area land-use from 1983 to 2012. It shows that the paddy crop land-use remained very big and stable, with a slight increase in the last years. In the planted area occupied 12 602 000 hectares, (~305 000 hectares less than in 2011). It is an extremely important fact for dengue epidemiology, which correlated with the weather conditions should be considered in the dengue reporting and surveillance system, as this area extension corresponds to ~25% of all Thailand area. Most of the paddy fields in Thailand are concentrated in the Central and Northeast Regions, as Figure 41 shows. However, the North Region might be as well at risk of vector transmission due to paddy plantations in view of important immigration rates from Myanmar, as discussed in the section on the international migration (See: p. 40).

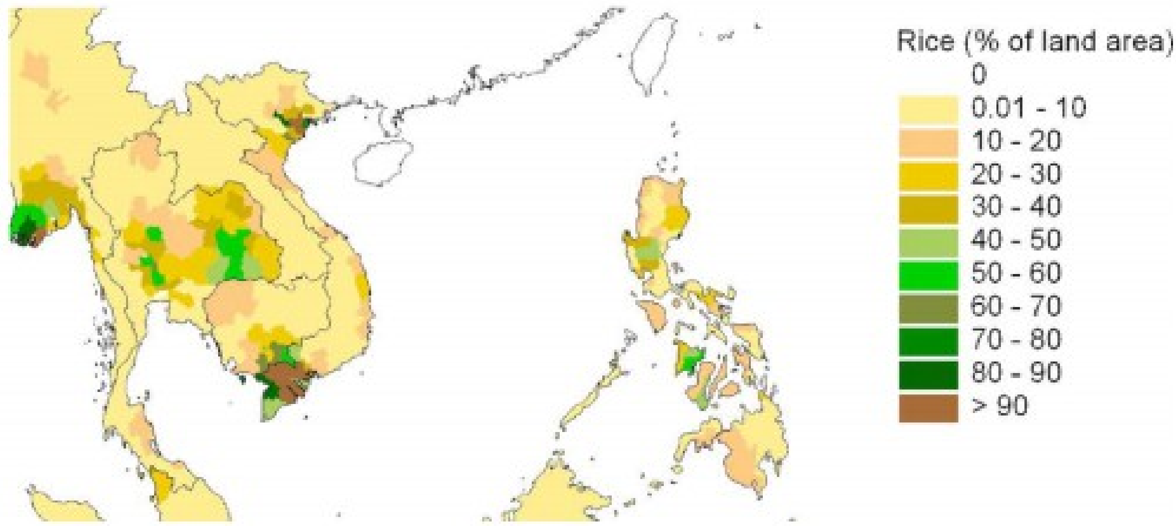

Figure 41: Paddy rice area as percentage of the district land area. Source: (Xiao et al. 2006)

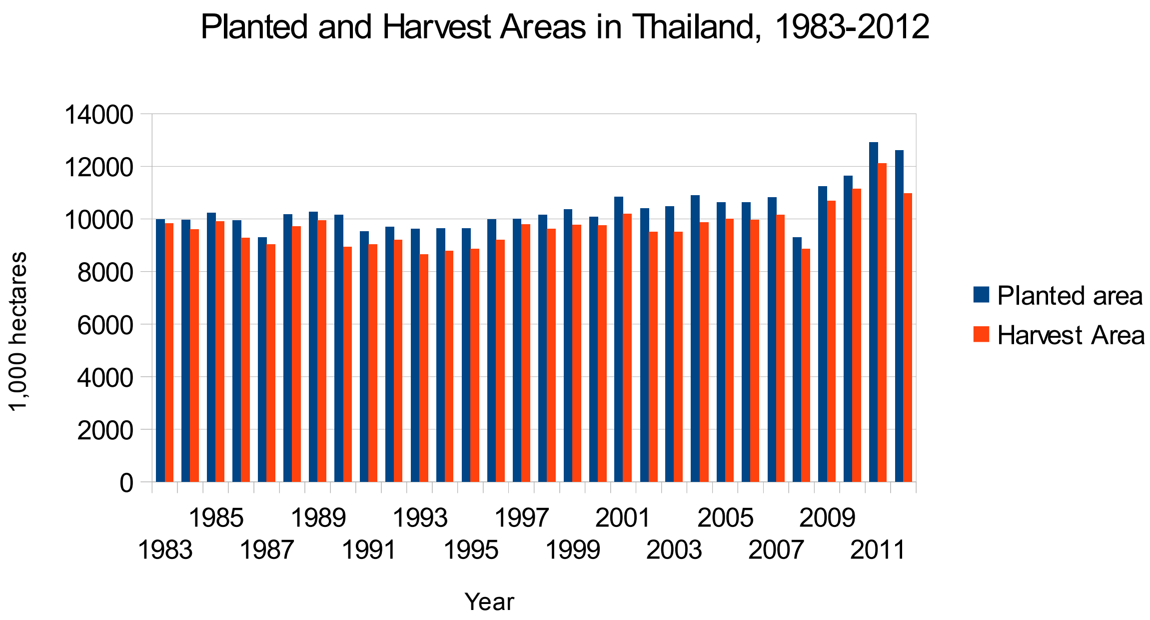

Figure 42: Paddy Crop Planted and Harvest Areas in Thailand, 1983-2012. Data obtained from the ASEAN Food Security Information System.

4.5.4 Summary

Section 4.5 revises the dengue-related Knowledge, Attitude and Practice (KAP) issues. It summarises the findings of other researches on the KAP among the Thai population. The special importance is here attributed to the statistically low dengue control and prevention knowledge among housewives, as usually they are responsible of water-related household practices and they tend to play the role of patients' care-providers. The section analyses as well the Health Beliefs Model in the context of dengue. An analysis of the learning rate of Thai population is provided. The learning rate measures the literacy and computation skills determining the capacity of solving daily-life problems, and which turns out to be low in the Thai society. In this section the attention is drawn to traditional water-related practices, which may turn out to be a potential vector-spread factor is particular measures are not undertaken. A particular role which may play one of the main economic and agricultural activities in Thailand, paddy crop planting, is dicussed. Paddy fields create a favourable habitat for *Aedes* mosquito-breeding. The surveillance and control of paddy fields in correlation with weather conditions might turn out to be crucial for the reporting system in Thailand providing that 25% of Thailand area is occupied with the paddy fields.

5 Discussion

It was found in the present study that from 1982 to 2012, despite gradually descending mortality rate, dengue incidence in Thailand remained stable. The scale of the dengue outbreaks was similar in the consecutive years, with more severe outbreaks occurring in relatively regular intervals. Moreover, the outbreak that took place in 2013 was the second biggest outbreak after the outbreak in 1987. However, when considering the incidence values it must be remembered that dengue cases tend to be under-reported, and that it might have affected particularly the count of dengue morbidity in the past. In view of the lack of vaccine and the gradual geographical spread of dengue, the improvement in dengue control and prevention is essential not only for the endemic or hyperendemic countries, such as Thailand, but also other countries, for at least two reasons. Firstly, their citizens often undertake frequent travel to endemic zones which may result in severe dengue infections, as it is more probable in secondary than in primary infections. Secondly, due to climate change and the vector's adaptation capacity, other countries may be threatened by becoming endemic in near future.

