Assessment of the Impact of CLIMATE CHANGE On BELIZE'S HEALTH SECTOR: DENGUE AND DENGUE HEMORRHAGIC FEVER

BELIZE SECOND NATIONAL COMMUNICATION (SNC) PROJECT

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TABLE OF CONTENTS

ACRONYMS

BI	Breteau Index
BTA	Belize Tourism Association
CAREC	Caribbean Epidemiology Center
CCCCC	Caribbean Community Climate Change Center
CI	Container Index
DALY	Disability Adjusted Life Years
DF	Dengue Fever
DHF	Dengue Hemorrhagic Fever
DSS	Dengue Shock Syndrome
ENSO	El Niño Southern Oscillation
EU	European Union
FHS	Family Health Survey
GDP	Gross Domestic Product
GHG	Green House Gas
HI	House Index
IPCC	Intergovernmental Panel on Climate Change
MOH	Ministry of Health
NAI	Non Annex One
NCSP	National Communications Support Programme
NHI	National Health Insurance
NMS	National Meteorology Services
PAHO	Pan American Health Organization
SNC	Second National Communication
SRES	Emission Scenarios
SSB	Social Security Board
TAR	Third Assessment Report
UNFCCC	United Nation Framework Convention on Climate Change
WHO	World Health Organization
WMO	World Meteorology Organization

LIST OF FIGURES & MAPS

LIST OF TABLES

EXECUTIVE SUMMARY

Belize, like many other Non-Annex One (NA1) Parties to the United Nations Framework Convention on Climate Change (UNFCCC) has been preparing its Second National Communications, in partial fulfillment of its obligation to implement the Convention as stipulated in Articles 4.1 and 12 of the Convention (United Nations, 1992).

It was decided to conduct a Vulnerability and Adaptation of the Health Sector since this was one of the sectors not addressed in the First National Communication report.

Since dengue is considered to be a climate sensitive disease which is endemic in Belize; that the potential for DHF to occur is likely, and also due to the concern over recent outbreaks of dengue in South and Central America, the Ministry of Health deem it opportune at this time to conduct a vulnerability and adaptation assessment on climate change and dengue, in order to determine the present and future level of risk, the present adaptive capacity and required adaptation measures to minimize future impact of this disease.

Dengue is the most important arboviral disease of humans, occurring in tropical and subtropical regions worldwide. In recent decades, dengue has become an increasing urban health problem in tropical countries. The disease is thought to have spread mainly as a result of ineffective vector and disease surveillance; inadequate public health infrastructure; population growth; unplanned and uncontrolled urbanization; and increase national and international travel. The main vector of dengue is the domesticated mosquito, *Aedes aegypti*, which breeds in urban environment in artificial containers that hold water. Dengue also can be transmitted by *Aedes albopictus*, which can tolerate colder temperatures.

Dengue is seasonal and usually associated with warmer, more humid weather. There is evidence that increased rainfall, humidity and temperature can affect the life cycle of the vector and virus, thus increasing the transmission potential.

The main goal of this assessment is to determine the present and future occurrence of dengue and DHF and to measure its impact on the health care system and the population in terms of morbidity and mortality, also to measure the socio-economic impact of adaptation measures. More specifically, the objectives were:

- Describe the present level of risk for dengue and DHF in Belize
- Project the future occurrence of dengue based on present risk levels and expected population growth, in the absence of climate change.
- Utilizing selected socioeconomic and climatic scenario, project the future impact of dengue and DHF in Belize.
- Recommend adaptation strategies to cope with potential impact.

The method used was determined after consultation with senior staff of the National Meteorological Service, the Statistical Institute of Belize, the Ministry of Health and the Vector Control Program, in order to assess existing modeling capability and the availability of data.

Since no modeling studies have been conducted in Belize, linking the occurrence of dengue to socio-economic, climatic or environmental factors, and since the available data does not allow for modeling (multiple regression analysis) to predict changes in the dependent variable (incidence of dengue) for unit change in the independent variables (climate parameters and others). The decision was made not to attempt the prediction of impact through mathematical modeling, but to use risk assessment to determine vulnerability.

Hence, the method use was the "Bottom-up, Risk-Based Hazard assessment framework" combined with the "Top-down" approach to conduct the vulnerability and adaptation assessment. Under this model, the climatic, socio-economic and environmental drivers of dengue are identified; present risk (vulnerability) of dengue and adaptation capability of the country is described based on historic and current data. Utilizing the risk management process, taking into account future climate scenarios, and expert judgment, determination is made as to how the projected climate changes will impact on dengue and what proactive adaptation measures needs to be implemented in order to reduce vulnerability and minimize impact.

Belize has determined that the A2 Emission Scenario best describes its future path to development. Under this scenario, Belize is described as a very heterogeneous country. The underlying theme is self-reliance and preservation of local identities. Fertility patterns across the country converge very slowly, which results in high population growth. Economic development is primarily locally oriented and per capita economic growth and technological change fragmented and slow.

The time period (time horizon) over which projections was made, took into account the limits of predictability. The projected Climatic scenarios therefore were made for the decades of the 2020's and 2050's.

Present vulnerability was determined by the presence of the *Aedes Aegypti* mosquito, any of the 4 virus serotypes capable of producing dengue, and socioeconomic and environmental factors.

The review of data related to the occurrence of dengue in the period 1995-2007 reveal that low levels of dengue transmission has been consistently occurring in all districts during this period. The trend is toward the increase and all virus serotypes have been isolated. The risk to the population as determined by the 2007 incidence was 0.00106 with the Corozal District exhibiting the highest risk. Data from different years consistently show June to November as the period of highest occurrence. There is a strong correlation (Pearson Product Moment "r" of 0.758) between dengue seasonal variation and monthly average rainfall.

An entomological cross-sectional survey conducted during the month of August 2008 revealed the presence of the virus in all districts. The vector density as determined using the Breteau and other entomological indices is high, requiring urgent attention. 17% of surveyed communities had a Breteau Index below 2%. This is the threshold (even though disputed) below which dengue transmission is unlikely. Thirty nine (39) percent had Breteau Indexes between 2 and 5 per cent; this level of larvae infestation supports the maintenance of endemic dengue and low level outbreaks. Eight communities (44%) had larvae infestation as determined by the Breteau Index, between 6 and 24 per cent; the probability of dengue outbreak is very high in these communities.

The temperature, humidity, rainfall, and altitude above sea level in Belize are within the values, conducive to the sustainable transmission of dengue. Taking into consideration the status of the environmental, biological and socioeconomic factors in Belize, and also the present adaptation capacity, the country has been categorized as having a “medium level vulnerability”.

Following the risk management process, risk scenarios were developed depicting ways in which dengue (the hazard) could affect different sectors of society, in order to identify dengue risk events. Using standardized Direct Impact Rating tables, Frequency/Probability Rating tables and the Risk Assessment Matrix table, each dengue risk event was ranked as follow:-

Increased cost of health care delivery	extreme risk
Increased cost of outbreak control	extreme risk
Work absenteeism	high risk
Personal income loss	high risk
Reduced national production	moderate risk
School absenteeism	moderate risk
Cancelled tourist visits	moderate risk

This ranking was achieved taking into consideration how each dengue risk event affects different sectors: the loss involved, the cost of control, and the value placed on the impact of each event by stakeholders.

1) Extreme Risk: This indicates an unacceptable level of risk that requires immediate control to move the activity out of extreme range
2) High Risk: This level will require high priority control measures to reduce risk to an acceptable level
3) Moderate Risk: Some controls will be required to move this risk scenario to lower levels

Adaptation measures recommended below, were based on what was considered to be the most cost effective control strategies, to address the potential impacts and which are consider to be acceptable to stakeholders.

- Improve national diagnostic capability and dengue management, especially for DHF/FSS.
- Implement an effective, sustainable, community based vector control program.
- Elicit the educational system to incorporate dengue prevention in the natural science curricula.
- Incorporate environmental sanitation as a permanent topic in schools’ PTA agenda.
- Enforce the environmental and public health laws.
- Promote and reinforce changes in human behavior through health communication and health promotion strategies, which include specific target audiences from the school curricula to mass media participation, among others, to reach most of the population and affect the society as a whole.
- Promote and strengthen entomological surveillance capability at the local level, to determine *Aedes aegypti* distribution and level of infestation, to detect areas of new infestation, and to support local level societies in taking necessary actions to prevent further spread of the mosquito.

- Strengthen the epidemiological surveillance system for early detection of dengue cases and rapid implementation of transmission control measures to reduce transmission and prevent the occurrence of epidemics.
- Train and equip regional rapid response teams for the control of dengue epidemics.
- Encourage employers to insure employees with SSB for employment benefits and with private and public (NHI) health insurance companies in order to guarantee health care to employees.
- Encourage the self employed worker to make use of the SSB "voluntary contribution program" and to seek health insurance coverage in the private or public health (NHI) sectors.
- Encourage the tourism industry and Public Health to do the following: a) incorporate good environmental sanitation practices into the existing requirements for hotel accreditation. b) Attach to the tourism tax funds that municipalities receive at present, requirements for proper sanitary control of parks, cemeteries, drainage and empty house lots.

The vulnerability and adaptation assessment exercise has concluded that, dengue is endemic in Belize; that four (4) serotypes of dengue viruses have circulated in the country; that medium level risk of dengue outbreaks exist, particularly DHF; that present entomological indices are unacceptable, requiring immediate action; that the projected increase in extreme events will exacerbate the potential for major outbreaks of dengue to occur in the future; that information to monitor implementation of control measures and to assess impact on risk reduction and disease occurrence, is inadequate; and that the implementation of a community based vector control program will be more sustainable and cost-effective than the centralized chemical based control strategy .

COUNTRY PROFILE

Belize is located in Central America lying in the outer tropics or subtropical geographic belt. It is bordered by Mexico to the north, Guatemala to the west and south and by the Caribbean Sea to the east. The geographic coordinates are 15.45 and 18.30 North Latitude and 87.30 and 89.15 West Longitude. Belize is 274 km (170 miles) long and is 109 km (68 miles) wide. The total land area is 22,700 km^2 (8,867 square miles). The climate is subtropical, very hot and humid, with a rainy season (middle of May to November) and a dry season (February to May) separated by a cool transitional period (November to February). The prevailing winds are easterly/north easterly trade winds generated by Bermuda subtropical high. The temperature ranges between of 75°F and 90°F. The average rainfall is 60 inches (1,500mm). In relation to elevation extremes the lowest point is the coastal area (0 m) and the highest point is the Doyle's Delight (≈1,164m). The population density was approximately 31 inhabitants per square mile in the year 2003. A former British colony, Belize is the only English-speaking country in Central America. It is more similar to other English–speaking Caribbean countries in culture, politics, and economy; however, due to its location Spanish is widely spoken.

Belize obtained its independence from Britain in 1981. It is a sovereign state governed by the principles of parliamentary democracy based on the British Westminster system. The titular head of state is Queen Elizabeth II, represented by a Governor General. A Prime Minister and Cabinet constitute the executive branch of the government while a thirty-one member elected House of Representatives and a nine-member appointed Senate form a bicameral legislature, the National Assembly.

In 1971 the capital was moved from Belize City to Belmopan because Belize City was destroyed twice by hurricanes. The country has six administrative districts: Corozal, Orange Walk, Belize, Cayo, Stann Creek and Toledo. Each urban area is administered by a locally elected town board, which is comprised of seven members. Unique to this system is Belize City, which has its own nine-member elected City Council. Village Councils assist in village level administration with the traditional "Alcaldes" or mayoral system of the south (Toledo District) incorporated into the structure. Districts are further subdivided into villages and government is presently in the process of defining boundaries for these subdivisions. These villages are governed by the Village Council Act.

DEMOGRAPHIC CHARACTERISTICS

Population

The 2000 census indicated that the total population was 249,800 and the mid year population estimates for 2005 was 291,800 (147,400 males and 144,400 females), for a sex ratio of 1.02:1.00). (2007 data may be available)

The inter-censal growth rate for 1991-2000 was 2.7%. This inter-censal growth rate was approximately one percentage point higher than the growth rate between 1980 and 1991.