In the present study, four types of factors and indicators were studied which might have shaped dengue epidemiology in 1982-2012 and contribute to the persisting disease high incidence and international spread: demography, international migration and trade, economics and infrastructure, and dengue-related knowledge, attitude and practice (KAP) together with water-related practice.

Demography

As far as the demographic issues are considered, the observed in other studies shift in dengue morbidity towards older-age groups was contrasted with the demographic transition undergoing in Thailand during the period from 1982-2012. Thai population was found to have passed through stages 3 and 4 of the DTM and to be heading towards becoming an ageing society, with the crude death and birth trend-lines nearly meeting, and the disparity between elderly and child population size having diminished 5 times.

These findings may turn out to be very important for dengue epidemiology as, traditionally, dengue was considered almost exclusively a childhood disease. It implies that most of the guidelines describing symptoms, detection methods, or treatment are designed for child patients. Furthermore, some typical for advanced age chronic illnesses such as diabetes or hypertension may increase the severity of dengue haemorrhagic fever complications.

Another demography-related aspect of dengue epidemiology evolution is the spread of dengue to rural areas, which is claimed in this study to be hypothetically rather related to the weak reporting system and maldistribution of health service units than with an actual previous higher morbidity in urban areas. Despite a gradual but slow urbanisation process undergoing in Thailand from 1982 to 2012, 66% of Thai population still live in rural settings, and due to the internal migration process of return kind observed in Thailand, this percentage may remain stable or even increase in future. Due to the increasing number of dengue cases reported in rural areas and studies confirming positive correlations of Aedes mosquito breeding with the middle and low population densities, the still prevailing rural character of Thailand should encourage decision-makers to continue promoting the improvement of the vector control and prevention in rural settings and a good distribution of health care units.

Migration and international trade

The second class of indicators studied in the present work is the international migration and trade. Both factors are considered one of the main causes of the global dengue diffusion as they result in international movement of human cases, vectors transmitting infections and contaminated goods. The internal migration in Thailand from 1982 to 2012 was mainly of return kind from urban to rural areas although the overall proportion of urban to rural population increased slightly which might be due to the international immigrant inflow. The seasonal urban-rural migration had important values and although railway travel diminished, the trend might be due to increased road density, which was ~2.5 times bigger in 2006 than in 1990, therefore increased car and bus travel. The augmented internal short-term migration increases the internal vector-diffusion.

In last decades three types of international migration trends from/to Thailand prevailed: initially outward labour migration, high-skilled workers immigration due to the industrialisation, and general vast labour immigration. The political and labour immigration to Thailand from neighbour hyper-endemic countries increased cross-border vector-diffusion. There are other important to dengue epidemiology implications of international migration kind. Poor housing, social security, and health care conditions of low-skilled, and particularly, illegal immigrant to Thailand increase the hazard of dengue transmission or/and introduction.

As far as the international air travel in concerned, the international commercial air movements were studied from/to Bangkok international airports, BKK and DMK, which constitute main international airports for Thailand and one of the most important hubs for Asian and global scheduled air traffic.

From 1996 to 2012, the size of international movements from/to BKK and DMK nearly doubled and in 2012 the airports served 221 541 commercial international air movements. The increase in the international air traffic is of great importance to dengue epidemiology due to fast global spread of dengue, the extension of areas at risk of dengue introduction, and the issue of frequent travellers, as a secondary, as compared to primary, dengue infection is much more probable to result in a severe dengue fever. The evolution of top destinations from/to BKK and DMK was as well analysed which might be useful for the dengue reporting system considering the vector-transmission patterns. All of the top air destinations countries reported during last years an alarming increase of dengue incidence, both in terms of the imported as well as locally-contracted infections. The conclusion might be drawn that the augmenting international air traffic not only increases dengue incidence in travellers but also the risk of vector introduction and/or spread.

In terms of international trade, important for dengue research indicators were studied. Thailand economy is exports-oriented and, importantly for dengue global diffusion, its exports are in a big measure based on vehicles, tyres, and natural rubber trade. It is extremely important as inappropriate conditions of goods, and particularly human-made containers made from rubber, are one of the most important vector breeding sites, therefore transmission mode. For all three types of goods, the values of exports experienced a great increase from 1982-2012. This fact should be taken in a serious consideration by decision-making actors as far as dengue prevention and control are considered.

Economics and infrastructure

The relationship between dengue epidemiology and Thai economy and infrastructure was studied for the period from 1982 to 2012. Such crucial issues and indicators were analysed as the Thai national health infrastructure, 'hard' infrastructure, and economic and disease burden in Thailand.

A positive evolution of the health care accessibility in Thailand was observed. However, most of the indicators studied showed a still persisting, although decreasing, disparity of health care accessibility among the regions. The implementation of the universal coverage health care policy, and previous medical welfare for poor programme, were found as a significant improvement which where the leading causes of the decrease from 66.5 in 1991 to 2.6 in 2009 the percentage of the Thai population without any health insurance. The health service utilization, population to health personnel, doctor, and bed ratios by region were studied and it was found that initially all the ratio values strongly differed depending on the region, Bangkok region having the best values and the

North East region having the lowest. Throughout the project's target period the results for all the regions greatly improved and disparities diminished, but important differences still persist, in particular in terms of the outpatient service utilization, population to health personnel and hospital bed ratios. The results contribute in at least to ways to dengue epidemiology. They may serve as encouragement for further improvement of health service and dengue control and prevention and accessibility-inequalities diminishing, as well as an explanation of previous tendency to consider dengue mainly urban and peri-urban disease – as it might have resulted from the differences in reporting system due to health units maldistribution and it concentration in urban areas.

The evolution of health expenditure in Thailand from 1995 to 2011 was as well analysed. It was found that in 2011 the total health expenditure was ~2.15 times higher than in 1995 and meanwhile the private expenditure remained rather stable, the general government expenditure on health experienced a ~3.5-fold increase. The share of out-of-pocket expenses in the private health expenditure diminished. The conclusion can be drawn that the disease burden, including dengue diseases, on the households, out of which many otherwise would not be able to afford the medical costs, might have diminished.

The indicators of the economic and disease burden of dengue for Thailand were collected and withdrawn from other researches and contrasted. Dengue economic and disease burden on Thai population is high, the comparison of the most up-to-date and comprehensive results in scientific literature resulted in its annual value estimation as 5.28 U.S. dollars per capita and 28 475 DALYs. In view of high private out-of-pocket and indirect costs, the poverty ratios in Thailand were studied. It was found that despite a significant decrease in the poverty ratios from 1982 to 2010, in 2010 13.2% still lived below the national poverty line. The results invite for the reflection on the impact of dengue on the national macro and micro-economics, once again confirming the severity of dengue epidemiology burden at both macro and micro levels, dengue affecting national and private expenditure, productivity and exhibiting the health and social repercussions of economic inequalities between poor and better-off population.

With regard to the 'hard' infrastructure, the data on water source was provided, stating, among others, that in 2007 37% of households used rainwater as source of drinking water, depending on the way of storage. This finding may be important for dengue prevention and control, as wrong practices in water storage may result in creating perfect habitat for *Aedes* larvae.

Dengue-related KAP

As far as dengue-related KAP is concerned, the literature was revised to summarise findings on dengue KAP as well as perceived susceptibility, severity, benefit, barriers and self-efficacy (HBM) among Thai population in the period from 1982 to 2012. Low dengue control and prevention knowledge among housewives was retained as particularly important finding since usually they are in charge of water-related household practices and they tend to play the role of patients' care-providers. A good KAP of housewives is therefore essential for an overall effective dengue prevention and control. It was hypothesised that a good KAP and HBM may be related to the learning rate of Thai population as the indicator measures the literacy and computation skills determining the capacity of solving daily-life problems. It was found that the learning rate among Thai population in 2009 was low, despite of a slight improvement as compared to the data for 2001. Important disparities persisted between rural and urban population, their learning rate ratios respectively being in 2009 of 37.9 and 58.1.

Rainwater harvesting Thai traditional practice was analysed as its cultivation for the water security and sustainability reasons must be retained by decision-makers in order to insist on mosquito-breeding prevention activities.

The data on the paddy crop fields extension in Thailand was analysed, as they seem to constitute a favourable habitat for dengue vector propagation. It was found that the paddy production is one the most important pillars of Thai trade and from 1983 to 2012 the size of paddy planted area gradually increased, in 2012 occupying 25% of all Thailand area. Due to the extension of the paddy fields in Thailand, the surveillance of mosquito breeding and weather conditions in the context of paddy production should have an important place among factors to be taken into consideration for the dengue reporting and surveillance system.

6 Conclusions

The goal of the project was to examine socio-economic and demographic changes in Thailand 1982-2012 which might be related to the evolution of dengue epidemiology. The thesis was designed to support the DENFREE project and the IC3 spatio-temporal model of climate-sensitive disease risk.

The background of the study presents basic information on dengue epidemiology, and discusses dengue infections classification, transmission mode, main transmission-hazard factors, and evolution of dengue global spread. Methods applied in the study consisted in literature review in search for patterns of socio-economic and demographic factors influence on dengue epidemiology. These patterns and correlations where used to conduct a research on dengue-related socio-economic and demographic changes undergone in Thailand from 1982 to 2012. A comprehensive database was created and the data collected for each indicator was contrasted with other findings and interpreted in the context of dengue epidemiology.
Further, the data collected can be incorporated into dengue prediction models to help capture the impact of socio-economic and demographic factors on dengue risk.

The DENFREE programme aims at identifying key factors determining dengue transmission, outcome of infection and epidemics, and developing novel diagnostic tools to detect asymptomatic infections. The prevention of dengue epidemics in Europe by the means of surveillance system lies in the area of DENFREE´s main focus. In this sense, our study contributes to the programme aims' execution as identifying and analysing socio-economic and demographic factors which

1) determine the scale of dengue incidence,
2) contribute to improving dengue reporting and surveillance system,
3) challenge the present dengue-epidemiology management as requiring changes in the present symptoms, treatment, and control guidelines,
4) contribute to determining dengue economic and disease burden.

Dengue incidence and mortality in Thailand 1982-2012

Regular and stable pattern of DHF morbidity was observed, with one of the biggest outbreak having taken place in 2013. This finding arose three conclusions. In view of lack of vaccine against dengue diseases, control and prevention programmes should be strengthened and rendered more efficient. Dengue control and prevention should be strengthened as well in terms of international travellers, particularly the frequent ones and in view of the threat of the vector introduction in endemic and in the vector-free areas. Finally, low morbidity rates in the past might be related to the under-reporting of dengue incidence.

Decreasing mortality rates may be due to improvement of dengue treatment, the increased accessibility of the health-care services and infrastructure, more efficient dengue control and prevention programmes, better dengue KAP among the Thai population, as well as a general improvement of socio-economic indicators.

High morbidity was observed in Central, and South Regions, and the southern part of the North Region. However, higher values of the morbidity rates for these regions might perhaps need revising due to the under-reporting and low health-care accessibility in some areas.

Demography

Thailand is heading towards an ageing-society, with low natural increase rate, and increased elderly-child ratios. This finding draws attention to the need for a revision of dengue symptoms, treatment, control and prevention guidelines as a shift in dengue-incidence modal age towards older-age groups is observed. Furthermore, an increased severity of DHF complications may tend to occur, as the DHF incidence augments among older patients with chronic illnesses such as diabetes or hypertension.

Rural population still prevails over the urban citizens in Thailand. Therefore, decision-makiers should insist on the efficacy of the dengue control and prevention programmes in rural zones. A better distribution of health care units and services should be as well obtained.

Migration and international trade

Decreased railway travel, increased road density and passenger cars/population rates were observed. This finding is important for dengue epidemiology as increased short-term and seasonal migration increases the internal vector-diffusion. The promotion of vector-control measures such as, for instance, air-conditioning in vehicles should be considered.

High rates of immigration from neighbour countries were observed in Thailand. It might have implied an increased cross-border vector-transmission, from other endemic countries which tend to also experience important dengue outbreaks.

Low-skilled workers and illegal immigrants are not being guaranteed by the government their human rights of housing, social security and health care basic standards. The consequent low standards of housing, social security, and health care provision among illegal and low-skilled workers immigrants increases the hazard of dengue transmission and/or introduction.

Increase of international air traffic was observed, and BKK and DMK play progressively more important role as two of the most important hubs for Asian and global scheduled air traffic. This trend implies an increased risk of dengue vector transmission and/or introduction to endemic areas, and increases the hazard of triggering a dengue outbreak as well in new geographical areas. Dengue control and prevention should be strengthened also in terms of international travellers, particularly the frequent ones, as severe forms of dengue fever tend to occur due to secondary rather than primary infections.

All of the countries with which the highest numbers of flights were exchanged reported alarmingly high dengue incidence rates during last years. Some of them where the countries where the cases reported are mainly imported infections from Southeast Asia.

The exports of vehicles, tyres and natural rubber were found to increase significantly during the study target period. The increased exports of human-made containers from rubber tend to greatly increase vector-transmission hazard. Therefore, security measures aiming at prevention of dengue-vector transmission should be implemented.

Economics and infrastructure

Thailand health infrastructure improved in terms of health service utilization, population to health personnel, doctor, and hospital bed ratios. However, significant disparities among regions persist. The conclusion arises that the decrease in DHF mortality is related to the improvement of health care utilization and accessibility indicators. On the other hand, in order to stem dengue outbreaks and its burden, a better distribution of the health care services and units should be assured. Moreover, the previous lower incidence results in rural areas might be related to under-reporting due to low health services and units accessibility.

Increase in public health expenditure, and a stable private expenditure were observed. Therefore, a decrease of the economic and disease burden on the households might be hypothesised. The finding might imply as well an improvement in the equality of health care services provision. However, a steady increase in the public health expenditure must be problematic for the government from a financial point of view. Stable private expenditure might be a sign of low elasticity of private demand in view of increasing costs.