The demographic profile is of a young population: the population 0-4 in 2001 was 37,105 as compared to 37,300 in 2007. For the year 2007, 38.9% of the population were under 14 years of age and 50.2% was 19 years and under. The elderly (60 years and older) accounted for 6.8% of the total population. The dependency ratio was 57.1 in 2007. Women of childbearing age (15-45 years) accounted for 45.5% of the total female population.

In 2000, the urban and rural percentages were 48% and 52% respectively. In 2007, the mid year population estimate showed a small increase in urban population where 48.96% of our population lives in the rural areas and 51.04% live in the towns. The Belize District (29.9%), has always maintained the highest proportion of the population while Toledo District (9.4%) maintains the lowest.

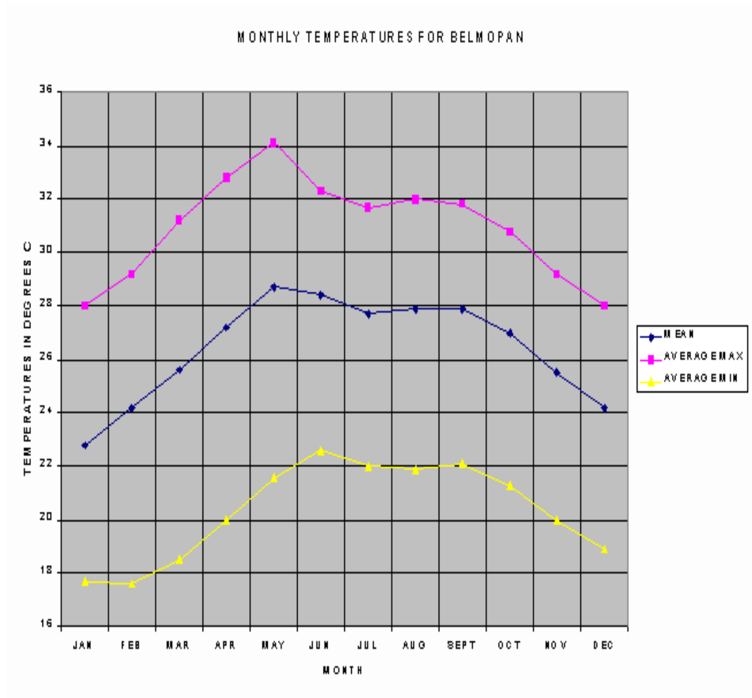
There has been a gradual decline in fertility rates over the past three decades. According to the 2000 population census, the total fertility rate (TFR) was estimated as 3.2 children per woman. The corresponding rate from the Vital Registration System in 1999 was 3.3 children per woman, which corroborates closely with the figure from the census. Even though the TFR has decreased, differences in fertility by urban/rural residence, educational and socioeconomic levels, as well as ethnicity and religion estimated from the 1999 Family Health Survey (FHS) revealed several facts. Rural women have on average one child more than urban women. Non-working women have approximately 3 children more than working women, while women of low socioeconomic level have approximately 4 children more than those of high socioeconomic level.

The major ethnic groups, according to the 2000 population census, indicated that the Mestizos constitute 48.7% of the population and they live mostly in the West and North (Cayo, Orange Walk and Corozal). The Creole population was estimated to be 24.9%, and they live in the mid-eastern coast (Belize). Maya groups constitute about 10.6% of the population, and of these, three major groups, the Mopan, Yucatec and Ketchi, primarily live in the Toledo and Corozal Districts. The Garifuna, who live mainly in the mid-to-south-eastern coast of Stann Creek District and along the east coast of the Toledo District, make up some 6.1% of the population. Other ethnic groups include East Indian (3.0%), Mennonite (3.6%) and other smaller groups representing 3.3% including Caucasian/White and Chinese.

Climate

Belize has a tropical climate with pronounced wet and dry seasons, although there are significant variations in weather patterns by region. Temperatures vary according to elevation, proximity to the coast, and the moderating effects of the northeast trade winds off the Caribbean. Average temperatures in the coastal regions range from 24° C (75.2˚ F) in January to 27° C (80.6˚ F) in July, graph 1. Temperatures are slightly higher inland, except for the southern highland plateaus, such as the Mountain Pine Ridge, where it is noticeably cooler year round. Overall, the seasons are marked more by differences in humidity and rainfall than in temperature.

Figure 1: Monthly Temperatures-
Belmopan



Average rainfall varies considerably, ranging from 1,524 millimeters (60 inches) in the north and west to over 4,064 millimeters (160 inches) in the extreme south. Seasonal differences in rainfall are greatest in the northern and central regions of the country where, between January and April or May, fewer than 100 millimeters of rain fall per month. The dry season is shorter in the south, normally only lasting from February to April. A shorter, less rainy period, known locally as the "Mauga season," usually occurs in late July or August, after the initial onset of the rainy season.

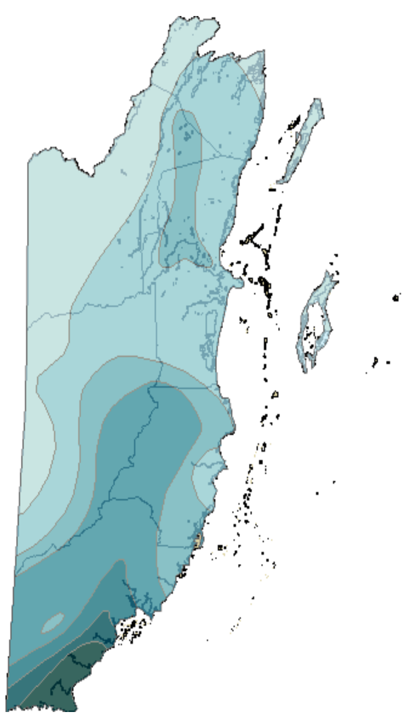


Figure 2: Spatial Distribution of Annual Average Rainfall in Belize

Rainfall Isohyets

- 40 - 60" (1016 - 1524mm)
- 60 - 80" (1524 - 2032mm)
- 80 - 100" (2032 - 2540mm)
- 100 - 120" (2540 - 3048mm)
- 120 - 140" (3048 - 3556mm)
- 140 - 160" (3556 - 4064mm)
- 160 - 180" (4064 - 4572mm)

Superimposed on the main characteristics of rainfall distribution, are the effects of geographical distribution and synoptic weather systems. In general, mountain/valley areas show the dominant monsoon distribution with the months of maximum rainfall (June and July) lagging May, the month with the hottest temperatures. Examples are Cabbage Haul, Belmopan and Hummingbird Hershey (Sibun Hills). Here, convective rainfall is enhanced by steep slopes and moist easterly winds during the Wet Season but the drier, subsiding Easterly trades inhibit convection during the months of dry weather. Drought is seldom felt in these areas. Smith and Panton (1981) identified four geographical features that influence Belize's climate: inland, coastal, mountain/valley and latitude. Leslie and McKinstry (1977) also defined five topographical zones in order to highlight these features and included the Northern Plains, the Belize River Basin, Mountainous, Southern Central Plains, and Southern Hilly. Low lying coastal areas exhibit two distinct months of maximum rainfall during the Wet Season attributable to peak activity of Tropical Easterly Waves and Tropical Storms or Hurricanes. The short term variability of rainfall amount and intensity can be seen as a result of topography, diurnal and coastal influences.

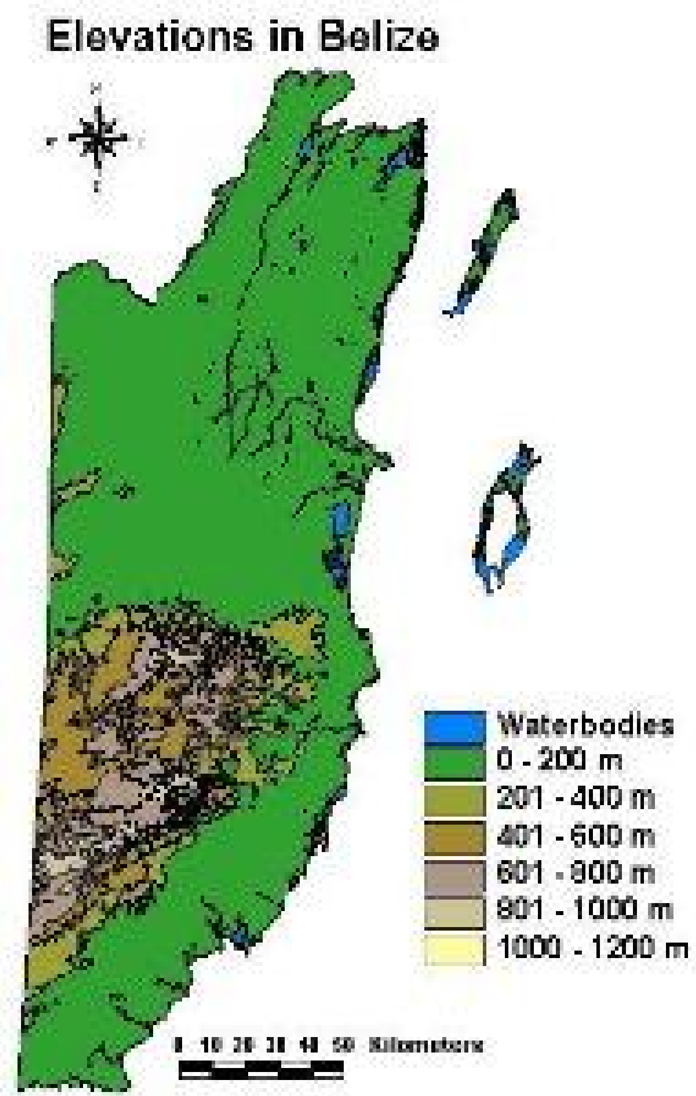
The number of rainy days varies considerably across the country. The Cayo District has an average of 125 rainy days per year, Belize District averages about 171 rainy days, Stann Creek District 183 days per year while in Punta Gorda there are often more than 200 days of rain every year. Many of these rainy days are insignificant though, with early morning showers (called "night rain" by the local residents) blossoming into beautiful rainbows. These "night rains" are caused by cool air moving down from the higher elevations, cooling the air along the coast thus resulting in light rain.

Hurricanes have played key and devastating roles in Belizean history. In 1931 an unnamed hurricane destroyed over two-thirds of the buildings in Belize City and killed more than 1,000 people. In 1955 Hurricane Janet leveled the northern town of Corozal. Only six years later, Hurricane Hattie struck the central coastal area of the country, with winds in excess of 300 kilometers per hour and four-meter storm tides. The devastation of Belize City twice within thirty years prompted the relocation of the capital some eighty kilometers inland to the planned city of Belmopan. Greta hit the southern coast of Belize causing more than US $25 million in damages along the southern coast in 1978. In recent years, hurricanes have occur with more frequency. Torrential rains resulting from Hurricane Mitch caused extensive damage to crops and roads in 1989. Keith, a category 4 hurricane affected mainly ambergris Caye and other small islands with 135 mph winds in October of 2000. Tropical Storm Chantal in August 2001 moved slowly across the country, causing extensive flooding in coastal areas and northern Belize. In October of 2001, Hurricane Iris hit southern Belize with 145 mph winds causing major damage to nearly 90% of the buildings in Placencia and nearby villages. Then in 2007, Hurricane Dean made landfall in the Corozal District as a category 5 storm, causing extensive damage to properties and crops in that district.

Topography

The land elevation of Belize ranges from zero feet above sea-level along the cost, to 4,002.6 feet of the Doyle’s Delight located on the Maya Mountains. However, close to 80% of the land mass is below 2,000 feet, see Figure 3 below.

Figure 3: Elevation Map



Economy:

Belize, like most countries exhibits "mixed economy" characteristics. The government has traditionally kept control of public services and some basic industries, so as to guarantee essential services to all citizens. The global trend however, has progressively gravitated towards privatisation of these services, and Belize has generally followed this trend in the privatization of electricity, water, and marine port and airport services. The government however, has maintained control over those industries that appear to lack the ability to raise sufficient capital investment from private sources.

Belize's exports have traditionally been agricultural in nature, counting sugar, citrus, bananas and more recently marine products as its main exports as it transacts with its main trading partners, the United States of America, Mexico, the United Kingdom and other EU countries.