High dengue economic and disease burden in Thailand was contrasted with decreased, but still important poverty rates. The high economic and social costs of dengue should encourage the decision-making national and international actors to combat dengue diseases. Due to high costs of dengue, some of the ill might be unable to seek treatment. Moreover, the consequences of illness may result devastating not only at a macro, but perhaps first of all at a micro-level, both in economic, and social terms.

Rainwater was observed as an important source of drinking water. Dengue control and prevention programmes should be implemented in order to improve dengue KAP related to the water-storage among the Thai population.

KAP and water-related practices

Low learning rate was found to persist in Thai society, with important rates disparity between rural and urban population. Low capacity of solving daily-life problems with the use of literacy and computation skills may have an important impact on dengue-related KAP. Low dengue KAP might be particularly severe at housewives, as, first, their KAP may be decisive for dengue prevention and control measures applied in household, and, second, because they are usually the care-takers of dengue patients.

It was found that rainwater harvesting and storage constitutes a traditional practice and that the cultivation of this tradition, encouraged by public authorities, is motivated by the water security and sustainability reasons. Therefore, mosquito-breeding prevention activities, such as, for instance, use of temephos, should be promoted and fostered.

It was observed that the paddy-planted area constitutes 25% of total Thailand extension. It is an important fact as paddy fields create a favourable habitat for *Aedes* larvae. The surveillance of dengue-vector breeding in the paddy fields together with the climate and weather surveillance should be undertaken for dengue prevention, surveillance, and reporting system.

Summary

Socio-economic and demographic factors determining the scale of dengue incidence

An improvement in many relevant indicators, such as the access to health security, units and services, or decreasing poverty, was stated in Thailand from 1982 to 2012. Despite that, the incidence of dengue was found to remain high. It was hypothesised that high morbidity might be related to the increase of the international air traffic, cross-border and internal migration, trade in vehicles, tyres and natural rubber; expanding paddy crop plantations. Additionally, disparities in health care and services distribution among regions and between urban and rural zones, as well as in learning rates, might have increased the incidence in the underprivileged zones. What is more, low housing, social security, and health services standards among illegal and low-skilled workers immigrants might have been at the origin of greater dengue transmission.

Socio-economic and demographic factors which may contribute to improving dengue reporting and surveillance system

Disparities in the access to health and social services might have provoked errors in dengue reporting. The differences between indicators for urban and rural zones might be at the origin of a hypothetically false former conviction that dengue was principally urban and peri-urban disease. The access to health and social services should be therefore improved and the disparities among regions and rural/urban zones should be reduced. The largely-extended paddy fields in Thailand provide a perfect habitat for *Aedes* laravae. Therefore, their surveillance is essential in terms of spatio-temporal disease-preventive models. In view of the increasing international travel and trade, it might be useful to study top air destinations as we found that the countries which exchanged most air movements with Thailand reported in the last years a significant increase in dengue incidence, both in terms of local epidemics, and of imported cases.

Socio-economic and demographic factors challenging the present dengue-epidemiology management as requiring changes in the present symptoms, treatment, and control guidelines

The demographic transition towards an ageing-society in Thailand was found to challenge dengue epidemiology as demanding establishing new symptoms, control, and treatment guidelines. The shift in the age distribution of dengue cases towards older age groups and the increasing percentage of elderly in Thai population require reconsideration of the guidelines. They imply as well a rise in severe dengue complications due to simultaneous high incidence of chronic disease in older patients.

Socio-economic and demographic factors which contribute to determining dengue economic and disease burden

Dengue epidemiology management was found to be challenged by high disease and economic burden of dengue, parallel to significant poverty rates, low dengue-related knowledge, inappropriate attitudes and practice in execution of daily-life and traditional practices.

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8 List of Figures and Acronyms

List of figures

List of Acronyms

9 Appendix A

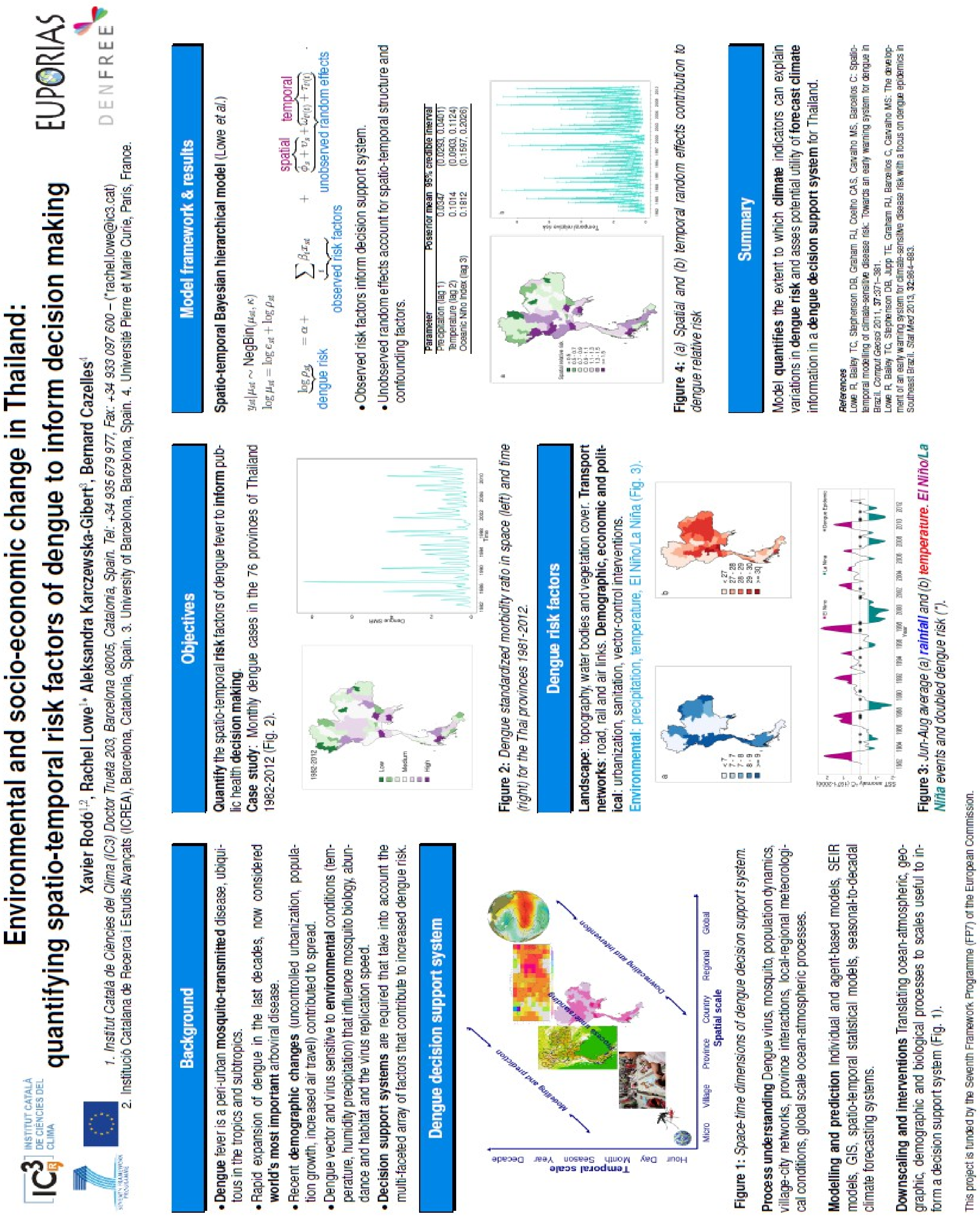

Figure 43: Rodo, X., R. Lowe, A. Karczewska-Gibert, and B. Cazelles. "Environmental and socio-economic change in Thailand: quantifying spatio-temporal risk factors of dengue to inform decision making." In AGU Fall Meeting Abstracts, vol. 1, p. 1123. 2013

10 Appendix B

Appendix B presents the data included in the thesis.