In the year 2000, Belize had an unprecedented GDP real growth of 12.3%, but, following several natural disasters, a slowing world economy, higher fuel prices and even programmed reductions in the central government's expenditures, the years immediately following experienced reductions in the GDP expansion, as it fell to 4.3% in 2002. However, increases in banana and farmed shrimp production and exports, coupled with a surge in tourism activity, contributed to 2003's GDP growth of 9.3%. Notwithstanding this expansion, inflation rose by 2.6% during the same year despite lower import duties and decreases in the US export price index. This was largely due to a rise in world oil prices over the years, and the inability of the Belizean Economy to keep absorbing these external shocks. Naturally, the price of services directly dependent on fuel inputs increased, in addition to others indirectly dependent such as medical care.

In 2007 the Belizean economy once again experienced an economic slowdown. Exports of papaya, sugarcane, banana, citrus, farmed shrimp, garments and electricity fell for a variety of reasons including weather and crop disease. Consequently, domestic exports contracted by 7.6% and real GDP growth fell to 1.6% as compared to 5.3% the previous year. Imports however, grew by 4.9%, creating a further expansion of the trade deficit and more than doubling the external current account deficit to 3.4% of GDP. An increase in petroleum production of 34.1% helped to offset, as did growth in free zone trade and the telecommunications sector.

Table 1: Inflation Rates 2003-2007

Year	Per Capita Income (Mkt. Prices)	GDP Real Growth	Inflation
2003	BZ$7,285.9	9.3%	2.6%
2004	BZ$7,507.2	4.6%	3.1%
2005	BZ$7,691.6	3.0%	3.7%
2006	BZ$8,097.3	5.3%	4.2%
2007	BZ$8,180.5	1.6%	2.3%

Source: Estimates of Revenue and Expenditure 2008-2009

Ministry of Health Budget

The Ministry of Health's portion of the GOB's budget has had a marked upward trend in the years 2004 to 2007. During this time segment it increased by $32,863,313.00 or 41% to account for 10.9% of the Government of Belize Budget for the year 2007.

Table 2: MOH Budget 2001-2007

Year	Revised MOH Budget	%of GOB Budget	%of GDP
2004	BZ$46,619,809	8.6%	2.2%
2005	BZ$53,222,465	8.4%	2.4%
2006	BZ$64,241,066	9.2%	2.7%
2007	BZ$79,483,122	10.9%	3.1%

Source: Estimates of Revenue and Expenditure for Fiscal Years 2005-2008

It has also had a minimal but steady rise in its portion of the GDP, increasing from 2.2% in 2004, to 3.1% in 2007. To place these figures in context, worldwide statistics indicate global average of 5.5% of GDP is spent on health, with 3.2% being the norm for Latin America and 5.8% for the United States. The highest published figures emanate from the wealthiest European nations at 6.6%.[2]

The rise in budgetary allocations to Health Services is not solely due to specific programmes such as Health Sector Reform, but as may be expected, to the growth of the Belizean population. Therefore, it is of essence to also analyze budget expansion in the context of allocations per capita.

The estimated Health Budget allocation per person for 2007 was $256.56, which was $42.28 more per person than the previous year. Variation in its growth rates reflects, among other things, the introduction of free ARVs and an increased activity with the Health Sector Reform Program.

Table 3: Trend in per capita allocation

Health Budget Allocation per Capita	
Year	Belize Currency
2004	$ 65.85
2005	$ 183.59
2006	$ 214.28
2007	$ 256.56

Poverty

The Poverty Assessment Report for 2002 showed that the percentage of the population living below the poverty line in Belize was 33.5%. This study further showed that poverty in the rural areas (44.2%) was much higher than that of the urban areas (23.7%). The Toledo District had the highest level of poverty in Belize (79.0%), and the Belize District had the lowest (24.8%). The corresponding rates in the other districts were higher in Orange Walk (34.9%) and Stann Creek (34.8%) as compared to Corozal (26.1%) and Cayo (27.4%). The proportion of the indigent population was 7.1% countrywide.

There is currently an initiative taking place to execute a new Country Poverty Assessment to be completed next year.

Labour Force

In Belize the employed labour force is defined as the population that is available, wanting and seeking work. The employment rate in Belize has increased steadily from 2003 (88.1%) to 2006 (90.6%), with a slight decrease of 2.7% in 2007 due to Hurricanes Dean and Felix.

Table 4: Main Labour Force Indicators 2003-2004

Indicators	2003	2004	2005	2006	2007
Labour Force	102,437	108,491	110,786	112,807	122,516
Employed	89,222	95,911	98,589	102,233	107,657
Unemployed	13,215	12,580	12,197	10,573	14,859
Employment Rate	88.1%	89.4%	89%	90.6%	87.9%
Unemployment Rate	12.9%	11.6%	11.0%	9.4%	12.1%

Source: Statistical Institute of Belize

Health Care System

The National Public Health System in Belize provides universal access to personal and population based services, essentially at no direct cost to the individual. This includes the provision of pharmaceuticals and other support services. The Government is the main provider of health services, though recently there has been an expansion of the private sector as it relates to secondary and tertiary care. The main financing source for the public sector is the consolidated fund of central government. A system of rural health centers with permanent staff is supplemented by mobile health services, community nursing aides, voluntary collaborators and traditional birth attendants working throughout the rural communities of the country.

The provision of hospital based care in these four regions includes inpatient and outpatient care, including accident and emergency, pediatrics, obstetrics and gynecology, internal medicine and surgical care. Clinical and non-clinical support services and some specialized tertiary services are also provided. A network of clinics, permanently staffed health centers and un- manned health posts is available to address the primary health care needs of the population.

Programmatic Areas

Promotional, preventive and curative services provided by the Ministry of Health are organized into programs addressing different technical areas for the purpose of managing health care delivery throughout the country. One such program is the Vector Control Program. This program has responsibility for the maintenance of a healthy environment that provides for the prevention and control of Malaria, Dengue and Chagas Disease. It executes, on an ongoing basis, a series of Malaria and Dengue control activities such as: active and passive case detection; presumptive and radical case treatment with a 14-day treatment scheme (five of which are supervised); adult mosquito control via indoor house spraying and spatial ULV spraying; chemical larvae control with Abate; and health education in schools.

Most communities in Belize have a voluntary collaborator, a community nursing aide or both. They serve as a link between the communities and the formal health system, and play an important role in the detection and treatment of Malaria cases. A section of the Vector Control personnel is dedicated to activities aimed at the control of the *Aedes aegypti* mosquito which is the main vector for Dengue in Belize. The activities include, premises inspection for the identification and destruction of mosquitoes breeding site; chemical treatment of domestic water containers which have the potential to become breeding sites for the *Aedes aegypti* mosquitoes; health education to householders; ULV spraying for adult mosquitoes control; and epidemiological investigation of suspected index dengue cases.

Unlike Malaria, Dengue does not have a dedicated surveillance system. Cases are diagnosed at the point of patient contact with the health sector and reported to the health information system of the Ministry of Health. Only a small number of cases diagnosed in the private sector are reported. Overall, the diagnosis and reporting of Dengue cases have been inconsistent over the years. Prior to the development of laboratory diagnosis capabilities in 2006, the guiding policy for the diagnosis was the following: Blood samples were taken from patients who presented themselves to a health facility with fever, body ache, retro-orbital pain and rash; the sample was sent to the Caribbean Epidemiological Center (CAREC) laboratory for testing, both for viral identification and serological reaction. If the results were positive, then the Vector Control program would issue an information bulletin to health care providers in the entire country outlining the prevailing symptoms as criterion for the diagnosis of suspected cases of Dengue. Report of cases to CAREC over the years has been inconsistent; sometimes only laboratory confirmed cases were reported, while for some years, it was both clinical and laboratory confirmed cases.

CLIMATE CHANGE, VULNERABILITY AND ADAPTATION ASSESSMENT OF DENGUE AND DENGUE HEMORRHAGIC FEVER IN BELIZE

Belize, like many other Non-Annex One (NA1) Parties to the United Nations Framework Convention on Climate Change (UNFCCC) has been preparing its Second National Communications, in partial fulfillment of its obligation to implement the Convention as stipulated in Articles 4.1 and 12 of the Convention (United Nations, 1992).

Within the Health Sector, the Global Circulating Models for climate change projects that in tropical low latitude areas such as Belize, a warmer climate system resulting from a doubling in Carbon Dioxide concentration in the atmosphere will lead to increased frequency of warm spells/heat waves, intense droughts, and heavy rainfall events. It is projected that these conditions will exacerbate those that increase the risk and incidences of vector-borne diseases and illnesses.

This Vulnerability Assessment of the Health Sector, conducted under the Second National Communication Project has served to describe present vulnerability and adaptive capacity; project future vulnerability and required mitigation measures as well as to identify the need for a more comprehensive assessment in order to determine with more precision, the future impact of dengue and other climate sensitive illnesses.

The Inter-Governmental Panel on Climate Change (IPCC) “Technical Guidelines for Assessing Climate Change Impact and Adaptation” was adapted to the reality of Belize in terms of availability of data, the existence of multiple regression models on Dengue and socio-economic, environmental and climatic predictors, and available time for the conduct of the assessment. Descriptive qualitative and quantitative methods were used where feasible, to assess the increase level of risk to dengue and dengue hemorrhagic fever based on different scenarios of future climate change.

Background

Dengue is the most important arboviral disease of humans, occurring in tropical and subtropical regions worldwide. In recent decades, dengue has become an increasing urban health problem in tropical countries. The disease is thought to have spread mainly as a result of ineffective vector and disease surveillance; inadequate public health infrastructure; population growth; unplanned and uncontrolled urbanization; and increase national and international travel. The main vector of dengue is the domesticated mosquito, *Aedes aegypti* that breeds in urban environment in artificial containers that hold water. Dengue also can be transmitted by *Aedes albopictus*, which can tolerate colder temperatures.

Dengue is seasonal and usually associated with warmer, more humid weather. There is evidence that increased rainfall, humidity and temperature can affect the life cycle of the vector and virus, thus increasing the transmission potential.

Classic Dengue Fever is considered endemic in Belize, and the Health Services has continuously monitored the occurrence of Dengue and Dengue Hemorrhagic Fever (DHF) and has expressed concerns over recent outbreaks of DHF in Brazil and other Central American countries. Belize has the environmental and socio-economic conditions for such outbreaks to occur; the conditions also exist for DHF to arise. The MOH resolved that is was timely that a vulnerability assessment be undertaken in order to determine the present and future level of risk of this disease. Since Dengue is a climate sensitive disease, it was expected that a change in climate parameters would impact its frequency and distribution in the country.

Objectives of the Assessment

The main goal of this assessment is to determine the present and future occurrence of dengue and DHF and to measure its impact on the health care system and the population in terms of morbidity and mortality, also to measure the socio-economic impact of adaptation measures.
In order to accomplish the objectives of the vulnerability and adaptation assessment, the consultant was asked to do the following:

- Describe the present level of risk for dengue and DHF in Belize
- Project the future occurrence of dengue based on present risk levels and expected population growth, in the absence of climate change.
- Utilizing selected socioeconomic and climatic scenario, project the future impact of dengue and DHF in Belize.
- Recommend adaptation strategies to cope with potential impact.

Terms of Reference

a) Scope of the Assessment

The goal of this Health Sector Vulnerability Assessment was to evaluate, under various Climate Change Scenarios, the climate change impacts in the health sector as it pertains to changes in the vector for Dengue and DHF

Some specific objectives included:

- To identify the geographic areas, and populations at risk from or vulnerable to the disease threat. Indicate the linkage between this study and the epidemiological profile of Dengue and DHF in Belize.
- To identify and estimate the social and economic costs to enable the Authorities to maintain or establish control, should the threat be realized.
- To identify other stakeholders with the potential to assist in mitigating the threat.
- To identify and make recommendations for adaptation measures intended to reduce the impacts of climate change on this area of the health sector. This was to be offered to the appropriate authorities in order to guide any mitigation/adaptation strategy that might be formulated to address the impacts of climate change on health.

b) **Risk Assessment**

The present level of risk (current vulnerability) was described based on the analysis of historical and present data related to the occurrence of dengue, and available entomological, climatic and socio-economic information. The present adaptation capabilities have also been described within the context of autonomous and explicit planned adaptive measures.

c) Deliverables:

Draft report that includes the following:

- Geographic range/extent and vulnerable populations that would be affected by the threat based on the projected scenarios.
- projections on the social consequences and implications for the delivery of health services
- recommendations of mitigation/adaptation measures to reduce the impacts of climate change in the Health Sector
- Presentation of results for peer review prior to the production of a final report.
- Deliver final report via hard and digital copy of results of the assessment to the SNC Project Office.

d) Methodology

The method used was determined after consultation with senior staff of the National Meteorological Service, the Statistical Institute of Belize, the Ministry of Health and the Vector Control Program, in order to see what modeling capability and data availability existed. The available options were to use mathematical models to predict future impact; descriptive analysis through literature review and expert judgment; the risk management approach or a combination thereof.

Consultation with other partners and stakeholders and comprehensive literature review, revealed the following:

To date, no modeling studies had been conducted in Belize, linking the occurrence of dengue to socio-economic, climatic or environmental factors. The surveillance system of the MOH does not collect information on socio-economic risk factors for Dengue and the entomological data that is collected is not consistent. The intensity and quality of data collection and recording, varies over time and among health regions.

The available data does not allow for modeling (multiple regression analysis) to predict changes in the dependent variable (incidence of dengue) for unit change in the independent variables (climate parameters and others). The absence of such models, precluded the consultant from making projections on future impact of dengue utilizing mathematical models.

Taking into account the situation as described above and following the IPCC recommendations for V&A assessment where impact data is unavailable, the following methodology was adopted:

The Bottom-up, Risk-Based Hazard assessment framework combined with the Top-down approach to conduct the vulnerability and adaptation assessment. Under this model, the climatic, socio-economic and environmental drivers of dengue are identified; present risk (vulnerability) of dengue and adaptation capability of the country is described based on historic and current data. Based on future climate scenarios, the risk management process, and utilizing expert judgment, determination is made as to how the projected climate changes will impact on dengue and what proactive adaptation measures needs to be implemented in order to reduce vulnerability and minimize impact.

A cost benefit analysis of alternative adaptation measures or no adaptation was made in order to facilitate policy decision. The risk management process provides a systematic, informative and science-based tool to help decision makers analyze the risk of climate variability and change, and select optimal course of action.

e) Data acquisition and compilation

Data on climate history and future projected changes was acquired from the National Meteorological Service of Belize (NMS). The socioeconomic scenario used was that described as the IPCC emission scenario A2, which was selected by the NMS, in consultation with other sector of development. Data related to the frequency, distribution and trend of dengue and non-climatic risk factors was gotten from the epidemiology unit of the Ministry of Health, the Vector Control Program, the Statistical Institute of Belize and through a national prevalent entomological survey financed and implemented by the SNC project, in coordination with the Vector Control Program, in August of 2008.

Documentation for literature review was acquired from PAHO, CCCCC, SNC project management office, NCSP and the Internet.

It was anticipated that the available rural entomological data was incomplete and inconsistent, so that in order to generate valid information on the frequency and distribution of the *Aedes aegypti* mosquito and its breeding sites, an entomological survey was conducted. Three villages were randomly selected from each district and within each village; random selection of a representative sample was made. This survey produced a picture (snapshot) of the risk that the vector poses in the country. A one day technical workshop was held in Belmopan to train the entomological surveyors in preparation for the actual data collection exercise. A brief description of the survey protocol follows:-

ENTOMOLOGICAL CROSS-SECTIONAL SURVEY

- **Objectives of the Survey**

The objective of this survey was to generate the data required to estimate the *Aedes aegypti* indices such as: House index, Container index, Breteau index for rural Belize, and to determine what type were the prevailing breeding containers.

- **Methodology**

In consideration of the objectives of the study and due to time and resource constrains, a cross sectional survey design was utilized in order to gather prevalent information on *Aedes aegypti* mosquito habitats and density.

- **Target Population**

Since the study aims at measuring the prevalence of entomological risk factors for dengue in rural Belize, the target population was determined to be all rural households in the country. By definition, the target population is that proportion of the population to whom the results of the survey is extrapolated.

- **Study Population**

Is defined as that proportion of the target population to whom the researcher has access and from where data collected. The study population comprised all households in the eighteen selected communities; hence all households were included in the sampling frame.

- **Sampling Process**

In order to get the required representative sample size for the survey, a random selection of three villages per district was done, followed by a random selection of households within each village. It was concluded that a combination of cluster and systematic random sampling procedures was appropriate for this setting. The cluster sampling entailed the random selection of three villages per district in order to have appropriate district representation; this was fallowed by systematic random selection of households within each village.

- **Sample Size**

For *Aedes aegypti* larvae survey, the determination of the number of house premises to be inspected in each locality depends on the precision required, level of infestation and availability of resources. Since the desired precision was 1% or less (ability to detect 1% larvae infestation), and the expected level of infestation was 2% or greater, the methodology proposed by the 1994 PAHO "Dengue Prevention and Control Guidelines" for sample size determination was utilized.

- **Data Collection Procedure**

Data was collected following standardized entomological protocols. Data collection was made on premises with water holding containers; premises with wet containers; premises with containers with larvae; larvae stage and larvae species. This data was utilized to estimate the: House index (HI), Container index (CI), and Breteau index (BI).

Two Entomologist Technicians per district, employees of the Ministry's Vector Control Programme, were selected and trained to collect field data as per protocol. Data collection was carried out simultaneously in each district and the task was completed in three days.

- **Data Collection Instrument**

Standardized forms utilized by the vector control program of the Ministry of Health was used to record the entomological data

- **Statistical Analysis**

The Statistical Program for the Social Sciences (SPSS) 10.0 was used to conduct data analysis. Counts, Frequencies, Proportions and Percentages were generated and presented in tables and graphs. Outputs were the following: House, Container and Breteau Indices per village and average per district. Types of containers and container relative frequency. For detailed information on the results of the study, see table # 5 below, and the section dealing with the analysis of "Present Vulnerability to Climate Change".

Table 5: Entomological Indices by District and Village, Belize 2008

District	Village	House Index	Cont Index	Breteau Index
Corozal	Ranchito	4%	2%	4%
	Paraiso	3%	2%	3%
	Little Belize	9%	2%	9%
Orange Walk	Douglas	2%	1.4%	0.2%
	Fire Burn	0%	0%	0%
	Trial Farm	3.8%	1.3%	4.7%
Belize	Double Head Cabbage	3.9%	1.1%	3.9%
	Barrel Boom	4.2%	3.1%	4.2%
	Crooked Tree	7%	2.4%	9%
Cayo	Santa Familia	9%	6.32%	16%
	Ontario	16%	7.28%	22%
	Cristo Rey	9%	5.21%	17.14%
Stann Creek	Valley Community	0%	0%	0%
	South Stann Creek	14%	13.6%	24%
	Hope Creek	7%	3.8%	9%
Toledo	Blue Creek	4.9%	2%	4.9%
	Forest Home	4%	.9%	4%
	San Antonio	8.7%	3%	12%

Source: entomological Survey, Vanzie et al, 2008.

SELECTION OF SCENARIOS

Climate scenarios has been described by the IPCC as plausible, and often simplified representation of the future climate, based on an internally consistent set of climatological relationship that has been constructed for explicit use in investigation the potential consequences of anthropogenic climate change, often serving as input to impact models. Climate projections often serve as the raw material for constructing climate scenarios, but climate scenarios usually require additional information such as the observe current climate.

In order to provide reference points with which to compare future projections, three types of baseline conditions are specified: climatic, environmental and socio-economic. Historic and present climatic data, A2 emission scenarios and present dengue drivers were utilized to project future climate scenarios. e.g. we are interested in knowing the likelihood of more rainy days per year, or longer dry season occurring. More rainy days provides more breeding condition for the dengue vector; longer dry season force people to store water in containers that eventually becomes mosquitoes breeding sites.

Under the A2 SRES scenario, Belize is described as a very heterogeneous country. The underlying theme is self-reliance and preservation of local identities. Fertility patterns across the country converge very slowly, which results in high population growth. Economic development is primarily locally oriented and per capita economic growth and technological change fragmented and slow.

Projection Time Frame.

The time period (time horizon) over which projections was made, took into account the limits of predictability. The projected Climatic scenarios therefore were made for the decades of the 2020's and 2050's.

The projected changes in environmental and socio-economic factors were based on the global circulating models A2 emission scenario. Climatic scenarios (plausible future climates), as defined by the Belize National Meteorological Services, was utilized in order to project possible impact on dengue.

Disease selection

The decision to select Dengue as the disease to be studied in relation to its vulnerability to climate change was made by the Ministry of Health based on the following factors:-

- Classical dengue is endemic in Belize and hence the risk of occurrence of the fatal dengue hemorrhagic fever exists.
- Studies have revealed that the occurrence of dengue fever is sensitive to temperature, humidity and rainfall increase.
- The IPCC's Third Assessment Report (2001) projects and increase in average world surface temperature ranging from 1.4 to 5.8˚C and change in seasonality and weather patterns over the course of the twenty-first century.

IMPACT ASSESSMENT

Impacts are estimated or projected as the differences over the study period between the environmental and socio-economic conditions projected to exist without climate change and those that are projected with climate change. The assessment includes qualitative and quantitative analysis and cost-benefits analysis.

Modeling impact and adaptation strategies in the health sector is an emerging field; the number of tools and approaches available explicitly designed for this purpose is still limited. The consultant therefore, in the absence of regression models to project future impacts, focused mainly on the risk management process to determine future vulnerability and required adaptation measures.

ADAPTATION ASSESSMENT

Response (Adaptation), are actions taken to reduce vulnerability or to reduce impact. These can be autonomous or planned. The burning of vegetable materials (e.g. cohune shell) in rural areas, and fish coils in urban households as mosquitoes repellent, is an example of autonomous adaptation. The spontaneous use of bed nets is also an autonomous response of individuals to a perceive risk. The planned response is that undertaken by the community, by local or national authorities in response to a policy decision. An example in Belize of a planned response is the Dengue control program of the Ministry of Health. This program was described in the introductory section of this document, hence there is no need to say more about it here, except that the program has room for improvement in the execution of planned activities and strategically it can be categorized as unsustainable. Not withstanding, the program has a surveillance component that assist in monitoring frequency and distribution of the disease and trend over time. The level of present adaptation capacity is no doubt mitigating the impact of dengue, but not enough to reduce the risk to levels where the likelihood of dengue transmission is minimal.

STUDY OUTPUTS

Results of this study have been presented in a report, produced in digital and hard copy, describing:-

(a) Background Information on Dengue

Clinical dengue

Definition, signs and symptoms
Dengue is an acute febrile viral disease characterized by sudden unset, fever for 3-5 days, intense headache, myalgia, arthralgia, retro-orbital pain, anorexia, gastrointestinal disturbances and rash. Minor bleeding phenomena, such as petechiae, epistaxis or gum bleeding may occur at any time during the febrile phase. If in addition to the above symptoms, the patient presents also with

signs of increase vascular permeability, hypovolemia and abnormal blood clotting mechanisms, the diagnosis of Dengue Hemorrhagic Fever (DHF) is made.

Diagnosis

A confirmatory case of Dengue is made when the virus is identified from a blood sample or a serological reaction to the dengue virus antigen occurs. The main procedures for laboratory diagnosis of dengue are known as virus isolation and characterization; molecular diagnosis; antigen detection and antibody detection. Each test has different degrees of complexities, sensitivity and specificity. Generally speaking, viral identification and characterization methods requires greater degree of technical capability and for this reason, most countries or regions conduct this procedure a few times during the initial phase of new outbreak. In some countries where laboratory capacity does not exist, symptomatic diagnosis of Dengue is accepted.

Types of dengue

The viruses of Dengue Fever are flaviviruses and include serotypes 1, 2, 3, and 4. The same viruses are responsible for DHF. Two or more infections to the same individual with different serotypes appear to increase the probability of developing DHF. Infection with one serotype confers immunity for life for that serotype but not against the other three

Dengue Hemorrhagic fever (DHF), Dengue shock syndrome

DHF is a febrile disease that is characterized by high fever, hemorrhagic phenomena, often with hepatomegaly, and, in severe cases, signs of circulatory failure. Such patients may develop hypovolemic shock resulting from plasma leakage. This is called dengue shock syndrome (DSS) and can be fatal.