The data on the international air traffic obatined thanks to the kindness of the Department of Civil Aviation of Kingdom of Thailand is not included here due to its size. However, it can be downloaded from the thesis data folder available online:
https://www.dropbox.com/s/umc8r665h4a49gi/Air%20Traffic.rar.

The thesis database is available here:
https://www.dropbox.com/s/cvkyv1u0ndyw8k4/Master%20Thesis%20Database.ods

Table 1
DHF incidence and mortality per 100 000 population in Thailand, 1982-2013. Source: the Thai National News Bureau and the Thailand Health Report 2008-2010, MoPH (available online: http://www.moph.go.th/ops/thp/thp/en/index.php?page=e_doc&group_=05).

Year	DHF incidence per 100,000 population	DHF mortality rate per 100,000 population
1982	45.89	0.55
1983	60.71	0.46
1984	137.27	0.99
1985	154.94	1.05
1986	52.88	0.45
1987	325.13	1.85
1988	49.38	0.33
1989	120.42	0.47
1990	163.43	0.75
1991	77.27	0.24
1992	71.16	0.24
1993	111.92	0.31
1994	40.09	0.21
1995	101.92	0.31
1996	63.09	0.19
1997	167.21	0.42
1998	211.42	0.69
1999	40.39	0.09
2000	30.19	0.05
2001	226.53	0.39
2002	187.52	0.28
2003	99.56	0.12
2004	62.59	0.08
2005	73.79	0.11
2006	74.89	0.09
2007	104.21	0.15
2008	141.78	0.16
2009	89.27	0.08
2010	NA	NA
2011	87.62	0.08
2012	116.88	0.12
2013	228.01	0.20

Table 2

Total, rural, urban, and living in agglomerations of 750 000 or more inhabitants population in Thailand. Source of data: UNESCAP online database (available here: http://www.unescap.org/stat/data/statdb/DataExplorer.aspx).

Year	Rural population	Urban population	Population living in agglomerations of 750 000 or more inhabitants	Total population
1982	35799	13448	N/A	49247
1983	36335	13830	N/A	50165
1984	36871	14219	N/A	51090
1985	37414	14618	N/A	52032
1986	37971	15032	N/A	53003
1987	38536	15457	N/A	53993
1988	39076	15881	N/A	54957
1989	39548	16285	N/A	55833
1990	39934	16649	6027	56583
1991	40262	16923	N/A	57185
1992	40499	17162	N/A	57661
1993	40687	17383	N/A	58070
1994	40882	17609	N/A	58491
1995	41126	17858	6338	58984
1996	41426	18136	N/A	59562
1997	41770	18437	N/A	60207
1998	42148	18755	N/A	60903
1999	42539	19084	N/A	61623
2000	42928	19416	6749	62344
2001	43308	19761	N/A	63069
2002	43678	20120	N/A	63798
2003	44009	20479	N/A	64488
2004	44265	20822	N/A	65087
2005	44422	21137	7879	65559
2006	44467	21417	N/A	65884
2007	44412	21665	N/A	66077
2008	44287	21898	N/A	66185
2009	44141	22137	N/A	66278
2010	44005	22398	9306	66403
2011	43890	22687	N/A	66577
2012	43784	23001	N/A	66785

Table 3

Crude birth, death, and natural increase rates in Thailand 1982-2012. Source of data: UNESCAP online database (available here: http://www.unescap.org/stat/data/statdb/DataExplorer.aspx).

Year	Crude Birth Rate	Crude Death Rate	Natural Increase
1982	24.7	6.9	17.8
1983	23.8	6.7	17.1
1984	23	6.4	16.6
1985	22.2	6.1	16.1
1986	21.5	5.9	15.6
1987	20.8	5.7	15.1
1988	20.2	5.6	14.6
1989	19.7	5.6	14.1
1990	19.2	5.6	13.6
1991	18.7	5.7	13
1992	18.3	5.9	12.4
1993	17.8	6	11.8
1994	17.3	6.1	11.2
1995	16.9	6.3	10.6
1996	16.4	6.4	10
1997	15.9	6.5	9.4
1998	15.4	6.6	8.8
1999	15	6.7	8.3
2000	14.6	6.8	7.8
2001	14.2	6.9	7.3
2002	13.8	6.9	6.9
2003	13.4	7	6.4
2004	13	7	6
2005	12.6	7	5.6
2006	12.3	7	5.3
2007	11.9	7.1	4.8
2008	11.6	7.2	4.4
2009	11.3	7.2	4.1
2010	11	7.4	3.6
2011	10.7	7.5	3.2
2012	10.5	7.6	2.9

Table 4

Child and elderly population as percentage of total Thai population, 1980-2012. Source of data: UNESCAP online database (available here:
http://www.unescap.org/stat/data/statdb/DataExplorer.aspx).

Year	Elderly population	Child population
1980	3.7	39.4
1981	3.8	38.5
1982	3.8	37.6
1983	3.9	36.7
1984	3.9	35.7
1985	4	34.8
1986	4	33.8
1987	4.1	32.9
1988	4.2	32
1989	4.3	31.1
1990	4.5	30.2
1991	4.7	29.6
1992	4.9	29
1993	5.1	28.4
1994	5.3	27.9
1995	5.5	27.3
1996	5.7	26.7
1997	5.9	26
1998	6.1	25.3
1999	6.3	24.7
2000	6.6	24.2
2001	6.8	23.7
2002	7	23.4
2003	7.3	23
2004	7.5	22.7
2005	7.7	22.3
2006	7.9	21.7
2007	8.2	21
2008	8.4	20.4
2009	8.6	19.8
2010	8.9	19.3
2011	9.1	18.9
2012	9.4	18.5

Table 5

Road density and passenger cars to 1000 population in Thailand, 1982-2010. Source of data: UNESCAP online database (available here: http://www.unescap.org/stat/data/statdb/DataExplorer.aspx).

Year	Road density	Passenger cars to 1000 population
1982	NA	NA
1983	NA	NA
1984	NA	NA
1985	NA	NA
1986	NA	NA
1987	NA	NA
1988	NA	NA
1989	NA	NA
1990	141	NA
1991	102	NA
1992	106	NA
1993	111	NA
1994	116	NA
1995	121	NA
1996	126	NA
1997	126	NA
1998	126	NA
1999	126	NA
2000	NA	NA
2001	NA	NA
2002	NA	NA
2003	NA	54
2004	NA	NA
2005	NA	61
2006	352	57
2007	NA	NA
2008	NA	NA
2009	NA	62
2010	NA	67
2011	NA	NA
2012	NA	NA

Table 6

Railway passenger and railway freight in Thailand, 1982-2011. Source of data: UNESCAP online database (available here: http://www.unescap.org/stat/data/statdb/DataExplorer.aspx).