The disease was first recognized in the Philippine in 1953. The syndrome was etiologically related to dengue viruses when serotypes 2, 3, and 4 were isolated from patients in that country in 1956; 2 years later dengue viruses of multiple types were isolated from patients during an epidemic in Bangkok, Thailand. During the next three decades, DHF was recognized in Cambodia, China, India, Indonesia, the Lao People's Democratic republic and several Pacific Island. As of 2007, DHF is present in most tropical countries of all continents.

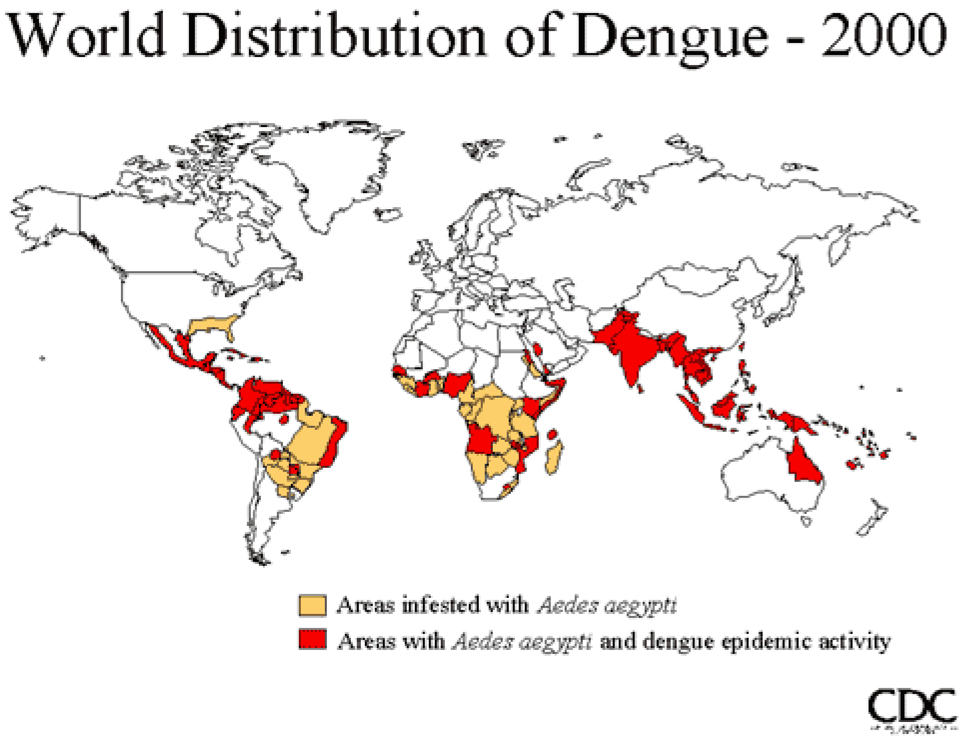
In each country of the regions where DHF has become endemic, the sequence has been more or less the same; frequent transmission of dengue viruses, first associated with sporadic cases of DHF, fallowed by DHF epidemics which progressively become more frequent, until DHF cases are seen virtually every year with major epidemics occurring at 3-5 years intervals. Depending on the severity of the outbreak and the existence of favorable conditions, the percentage of DHF could go anywhere from 2 to 10% of the total number of cases in any given outbreak.

(b) Epidemiology of dengue

Distribution

During the past several decades, dengue viruses have progressively extended their geographic distribution, and are currently some of the most important mosquito-borne viruses associated with human illness.

Figure: 4: World Distribution of Dengue in 2000



This distribution map from the Center for Disease Control (CDC) shows the regions and countries where dengue transmission is taking place. As can be seen, dengue is occurring primarily in tropical countries.

(c) Risk factors

Vector

Dengue viruses are transmitted from person to person by *Aedes (Ae.)* mosquitoes of the subgenus *Stegomyia*. *Ae. aegypti* is the most important epidemic vector, but other species such as *Ae. albopictus, Ae. polynesiensis,* members of *Ae. scutellaris* complex, and *Ae. (Finlaya) niveus* have also been incriminated as secondary vectors. All except *Ae. aegypti* have their own restricted geographical distribution and, although they may be excellent hosts for dengue viruses, they are generally less efficient epidemic vectors than *Ae. aegypti.*

The female *Aedes* mosquito usually becomes infected with dengue virus when she takes blood from a person during the acute febrile (viraemic) phase of illness. After an extrinsic incubation period of 8 to 10 days, the salivary glands of the mosquito become infected and the virus is transmitted when the infective mosquito bites and injects the salivary fluid into the wound of another person. Following an incubation period in humans of 3-14 days (4-6 days average), there is often a sudden onset of the disease, with fever, headache, myalgias, loss of appetite, and a variety of nonspecific signs and symptoms, including nausea, vomiting and rash.

Viraemia is usually present at the time of or just before the onset of symptoms and lasts an average of five days after the onset of illness. This is the crucial period when the patient is most infective for the vector mosquito and contributes to maintaining the transmission cycle if the patient is not protected against vector mosquito bites.

Environmental

Altitude

In the report of an outbreak of Dengue in the state of Guerrero, Mexico in 1988, Emilio Guerrero concluded that the epidemiologic and serologic confirmation of a dengue outbreak at 1,700 meters above sea level represents the capability of *Aedes aegypti* to adapt to new environments, and the potential for epidemic spread in cities at comparable altitudes or higher.

In its “Regional Guidelines on Dengue” WHO states that Altitude is an important factor in limiting the distribution of *Ae. aegypti*. In India, *Ae. aegypti* ranges from sea level to 1000 meters above sea level. Lower elevations (less than 500 meters) have moderate to heavy mosquito populations while mountainous areas (greater than 500 meters) have low populations. In countries of South-East Asia, 1000 to 1500 meters appears to be the limit for *Ae. aegypti* distribution. In other regions of the world, it is found at even higher altitudes, i.e. up to 2200 meters in Colombia.

Jonathan Platz in his paper “Global Climate Change: Implication for Sustainable Development” states that warming trends, can shift vector and disease distribution to higher latitudes or altitudes, as was observed in Mexico when dengue reached an altitude of 1,700 meters during an unseasonably warm summer in 1988. In an earlier study in Mexico, the most important predictor of dengue prevalence in communities was found to be the median temperature during the rainy season.

Temperature/humidity/rainfall

Temperature also drives epidemic dynamics of dengue transmission. Warmer water temperatures in breeding vessels reduces the size of emerging adults that subsequently must feed more frequently' to develop an egg batch. Viral development time inside the mosquito also shortens with higher temperatures, increasing the proportion of mosquitoes that become infectious at a given time. Thus, mosquitoes bite more frequently and are potentially more infectious at warmer temperatures. Hence, important environmental and climatic determinants for dengue transmission are abundant rainfall, which creates conditions for increased Ae. *aegypti* populations, and elevated temperature and humidity which shorten the extrinsic incubation period of the virus in the mosquito.

Socio-economic

The main socio-economic factors related to the transmission of dengue are poor housing conditions, overcrowding, poor hygienic practices, improper water storage and unsanitary garbage disposal practices.

(d) Control measures

The strategies been utilized by most countries today is one of integrated control as opposed to disease eradication. They can be summarized as:-

Risk stratification
Prioritization of high risk areas
Environmental management with community participation
Enforcement of sanitary legislation

The main focus is to reduce the vector to levels where transmission is unlikely.

THE GLOBAL BURDEN OF DENGUE

In the World

Dengue and dengue hemorrhagic fever have emerged as a major public health problem in the world. The primary vector mosquito has spread throughout the tropics and into susceptible human populations in urban and increasingly rural areas. The urbanization process, which has left many without adequate water, sewer systems or waste management, and created new breeding grounds for the vector, has accelerated the spread of the disease. Vector control activities have not halted the explosion in transmission of the disease.
The global population at risk is estimated to range from 2.5 to 3 billion individuals living mainly in urban areas in tropical and subtropical regions. However, while dengue was formerly thought to be strictly an urban problem, it is now recognized as also being of significance in rural areas of developing tropical countries. It is estimated that there are at least 100 million cases of dengue fever annually and 500,000 cases of DHF which require hospitalization. Of the latter, 90% are children under the age of 15 years. DHF mortality rates average 5%, with approximately 25,000 deaths each year. According to a 2001 IPCC report on climate change, dengue and DHF are responsible for 653,000 disability adjusted life years (DALYs) annually.

WHO has categorized countries with transmission of dengue as type A and B.

Category “A” countries are those that meets the following conditions:

- Major public health problem
- Leading cause of hospitalization and deaths among children
- Cyclical epidemics in urban center with 3-5 years periodicity
- Spreading to rural areas
- Multiple virus serotypes circulation

- *Aedes aegypti* is the principal circulation vector
- Role of *Aedes albopictus* is uncertain

Category "B" are countries with the following conditions:

- DHF is an emerging disease
- Cyclical epidemics are becoming more frequent
- Multiple virus serotypes circulating
- Expanding geographically within countries
- *Aedes aegypti* is the principal epidemic vector
- Role of *Aedes albopictus* is uncertain

In the Americas

Even though reports of dengue in the Americas date back to two hundred years, it is only during the past 50 years that the frequency and intensity of the outbreaks have increase. Four serotypes of the dengue virus are circulating in the continent, affecting the Caribbean region and Central and South America. Since 1960, cases of dengue have been reported in the millions despite the gross underreporting that exist in most countries.
Between 1977 and 1980, 702,000 cases were reported by affected countries in which Den-1 was the principal serotype circulation in the Americas. During this period, 40% of Cuba's 10 million population was infected.

Few studies of the economic impact of dengue and DHF/DDS in the Americas have been conducted. A study in Puerto Rico during the 1977 dengue epidemic estimated that the cost in medical services and loss of work were between US$ 6 million and US$ 16 million; according to recent studies, the cost of the disease's epidemic in Puerto Rico since 1977 is estimated to be between US$ 150 million and US$ 200 million.

The cost of the DHF/DSS in the Cuba epidemic in 1981 was estimated at about US$ 103 million, a figure that includes the cost of control measures and medical services. Of this total, US$ 41 million went for medical care; US$ 5 million, for salaries paid to adult patients; US$ 14 million, for lost production; and US$ 43 million, for the direct initial cost of the *A. aegypti* control program.

In Belize

First outbreak of dengue in Belize was in 1978; since then there have been mild outbreaks every two to three years. The outbreaks have become more frequent and dengue is now considered endemic in this country. There have been a couple suspected cases of DHF, but epidemiological investigations concluded that there were no evidence of DHF and they were classified as classical dengue with hemorrhagic manifestation. For more detailed information on recent and present incidence of dengue, see the section on present vulnerability.

ASSESSMENT OF PRESENT VULNERABILITY AND ADAPTATION CAPABILITIES

This section gives a view of the Dengue situation in Belize during the period 2002-2007. It highlights the existing risk of dengue to the population and makes future projections. It describes the frequency, distribution and trend of Dengue and its environmental, socioeconomic and climatic risk factors. Complete data on the occurrence of dengue could only be found for the years 1995, 2002, 2005 and 2007 see table # 6. Data for other years between those mentioned was inconsistent and incomplete therefore it was not utilized.

Table 6: Dengue Cases Recorded with complete data

Dengue Cases for Years with Complete Data

	YEARS			
DISTRICTS	**1995**	**2002**	**2005**	**2007**
Corozal	1	9	8	72
O. Walk	21	7	3	17
Belize	46	22	19	159
Cayo	15	3	614	18
S. Creek	7	0	5	39
Toledo	10	0	1	3
Don't Know			2	23
Totals	100	41	652	331

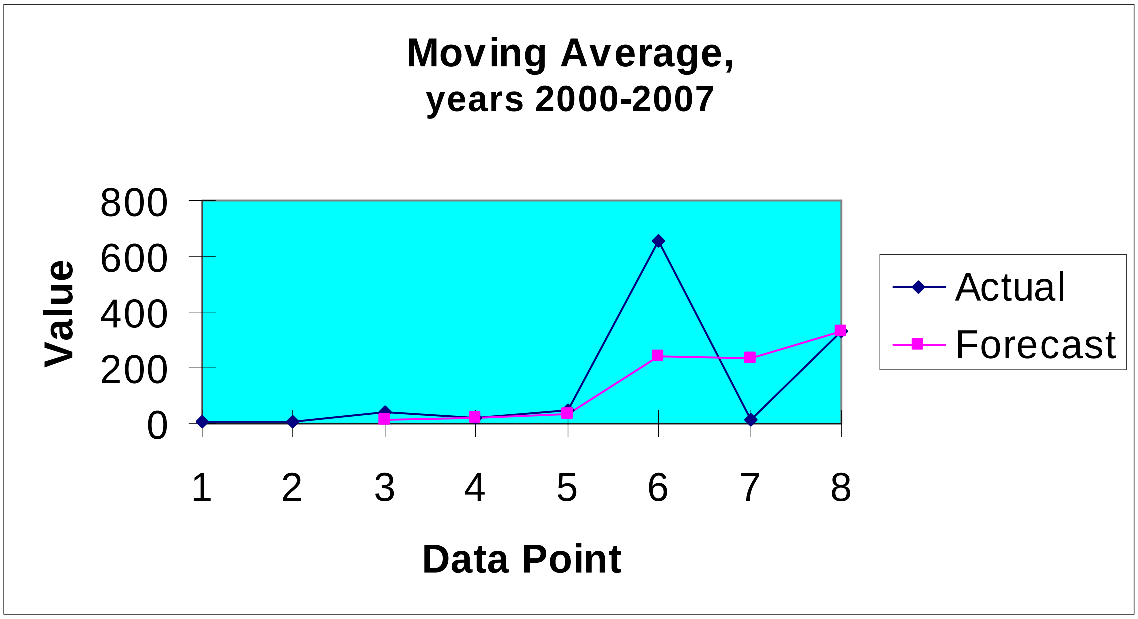
The total number of dengue cases in Belize for the year 2007 was 331, 48% (159) of which occurred in the Belize district. The risk of dengue per thousand inhabitants in the Belize District (1.7), is slightly lower than that of the Corozal district (1.9). The risk (Incidence) of a person developing dengue in Belize during the year 2007 as determined by epidemiologic data for that year was 0.00106. This is the same as saying that during the year 2007, 1.06 persons out of every thousand inhabitants developed dengue.

Incidence is an epidemiologic measure that is used mainly to: assess risk; to compare groups on a variable of interest; to identify trend in morbid events e.g. dengue, and to calculate future occurrence of disease based on projected population growth.

The Statistical Institute of Belize has projected the population to reach 368,693 for the year 2020 and 499,836 inhabitants for the year 2050. Based on this projected population growth, the expected number of dengue cases for the years 2020 and 2050 are 391 and 530 respectively. The main assumption in this calculation is that with the exception of population growth, all other risk factors remain the same. Of course, we know that according to the Global Circulation Models, global temperatures will increase by 2˚C to 4.5˚C by the end of this century, with the best estimate been 3˚C. This increase in temperature is expected to be accompanied by increase in the frequency and intensity of extreme events that are beyond the coping capacity of the population and for which adaptation measures will have to be incorporated into national development plans.

The combined incidence for the years with complete data was estimated to be 0.00105, or 1.057 persons per thousand inhabitants. As can be seen, there is no significant difference between the combined incidence and that of the year 2007. The calculation is accomplished by dividing the sum of the cases for those three years, by the average population for those same years multiplied by the years of observation (3 years).The overall trend of dengue occurrence in Belize (fig. 7) as suggested by 2002-2005 data, is toward the increase in all districts.

Figure 5: Dengue trend, 1995- 2007



The required data to describe distribution of cases by serotype was not available. This is because the majority of reported cases are based on clinical diagnosis. Due to the few cases that were sent to the regional laboratory each year, especially at the beginning of a suspected outbreak, it is now known that over the years, the four serotypes of dengue viruses have circulated in Belize. The years of first appearances of the different dengue serotypes are as follows:-

Table 7: Dengue serotype emergence

Year	Number of cases	Serotype
1978		1
1982	482	4
1997	141	3

The consultant was unable to get data on number of case that occurred in the year 1978. The identification and characterization of dengue viruses was done in Puerto Rico through CAREC. It is believe that Den-type 2 has also circulated in Belize.

Group distribution of dengue

The age distribution as reflected in graph 5 has no outstanding feature. It should be noted nonetheless, that countries which have experienced DHF outbreaks refers higher attack rate among children than adults. The severity of dengue and DHF is also greater among children.

Figure 6: Age distribution of Dengue cases - 2007

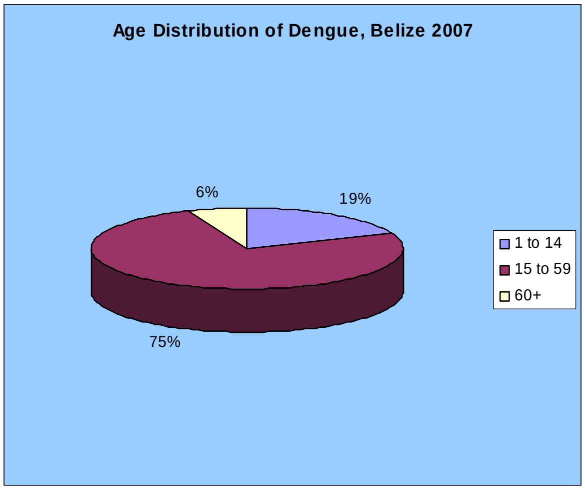
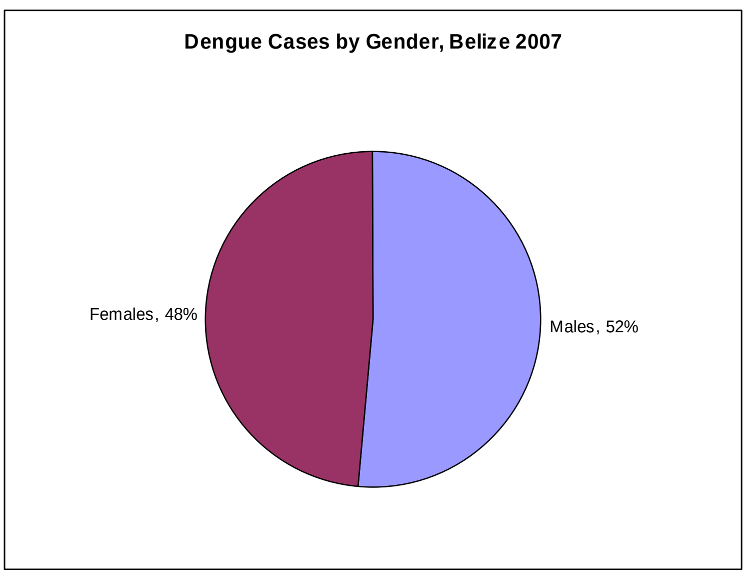


Figure 7 below depicts the distribution of dengue cases by gender. The incidence among males is slightly higher (4%) than in females. The lower percentage of cases among children and females could be a reflection of the practice, particularly in the rural areas, of protecting mothers and children from nuisance mosquitoes and other insects through the use of bed nets.

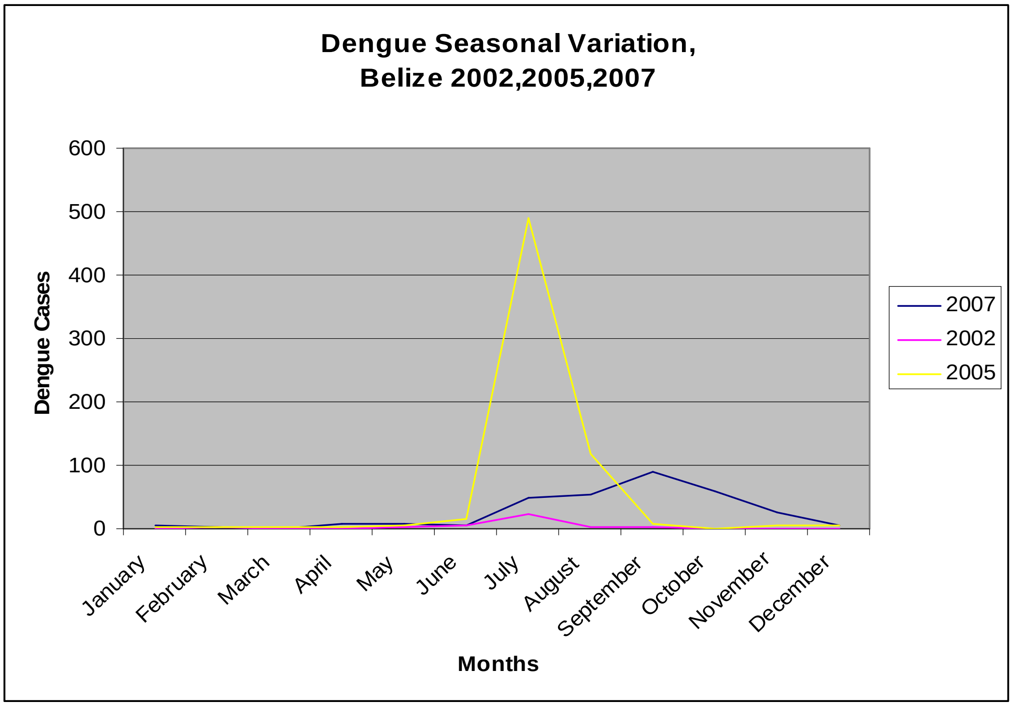
Figure 7: Dengue Cases by Gender – 2007



Seasonal variation

A Line graph was constructed with cases by month in order to see if there were any indications of seasonal variation in the occurrence of dengue. Cases for the years 2002, 2005 and 2007 were utilized since these were the only years for which complete data per month was available. Figure 8 below shows a clear pattern in the occurrence of cases, with the majority occurring between June and October.

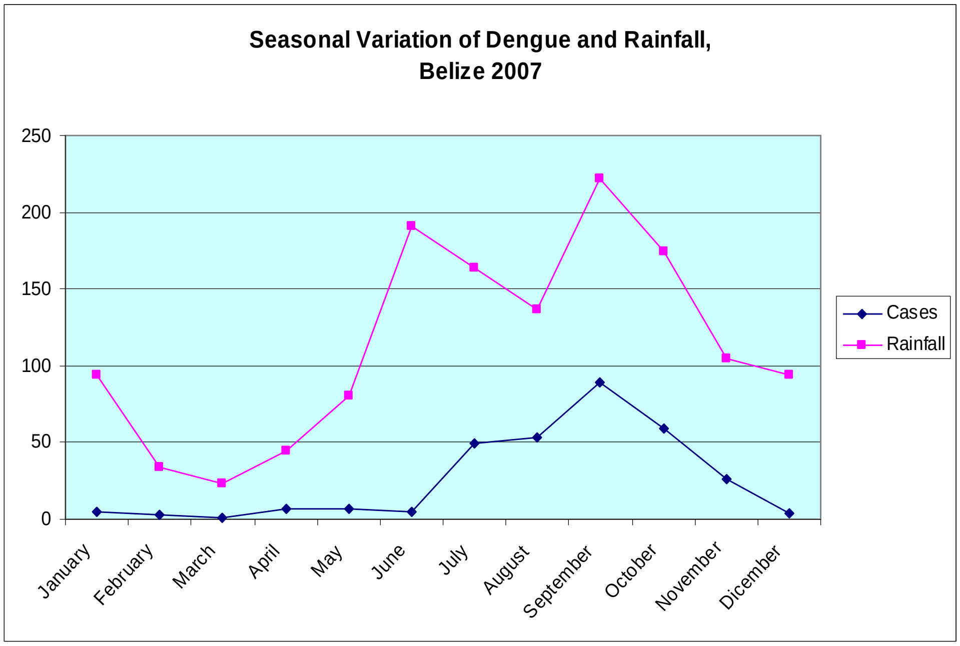
Figure 8: Seasonal variation of Dengue in Belize – 2002, 2006, 2007



There are a relatively low number of cases during the dry season which is from January to end of May; this is followed by a sharp increase in the middle of June extending to the middle of October. Between October and December, there is a gradual decrease in the number of cases to an average of five or less. The same pattern is seen in each of the years included in this analysis. It is interesting to observe that the increase in cases logs approximately two weeks behind the increase in rainfall, as can be seen in the graph below.