Railway Passenger - transport of rail passengers in millions by rail over a distance of 1 km.
Railway Freight – transport in million tons of goods by rail over a distance of 1 km.

Year	Railway Passenger	Raliway Freight
1982	9231	2421
1983	9699	2413
1984	9643	2618
1985	9140	2718
1986	9274	2583
1987	9583	2729
1988	10301	2867
1989	10936	3065
1990	11612	3291
1991	12820	3365
1992	14136	3075
1993	14718	3059
1994	13814	3072
1995	12975	3242
1996	12279	3365
1997	11878	3483
1998	10947	2921
1999	9959	3016
2000	9935	3384
2001	10321	3724
2002	10378	3908
2003	10251	3987
2004	9332	4085
2005	9195	4037
2006	9195	NA
2007	NA	NA
2008	8037	3161
2009	8037	3161
2010	8037	3161
2011	7504	2455

Table 7

Net international migration rates in Thailand, 1980-2010. Source of data: UNESCAP online database (available here: http://www.unescap.org/stat/data/statdb/DataExplorer.aspx).

Year	Net Migration Rate
1980-1985	1.4
1985-1990	1.9
1990-1995	-3.8
1995-2000	2
2000-2005	3.4
2005-2010	-2.2

Table 8

Foreign immigration in Thailand, 1990-2010. Source of data: UNESCAP online database (available here: http://www.unescap.org/stat/data/statdb/DataExplorer.aspx).

Year	Foreign Inmigration
1990	529
2000	1258
2010	3224

Table 9

The value of international trade in tyres in US dollars, in Thailand, 1989-2012. Source of data: the United Nations Commodity Trade Statistics Database (available online: http://comtrade.un.org/db/).

Year	New, Exports	Used, Exports	New, Imports	Old, Imports
1989	53320183	4490650	17287075	2450784
1990	67296116	5134764	35336909	2180702
1991	78478394	4940945	22466572	2315035
1992	108761838	5914992	25476715	4020140
1993	127666494	6801003	32660733	4775780
1994	150213385	7971916	39386193	7042244
1995	180954128	10677606	44594400	8636373
1996	202609874	8590145	40466611	9042075
1997	233172847	9799437	30648679	9791497
1998	276097940	9277400	12595880	8222627
1999	270119753	12001855	23023219	8208706
2000	300098549	13096871	27049925	10155675
2001	336484107	12989456	36109406	10955665
2002	391348898	13091462	39214841	11727665
2003	427017528	18827067	47702736	11201772
2004	615323119	24237779	70147908	12449205
2005	828963627	29135508	85236737	14021943
2006	1117884360	37820520	120340073	16085861
2007	1511574426	47940215	177591281	17805536
2008	1946190105	55160984	181198403	23411537
2009	1775238818	41504556	165501250	26314967
2010	2552775634	52092213	239446776	36167924
2011	3617510764	84892837	307571846	34571235
2012	3301701818	89053309	416939745	41604823

Table 10

Value of trade in vehicles other than railway, in US dollars, in Thailand 1982-2012. Source of data: the United Nations Commodity Trade Statistics Database (available online: http://comtrade.un.org/db/).

Year	Export	Import
1982	14224756	99107696
1983	22582160	146787808
1984	15349873	137557824
1985	18316516	123525912
1986	9304069	119292368
1987	12881783	157233456
1988	N/A	1351786597
1989	126057767	1882310411
1990	136102006	2646242706
1991	180744539	2165413841
1992	212350116	2636189681
1993	530167853	3656536027
1994	798083724	4266067177
1995	658350592	5488515072
1996	745876924	5129645254
1997	1132501794	2556875820
1998	1312048006	560668711
1999	1981134767	1346745787
2000	2518626292	2049588508
2001	2766723288	2020077220
2002	3003188767	2319332056
2003	4135335097	3159710041
2004	5775704016	3674683601
2005	8152289419	4035743177
2006	10093003547	3916834574
2007	12821227221	4471360623
2008	16494710083	5740315443
2009	11994653253	4690729091
2010	18583017321	7817435154
2011	18163995299	8645359823
2012	24290549656	12413394032

Table 11

Percentage of households by source of drinking water, Thailand, 2007. Source of data: Thai National Statistical Office Database (available online: http://web.nso.go.th/index.htm).

Source of Drinking Water	Percentage of Households
Bottle-water	28.7
Inside piped water supply	21.2
Inside piped underground water	7.1
Outside piped or public tap	1.1
Well or underground water	3.9
River, stream etc	0.6
Rain water	37
Other	0.6

Table 12

Percentage of households by type of water supply, Thailand, 2007. Source of data: Thai National Statistical Office Database (available online: http://web.nso.go.th/index.htm).

Type of Water Supply	Percentage of Households
Inside piped underground water	19.6
Other	0.7
Rain water	0.6
Outside piped or public tap	2.4
Well or underground water	6.6
River, stream etc	2.1
Inside piped water supply	68.1

Table 13

Health expenditure in Thailand, 1995-2011. Source of data: UNESCAP online database (available here: http://www.unescap.org/stat/data/statdb/DataExplorer.aspx).

Year	Total health expenditure per % of GDP	Total Health Expenditure Per Capita PPP Dollars	General Government Health Expenditure in per capita PPP dollars	General Government Health Expenditure as % of government expenditure	General Government Health Expenditure as % of Total Health Exp.	Private Health Expenditure as % of Total Health Exp.	Out of pocket expenditure as % of private health exp.	Private Health Expenditure Per Capita in PPP Dollars	Out-of-Pocket Private Expenditure in Health per Capita in PPP Dollars	Not-Out-of-Pocket Private Expenditure in Health per Capita in PPP Dollars
1995	3.5	164	77	10.8	47	53	80.4	87	70	17
1996	3.8	190	90	11.3	47.2	52.8	80.4	100	81	20
1997	4	196	106	10.9	53.9	46.1	80.1	90	72	18
1998	3.7	164	90	9.2	54.8	45.2	78.3	74	58	16
1999	3.5	161	88	7.8	54.9	45.1	76.5	73	56	17
2000	3.4	166	93	11	56.1	43.9	76.9	73	56	17
2001	3.3	167	94	10.4	56.4	43.6	75.8	73	55	18
2002	3.7	197	125	9.8	63.5	36.5	74.6	72	54	18
2003	3.6	206	132	13	63.8	36.2	74.2	75	55	19
2004	3.5	219	142	12.4	64.9	35.1	74.3	77	57	20
2005	3.5	237	152	12.4	64.4	35.6	76.5	84	65	20
2006	3.5	251	182	13.7	72.7	27.3	63.7	69	44	25
2007	3.6	274	210	14.5	76.3	23.7	61.2	65	40	25
2008	4	318	242	16.1	76.2	23.8	60.9	76	46	30
2009	4.2	328	244	15	74.6	25.4	59.6	83	50	34
2010	3.9	331	248	14.3	75	25	55.8	83	46	37
2011	4.1	353	267	14.5	75.5	24.5	55.8	86	48	38

Table 14

Percentage of Thai population by type of health insurance, 1991-2009. Source of data: 2008-2010 Thailand Health Report, MoPH (available online: http://www.moph.go.th/ops/thp/thp/en/index.php?page=e_doc&group_=05).