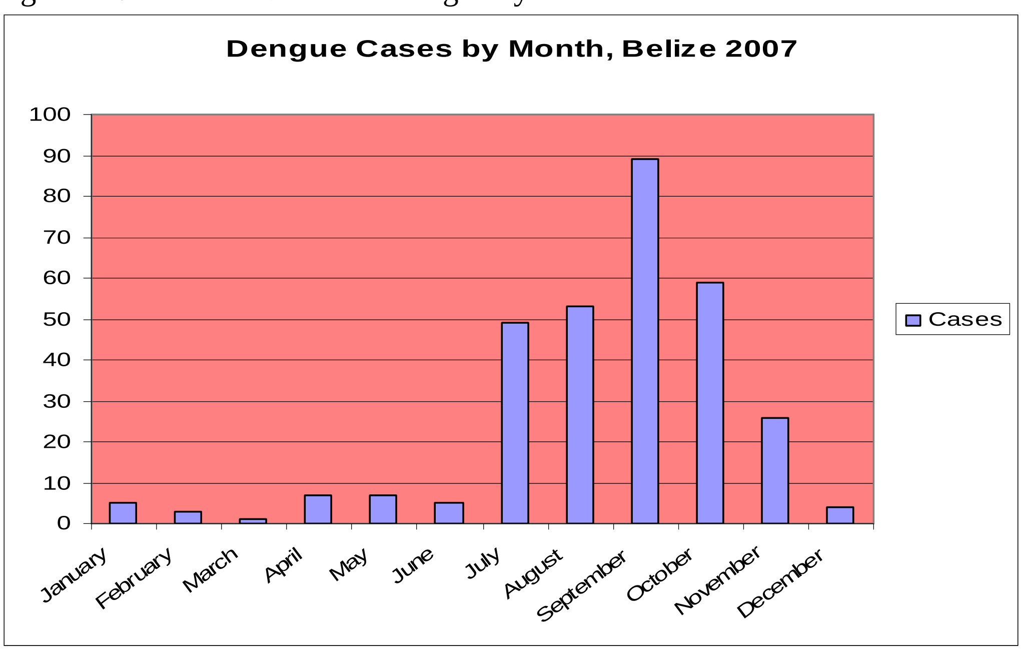
The seasonal variation in the occurrence of dengue cases follows the same rainfall pattern as outlined in Figure 9 below. A correlation analysis to assess the relationship between

Figure 9: Seasonal Variation between dengue and rainfall



Dengue and rainfall was done; the Person product moment correlation (r) was estimated to be 0.758418. This value of "r" suggests a strong correlation between rainfall and the occurrence of dengue. In layman terms what this means is that rainfall is directly or indirectly influencing the incidence of dengue. This however, does not come as a surprise since containers, potential breeding sites for the *Aedes aegypti* mosquito, becomes productive only when they are filled primarily by the rain.

Figure 10: Incidences/Cases of dengue by month 2007



The case distribution by month is shown in Figure 9 above. Most cases occur during the July-October period. These are the months with the highest rainfall in the country. Due to lack of data, it was not possible to compare the seasonal variation of dengue for the western and southern districts to that of the center and north. It would be interesting to see if the dengue epidemiological curve in the south anticipates that of the north, since the pattern of rain in these two regions varies significantly.

Vectors

The presence of the *Aedes aegypti* mosquito is fundamental to the occurrence of dengue in any ecosystem. The concept of epidemiological triangle of disease transmission is well known by public health practitioners. It says that three fundamental elements need to coexist in order for disease transmission to occur. These elements are: the host, the agent and the environment; transmission can not take place in the absence of any of these three elements. Other elements (factors) which are characteristics of the host, agent or the environment, may facilitate or protect against transmission.

As it relates to dengue transmission, the host is human; the agent is the dengue virus and the environment is represented by the vector and climatic parameters. All three elements required for the transmission of dengue are present in Belize on a permanent basis and for that reason; the disease has become endemic showing periodic epidemics when characteristics of these elements are such that transmission is enhanced.

The main dengue vector in Belize is the *Aedes aegypti* mosquito. To date studies have not revealed the presence of other vectors such as the Aedes albopictus. Since the environmental conditions as it relates to temperature, humidity, rainfall and altitude are within the ideal ranges in all districts, the entire country is considered to be at risk of dengue transmission. The level of risk is determined more by life style and socio-economic conditions of communities, than by geographical location.

An entomological cross-sectional survey was organized and conducted in August of 2008, by the Belize SNC project with the support of the Vector Control Program of the MOH. The main objective was to collect reliable data on the frequency and spatial distribution of the *Aedes aegypti* larvae in the country. The mosquito density as measured by the Breteau, House and Container indices, gives an accurate indication of the existing level of risk of dengue transmission. The findings of the study were the following: 17% of surveyed communities had a Breteau index below 2%. This is the threshold (even though disputed) below which dengue transmission is unlikely. Thirty nine (39) percent had Breteau indexes between 2 and 5 per cent; this level of larvae infestation supports the maintenance of endemic dengue and low level outbreaks. Eight communities (44%) had larvae infestation as determined by the Breteau index, between 6 and 24 per cent; the probability of dengue outbreak is very high in these communities (See annex table/graph 1E, 2E, 1C).

Since the selection of participating communities and households within communities was randomly done, and since the sample size selected was large enough to detect larvae infestation as low as of 1% (precision), the internal and external validity of the study is such that the results of the study can be extrapolated to the entire rural Belize. Due to time and resources, the survey was not conducted in urban areas, but the review of available urban data suggests that the level of infestation is greater there. Further studies would have to be conducted in other to quantify vector density in the urban setting. The study also showed that the most productive containers found in the rural areas were drums and tires (see annex D, table 1D).

Correlation analysis was done between Breteau Index for all villages surveyed, and climate variables (rainfall, temperature) taken at weather station near each village. The analysis was done for every day of the month of August up to day 28, which is when the study was conducted. Moderate correlation was found for days 25^{th} and 26^{th} between rainfall and Breteau index. The Person Product Moment correlation for the 25^{th} and 26^{th} were 0.437 and 0.362 respectively. This finding suggest that increased rainfall 3 to 4 days before the survey was carried out, might have played a role in creating the conditions for the female mosquito to lay her eggs. No correlation was found between BI and temperature for any of the days analyzed.

Socio-economic factors

A project proposal for the control of dengue in Belize utilizing the COMBI strategy was developed in the year 2003 by personnel of the Ministry of Health with technical support of the Pan American Health Organization (PAHO). An evaluation of the prevailing situation in Punta Gorda town (pilot site) was done and the findings were recorded as follows: - It was observed that approximately 50% of home owners were not practicing proper bagging and disposal of garbage. Garbage was not properly disposed of in the municipal dumpsite and because of this, and the advent of the rainy season, according to community members, the presence of mosquitoes increased during the months of June to November.

The garbage was not being crushed/compacted before deposited at the dump site and due to this practice; mosquitoes were laying their eggs in opened containers thus causing the abundance of mosquitoes as reported by populations living near the dump site."

The findings of this assessment in the southern town of Punta Gorda, is a reflection of a larger problem affecting other communities across the country. Garbage disposal practices in many communities create peri-domiciliary conditions which are ideal for the dengue vector to reproduce. This is compounded by the fact that organized refuse collection is inadequate and in some areas non-existent.

The *Aedes aegypti* mosquito has been called the "urban mosquito" because of its preference for habitats around and within homes, with easy access to human blood. In most countries, dengue is found in urban setting with high population density. That holds true for Belize also, but unlike other places, the social conditions and practices in rural Belize do not differ much from the urban settings. Rural communities generate similar per capita amount of garbage than urbanized towns, and because of their westernized consumption practices, the garbage generated has a large amount of metal, plastic and glass containers. These containers when improperly disposed of serve as ideal breeding sites for the dengue vector.

Poverty

Poverty has long been identified as a risk factor for many chronic and infectious diseases, including dengue. Poor people usually live in homes where internal and external environmental conditions facilitate virus-host interaction. In addition to living in unprotected homes, poor people often live in crowded conditions and are unable to purchase repellants and other means of personal protection.

The Poverty Assessment Report for 2002 showed that the percentage of the population living below the poverty line in Belize was 33.5%. This study further showed that poverty in the rural areas (44.2%) was much higher than that of the urban areas (23.7%). These statistics points to the percentage of the population who because of their economic situation, in addition to other risk factors they may have, are at risk of becoming ill with dengue or other vector borne diseases.

Despite the improvement in access to piped water in rural areas in recent years, a significant percentage of homes still have to store water to meet their daily needs. This practice serves to create the condition for the *Aedes aegypti* mosquito to reproduce, since these containers are often left open and in areas shaded from the sun. In brief, the socio-economic condition described in countries where dengue transmission exist, are prevalent in Belize. The quantification of the frequency and distribution of these factors can only be achieved through scientific field studies.

Environmental Factors

The manmade environmental factors such as housing condition, improper garbage disposal and inappropriate water storage, have already been describe under "Socio-economic factors". This section will focus on those environmental factors that affect us all and over which we have no control. Whether we are wealthy or poor, young or old, healthy or sick, we are all affected by the climate. Climate is defined by the IPCA as "the average weather or more rigorously, as the statistical description in terms of the mean and variability of its properties over a period of time, ranging from months to thousands of years. The classical period is 3 decades, as defined by the World Meteorological Organization (WMO). These quantities are most often surface variables such as temperature, precipitation, and wind". All organisms live in habitats that are conducive to their reproduction and development and often that habitat is defined by temperature, precipitation and humidity.

A significant number of studies in different countries have found a moderate to strong correlation between dengue and rainfall. The same is true for average temperature. The *Ae. Aegypti* mosquito is unable to survive in temperatures below 50˚F, but strives in temperatures above70˚F. The mosquito population increased during the rainy season due to increased formation of breeding sites.

The mean annual humidity in Belize is 83%; the average temperature is 79˚F, with an average range of 75.2 to 80.6˚F; extremes temperatures can range from 50 to 95˚F.The average rainfall varies from 60 inches of rain in the north to 160 in the south. All settlements in Belize are located at an altitude below 2,000 feet. All known population settlements in Belize are located within the ranges of climate parameter which are ideal for the proliferation of the *Aedes aegypti* mosquito and hence, are at risk of dengue transmission.

Response capacity

Responses are actions taken to reduce vulnerability or to reduce impact. These can be autonomous or planned. The burning of vegetable materials (e.g. cohune shell) in the rural areas, and fish coils in urban households as mosquito repellant is an example of autonomous adaptation. The spontaneous use of bed nets is also an autonomous response of individuals to a perceive risk. The planned response is that undertaken by the community, by local or national authorities in response to a policy decision. An example in Belize of a planned response is the Dengue control program of the Ministry of Health. This program was described in the introductory section of this document, hence there is no need to say more about it here, except that the program have room for improvement in the execution of planned activities and strategically it can be categorized as unsustainable. Not withstanding, the program has a surveillance component that assist in monitoring frequency and distribution of the vector and trend over time.

VULNERABILITY

Vulnerability is defined by the IPCC as the "potential to be harmed". Is the extent, in the context of Belize, to which we are and can be impacted by dengue outbreaks due to climate change. Human population, as with individuals vary in their vulnerability to certain health outcomes. A population vulnerability is a joint function of, first, the extent to which particular health outcome is sensitive to given risk factors and second, the population's capacity to adapt to increased or new risk. The vulnerability of a population depends on factors such as population density, level of economic development, food availability, income level and distribution, of public health care. (Climate change and Human Health. WHO, 2003).

Below is an example of factors affecting vulnerability as outlined by A. McMichael et al.

LEVEL	Influence on Vulnerability	Description
Individual	Disease status	Those with pre-existing conditions for example, may be more vulnerable to direct effects such as heat waves
	Socioeconomic factors	Poor in general are more vulnerable
	Demographic factors	Elderly are more vulnerable to heat waves, infants to diarrheal diseases
Community	Integrity of water and sanitation systems and their capacity to resist extreme events. Local food supplies and distribution systems. Access to information. Local disease vector distribution	Lack of early warning of extreme events

Geographical	Exposure to extreme events	Influence of El Niño cycle or occurrence of extreme weather events more common in some parts of the world
	Altitude	Low-lying coastal population more vulnerable to the effects of sea level rise
	Proximity to high-risk disease areas	Populations bordering current distribution of vector-borne disease may be particularly vulnerable to changes in distribution
	Rurality	Rural residents often have less access to adequate health care; urban residents more vulnerable to air pollution and heat island effect
	Ecological integrity	Environmentally degraded and deforested areas more vulnerable to extreme weather events.