Year	Universal Coverage Scheme	UCS, paying 30 baht-visit	UCS, not paying 30 baht-visit	Medical Welfare for the poor	Medical benefits for civil servants and state enterprise employees	Social security and workers' compensation fund	Voluntary Health Insurance, Health Card, MoPH	Voluntary Private Health Insurance	Any Health Insurance	No Health Insurance
1991	NA	NA	NA	12.7	15.3	NA	1.4	3.1	33.5	66.5
1992	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
1993	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
1994	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
1995	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
1996	NA	NA	NA	12.6	10.2	5.6	15.3	0.8	45.5	54.5
1997	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
1998	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
1999	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
2000	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
2001	0.9	0.9	0	31.5	8.5	7.2	20.8	1.3	71	29
2003	74.7	74.7	0	NA	8.9	9.6	NA	1.7	94.9	5.1
2004	73.5	42.9	30.6	NA	9.4	10.7	NA	0.8	94.3	5.7
2005	72.2	44.1	28.1	NA	9.8	11	NA	1	95.1	4.9
2006	74.3	45.7	28.6	NA	8.9	11.4	NA	0.7	96	4
2007	73.6	30.9	42.8	NA	9.1	21.1	NA	1.1	96.3	3.7
2008	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
2009	76.1	0	76.1	NA	7.7	12.3	NA	0.9	97.4	2.6

Table 15

Rate of outpatient service utilisation in Thailand by region, 2001-2009. Source of data: Thailand Health Report, 2008-2010, MoPH (available online: http://www.moph.go.th/ops/thp/thp/en/index.php?page=e_doc&group_=05).

Year	Rate of Outpatient Service Utilization in the region of Bangkok	Rate of outpatient service utilization in the Central region	Rate of outpatient service utilization in the North region	Rate of outpatient service utilization in the Northeast region	Rate of outpatient service utilization in the South region
1995	NA	NA	NA	NA	NA
1996	NA	NA	NA	NA	NA
1997	NA	NA	NA	NA	NA
1998	NA	NA	NA	NA	NA
1999	NA	NA	NA	NA	NA
2000	NA	NA	NA	NA	NA
2001	4	2	1.6	1.2	1.7
2002	3.9	2.1	1.6	1.3	1.7
2003	4.4	2.3	1.7	1.3	1.7
2004	4.4	2.3	1.8	1.3	1.8
2005	5.1	2.5	2	1.4	1
2006	5.4	2.7	2	1.5	1.9
2007	6.4	2.9	2.1	1.6	2.1
2008	4.1	3.3	2.2	1.5	2.1
2009	3.7	4.2	3.1	3.1	3.2

Table 16

Rate of Inpatient Service Utilization in Thailand by region, 1995-2009. Source of data: Thailand Health Report 2008-2010, MoPH (available online: http://www.moph.go.th/ops/thp/thp/en/index.php?page=e_doc&group_=05).

Year	Rate of Inpatient Service Utilization in the region of Bangkok	Rate of inpatient service utilization in the Central region	Rate of inpatient service utilization in the North region	Rate of inpatient service utilization in the Northeast region	Rate of inpatient service utilization in the South region
1995	11.6	12.4	9.4	8.4	10.7
1996	NA	NA	NA	NA	NA
1997	15.5	13.8	11.9	11	12.3
1998	NA	NA	NA	NA	NA
1999	19.9	15	12.7	10.4	12
2000	NA	NA	NA	NA	NA
2001	22.3	15.7	15	10.7	13.9
2002	NA	NA	NA	NA	NA
2003	20.3	14.4	13.1	10.7	13.5
2004	NA	NA	NA	NA	NA
2005	21.7	15.6	12.8	10.6	13.8
2006	20.1	16.1	13.3	10.9	14.6
2007	26.2	15.9	13.5	11.3	15
2008	14.4	15.3	13.2	11.2	16.6
2009	11	15.2	10.9	11.3	15.7

Table 17

Rate of population to health personnel at subdistrict health centres in Thailand by region, 1982-2009. Source of data: Thailand Health Report 2008-2010, MoPH (available online: http://www.moph.go.th/ops/thp/thp/en/index.php?page=e_doc&group_=05).

Year	Central	North	South	Northeast
1983	NA	NA	NA	NA
1984	NA	NA	NA	NA
1985	NA	NA	NA	NA
1986	NA	NA	NA	NA
1987	1833	2387	2064	3167
1988	NA	NA	NA	NA
1989	NA	NA	NA	NA
1990	NA	NA	NA	NA
1991	NA	NA	NA	NA
1992	NA	NA	NA	NA
1993	NA	NA	NA	NA
1994	NA	NA	NA	NA
1995	NA	NA	NA	NA
1996	1125	1512	1161	1785
1997	1109	1293	1079	1582
1998	1207	1389	1129	1681
1999	1180	1349	1127	1655
2000	1059	1292	1141	1666
2001	1453	1572	1378	1938
2002	1470	1603	1416	1971
2003	1552	1713	1511	2097
2004	NA	NA	NA	NA
2005	NA	NA	NA	NA
2006	1625	1662	1557	1956
2007	1634	1674	1572	1968
2008	1523	1489	1339	1722
2009	1556	1449	1327	1681

Table 18

Population to doctor ratio in Thailand by region, 1983-2009. Source of data: Thailand Health Profile 2008-2010, MoPH (available online: http://www.moph.go.th/ops/thp/thp/en/index.php?page=e_doc&group_=05).

Year	Bangkok	Central	North	South	Northeast
1983	1404	7179	10879	10061	19675
1984	NA	NA	NA	NA	NA
1985	NA	NA	NA	NA	NA
1986	NA	NA	NA	NA	NA
1987	1418	6663	8297	7705	12694
1988	NA	NA	NA	NA	NA
1989	NA	NA	NA	NA	NA
1990	NA	NA	NA	NA	NA
1991	958	6079	5805	6317	10970
1992	NA	NA	NA	NA	NA
1993	NA	NA	NA	NA	NA
1994	NA	NA	NA	NA	NA
1995	999	4091	5591	5844	10936
1996	NA	NA	NA	NA	NA
1997	NA	NA	NA	NA	NA
1998	NA	NA	NA	NA	NA
1999	760	3653	4869	4888	8116
2000	NA	NA	NA	NA	NA
2001	NA	NA	NA	NA	NA
2002	NA	NA	NA	NA	NA
2003	924	3301	4609	4766	7409
2004	NA	NA	NA	NA	NA
2005	NA	NA	NA	NA	NA
2006	NA	NA	NA	NA	NA
2007	850	2683	3279	3354	5308
2008	955	2839	3386	3694	5028
2009	965	1864	2002	2250	2870

Table 19

Population to hospital bed ratios in Thailand by region, 1979-2008. Source of data: Thailand Health Report 2008-2010, MoPH (available online: http://www.moph.go.th/ops/thp/thp/en/index.php?page=e_doc&group_=05).

Year	Northeast	North	South	Central	Bangkok
1979	1511	980	665	543	337
1980	NA	NA	NA	NA	NA
1981	NA	NA	NA	NA	NA
1982	NA	NA	NA	NA	NA
1983	1167	797	596	453	310
1984	NA	NA	NA	NA	NA
1985	NA	NA	NA	NA	NA
1986	NA	NA	NA	NA	NA
1987	1172	736	627	468	245
1988	NA	NA	NA	NA	NA
1989	NA	NA	NA	NA	NA
1990	NA	NA	NA	NA	NA
1991	1074	682	603	506	257
1992	NA	NA	NA	NA	NA
1993	NA	NA	NA	NA	NA
1994	NA	NA	NA	NA	NA
1995	875	568	530	395	221
1996	NA	NA	NA	NA	NA
1997	NA	NA	NA	NA	NA
1998	NA	NA	NA	NA	NA
1999	780	509	478	376	199
2000	NA	NA	NA	NA	NA
2001	NA	NA	NA	NA	NA
2002	NA	NA	NA	NA	NA
2003	752	502	500	402	210
2004	NA	NA	NA	NA	NA
2005	NA	NA	NA	NA	NA
2006	NA	NA	NA	NA	NA
2007	723	497	490	386	196
2008	779	492	500	402	312

Table 20

Poverty in Thailand, 1981-2011. Source of data: UNESCAP online database (available online: http://www.unescap.org/stat/data/statdb/DataExplorer.aspx).

Year	Population living in poverty	Population below the national poverty line	Poverty Gap	Income/consumption of poorest quintile	Gini index	Poverty headcount ratio at $2 in 2005 PPP
1981	21.9	NA	NA	NA	NA	44
1988	17.2	65.3	NA	NA	NA	41
1989	NA	NA	NA	NA	NA	NA
1990	11.6	58.1	2.4	5.9	45.3	37.1
1991	NA	NA	NA	NA	NA	NA
1992	8.6	50.1	1.6	5.4	47.9	30
1993	NA	NA	NA	NA	NA	NA
1994	4.1	42.6	0.7	6.1	43.5	20.5
1995	NA	NA	NA	NA	NA	NA
1996	2.5	35.3	0.4	6.2	42.9	14.6
1997	NA	NA	NA	NA	NA	NA
1998	2.1	38.7	0.3	6.4	41.5	15.3
1999	3.2		0.5	6.1	43.1	17.8
2000	3	42.6	0.5	6.2	42.8	18
2001	NA	NA	NA	NA	NA	NA
2002	1.6	32.6	0.3	6.3	42	13.4
2003	NA	NA	NA	NA	NA	NA
2004	NA	26.9	NA	NA	NA	NA
2005	NA	NA	NA	NA	NA	NA
2006	1	23.4	0.2	6.1	42.4	7.6
2007	NA	20.9	NA	NA	NA	NA
2008	0.4	20.5	0	6.6	40.5	5
2009	0.4	19.1	0.1	6.7	40	4.6
2010	0.4	16.9	0	6.8	39.4	4
2011	NA	13.2	NA	NA	NA	NA

Table 21

Learning rate in Thailand, 2001-2009. Source of data: Thailand Health Profile 2008-2010, MoPH (available online: http://www.moph.go.th/ops/thp/thp/en/index.php?page=e_doc&group_=05).

Year	Urban Resider	Rural Resident	Whole Country
2001	53.2	27.2	35.9
2002	52.9	28.7	36.9
2003	54.9	30.1	35.5
2004	55.4	32.1	39.9
2005	56.6	32.2	39.8
2006	57.2	34.1	41.3
2007	58	35.5	42.5
2008	58.1	36.7	43.4
2009	58.1	37.9	44.4

Table 22

Paddy crop data, 1983-2012. Source of data: ASEAN Food Security Information System (available online: http://www.afsisnc.org/statistics)

Planted area and harvested area is in 1,000 hectares; yield in ton/hectare;Production in 1,000 tons.
Farmgate price, wholesale price and cost of production are in US Dollar/ton.
Import and export guantities are in 1,000 tons.
Import and export values are in million US Dollar.

Year	Planted area	Harvest Area	Production	Yield	Imports quantity	Imports value	Exports quantity	Exports value
1983	9984.67	9830.88	17251.82	1754.86	0	0	3476.48	874.5
1984	9950.42	9597.61	19606.11	2042.81	0	0	4615.8	1094.67
1985	10220.24	9905.91	20017.57	2020.77	0	0	3962.24	827.81
1986	9935.83	9276.22	20073.83	2164.01	0	0	4523.6	770.99
1987	9295.09	9028.59	18667.03	2067.55	0	0	4443.3	880.44
1988	10170.24	9727.56	18811.18	1933.8	0	0	5701.46	1368.22
1989	10272.95	9944.9	18629.89	1873.31	0	0	6311.41	1765.39
1990	10155.69	8942.78	19082.45	2133.84	0	0	4017.09	1083.22
1991	9518.91	9028.33	19240.1	2131.08	0	0	4333.02	1193.62
1992	9706.33	9193.76	21451.64	2333.28	0	0	5117.6	1422.64
1993	9611.07	8648.25	17707.11	2047.48	0	0	4987.46	1298.66
1994	9645.96	8777.15	21005.86	2393.24	0	0	4858.64	1234.87
1995	9633.94	8847.83	21050.21	2379.14	0	0	6197.99	1947.79
1996	9978.01	9197.47	22102.85	2403.15	0	0	5460.22	1997.91
1997	10004.64	9794.75	22772.76	2325	0	0	5567.36	2067.49
1998	10157.64	9625.68	23907.76	2483.75	0	0	6540.24	2087.42
1999	10365.34	9774.09	23581.64	2412.67	1.49	0.79	6838.79	1944.33
2000	10078.57	9745.09	24947.54	2560.01	0.52	0.24	6141.34	1626.95
2001	10833.35	10193.9	28487.41	2794.55	0.27	0.16	7685.05	1584.56
2002	10388.17	9514.14	27051.95	2843.34	0.63	0.33	7327.01	1617.98
2003	10479.26	9513.3	29336.7	3083.76	7.77	2.33	7345.97	1933.55
2004	10900.25	9865.32	29299.04	2969.9	1.1	0.55	9989.91	2763.68
2005	10623.31	9997.23	29387.01	2939.52	2.48	1.09	7537.34	2321.84
2006	10621.34	9970.42	29792.05	2988.04	1.67	0.96	7434.54	2566.83
2007	10818.56	10165.16	29641.87	2916.03	3.42	1.99	9192.52	3467.4
2008	9285.25	8861.55	32119.35	3624.57	13.74	10.48	10216.04	6204.1
2009	11229.94	10683.55	31650.63	2962.56	76.97	18.99	8619.87	5015.5
2010	11635.19	11141.45	32116.06	2882.58	5.35	0	8939.6	5301.3
2011	12908.22	12119.52	35583.64	2936.06	10.7	8.93	10706.23	6431.25
2012	12602.41	10959.28	31625.25	2885.71	26.95	0	6734.4	4599.6