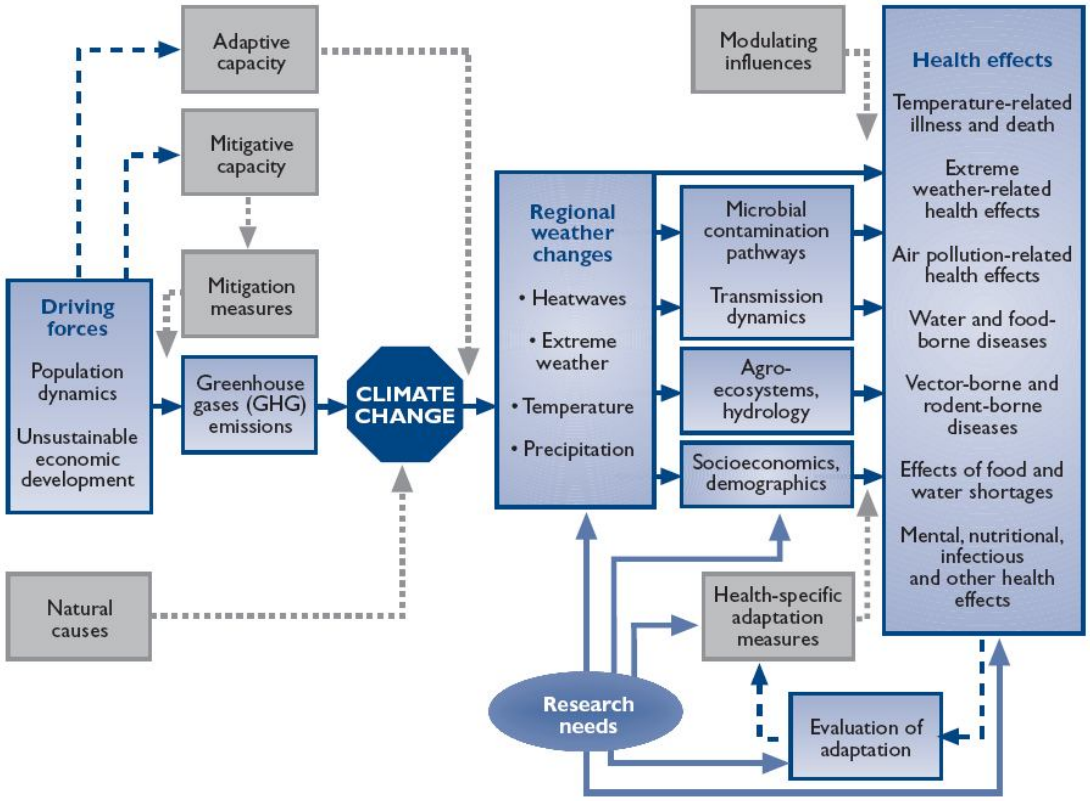
Based on the analysis of prevailing natural and human systems' drivers of vulnerability, and also the existing adaptive capacity, it can be concluded that the present vulnerability of the Belizean population to dengue and DHF outbreaks can be categorized as "Medium level".

THEORETICAL FRAMEWORK FOR CLIMATE CHANGE IMPACT ON HEALTH

Dengue is the most important arboviral disease of humans, occurring in tropical and subtropical regions worldwide. In recent decades, dengue has become an increasing urban health problem in tropical countries. The disease is thought to have spread mainly as a result of ineffective vector and disease surveillance; inadequate public health infrastructure; population growth; unplanned and uncontrolled urbanization; and increase travel.

Dengue is seasonal and usually associated with warmer, more humid weather. There is evidence that increased rainfall in many locations can affect the vector density and transmission potential. The climate variability phenomena known as El Niño southern oscillation (ENSO), may act directly by causing changes in water storage practices brought about by disruption of regular supplies. Rainfall may affect the breeding of mosquitoes but this may be less important in urban areas: *Aedes aegypti* breed in small containers, such as plant pots, which often contain water in the absence of rain. Between 1970 and 1995, the annual number of epidemics of dengue in the South Pacific was positively correlated with the Southern Oscillation Index (SOI). This is plausible since; in this part of the world, high positive values of the SOI (denoting La Niña conditions) are associated with much warmer and wetter conditions that the average, which is ideal for the breeding of mosquitoes. Hales et al. examined the relationship between ENSO and monthly reports of dengue cases in 14 island nations in the pacific. There was positive correlation with dengue in ten countries.

Climate Change and human health: Pathway from driving forces, through exposures to potential health impacts. Boxes under "Research needs" represent input required by the health sector.



Source: Patz J.A. et al. Environmental Health Perspectives 108(4): 367-376 (2000).

Natural and human drivers produce GHG. These in turn cause climate change which is expressed as regional weather changes, heat waves, extreme weather events, higher or lower temperatures and precipitation. These changes in climate affect the microbial contamination pathways and socio-economic demographic, thus causing disease and injuries among people.

FUTURE VULNERABILITY ASSESSMENT

Hazard definition

One of the major environmental challenges facing the Caribbean is that of global climate change and its associated consequences of sea levels rise, intensification of storms and changing weather patters. Caribbean governments, like those of other Small Island Developing States, have undertaken a strategy to adapt to climate change with the hope that by so doing, their economic and environmental systems would be able to withstand the predicted deleterious impact of climate change.

Hazard has been defined as: A source of potential harm, or a situation with a potential for causing harm, in terms of injury; damage to health, property, the environment, and other things of value. Considering the level of uncertainty, technological development and availability of data, the risk management approach was considered to be suitable for bringing precision to the decision making process involved in developing climate change adaptation options for implementation. Caribbean Risk Management Guidelines, 2003.

This methodology is based on the Canadian National Standard (CAN/CSA-Q85097): Risk management: Guidelines for decision makers.

The steps in this risk management approach are: hazard analysis, risk estimation, risk evaluation, adaptation and risk control, and implementation.

The Third Assessment Report (TAR) of the IPCC predicts that if the present global trend of Green House Gas emissions continues, global sea level is expected to rise by 0.09 to 0.88 meters and global temperature is expected to increase by 1.4 to 5.8˚C by the end of this century. The TAR also reinforces the observation that impacts of sea level rise and temperature increase are likely to be more severe in Small Developing Island and low-lying coastal states. Numerous studies to date reveal that countries are very vulnerable to climate change impacts.

The following sectors were considered to be at risk:

- Human settlements
- Tourism
- Agriculture and Food Security
- Water
- Health
- Banking/Insurance
- Infrastructure
- Coastal, Marine and Terrestrial Ecosystems

As part of the risk analysis process, countries are expected to identify risk for each of these sectors. This can be accomplished by examining the vulnerability to each or any of the fallowing potential hazards expected from climate variability and climate change:

- Increase atmospheric and sea-surface temperature
- Decreased precipitation on average in the rainy season and increase annual evaporation
- More intense storms
- Changing weather patters
- Sea level rise

Belize's National Meteorological Service, based on historical climatic data, projects that it is *likely* that atmospheric and sea-level temperatures will increase and that there will be changes in weather patters (extended rainy seasons, prolonged droughts, and ENSO occurrence).

Unlike countries with more diverse topography, Belize is not expected to experience changes in geographical range and distribution of dengue transmission. Most of the country is suitable for dengue transmission in terms of climate parameters and altitude. A small increase in temperature for example, will not reduce nor extend the range of vector habitat. However, change in seasonality (prolonged rainy season) is expected to render natural and artificial breeding artifacts more productive for a longer period of time. Extended dry season will induce changes in human behavior, as it relates to capture and storage of water, which in turn increases the availability of breeding sites for the dengue vector.

The Hazard

The health sector probably has the least information in the region as it relates to climate change vulnerability and impact. The Caribbean region displays favorable climate for many disease vectors. Therefore, climate-related chronic, contagious, allergic, and vector-borne diseases (e.g., malaria and dengue, asthma and hay fever), linked to plants or fungi whose ranges and life cycle are strongly affected by climate change and weather, can be expected to increase with global warming.

Dengue and DHF have been identified by the MOH as the climate sensitive health conditions to be assess, due to the potential for epidemics to occur and the existence of favorable conditions for DHF and related fatalities to appear. The potential increase of dengue and DHF as a consequence of climate variability and climate change has been identified as a hazard that will posed a risk to different sectors or sub-sectors.

Estimating the Risk

This step involves estimating the frequency and severity of the impact of climate variability and climate change (CV/CC) risk scenarios on the country. In Belize, it is anticipated that increase frequency of dengue and DHF outbreaks could affect several sector of development. It could affect the tourism industry due to cancelled visit; the health sector due to increase health care delivery cost and control activities; labor due to absenteeism; GDP due to reduce production and economic activities; education due to student absenteeism, and individuals due to reduce income and treatment cost.

For individuals that are experiencing dengue, apart from the personal discomfort and suffering they endure, they have to confront, in many cases, lost of income and the possibility of death if the condition progresses to DHF/DSS.

An increase incidence of Dengue could affect the health sector through increase cost of patient care; vector control activities; the need for increased active surveillance; health education and health promotional activities.

The listing of Belize in the International Travel Advisory, as a country with high risk for dengue transmission or the announcement of an outbreak of DHF, could significantly reduce the number of people visiting the country thus negatively affecting the tourism industry. According to the Belize Tourism Association (BTA), 25% of the active population is employed in the tourism industry. A downfall in tourist arrivals could adversely affect the economy.

An increase in the number of Dengue cases in Belize as a consequence of changes in related risk factors, including climate variability and climate change, will also have in impact on the labor force. The average recovery time for a case of classical Dengue is 10-12 days and a DHF case recovery period is 3-4 weeks. The product of the recovery days times the number of cases provides an estimate of man days lost to Dengue and DHF in the country. The estimated man days lost in the years 2005 and 2007 was 6,520 and 3,310 respectively.

For self employed and subsistence farmers, the impact of the disease is greater, since they have no health insurance nor are they Social Security contributors; as a consequence, they obtain no income during the convalescence period.

Children are also at risk of developing dengue and DHF. While experiencing the disease, they are unable to attend school or to conduct scheduled exams, thus contributing to school absenteeism and lower academic performance. The above stories are known as risk scenarios; they allow us to dissect the hazard (dengue) and to see exactly how it affects different sectors.

From the above described risk scenarios, it can be concluded that the occurrence of Dengue is a hazard that has the potential to be a risk to the population, the health system, to the tourism industry, to education and to organized labor and the self-employed.

A direct impact rating matrix has been utilized (see annex A, tables 2A-9A) to estimate the severity of the impact caused by Dengue and a Frequency/Probability table (see annex A, table 1A) highlights the likelihood of occurrence of the hazard.

The events or drivers of the above described risk scenarios are the following:

- Cancelled tourist visits
- Increase cost of health care delivery
- Strain on health care services due to increase demands for epidemics control
- Work absenteeism
- Reduced national production
- School absenteeism
- Reduced personal income

The probability of the occurrence of dengue and DHF with and without climate change has been determined to be <u>Moderately Frequent</u> and <u>Occurs Often</u> respectively, the direct impact that each event in the risk scenarios can produce on the population and the economy, is outlined in the Direct Impact Rating tables in (Annex A, tables 2A-9A).

Evaluating the risk

This is the process by which risks are examined in terms of cost, benefits and acceptability taking into accounts the needs and concerns of stakeholders. The purpose of evaluating the risk serves to integrate the overall risk management process. . It also allow for the ranking of the risk from “least severe” to “most severe”, and to assess the acceptability of the risk.

Work from previous steps such as the identification of hazards; the development of risk scenarios, and stakeholders' needs and concerns, are validated. In summery, the evaluation of risk, ranks the risks from "least severe" to "more severe"; estimates the cost of potential loss, and assess the acceptability by stakeholders of the risk.

The objective of this section was achieved by aggregating the data from the Frequency/Probability and Direct Impact tables and the perception of the risk from stakeholders and experts. The aggregated risk scenarios events were measured against a Risk Assessment Matrix (annex B, tables 1B-7B) in order to rank these risks from least to more severe.

Risk scenarios events were ranked as fallow:

i. "Cancelled Tourist Visits", ranked as <u>moderate</u> risk. Some control will be required to move this risk scenario event to lower levels. The frequency of this event is considered to be ***occasional*** because only moderate to large scale outbreaks reach the international media and travel warnings are issued. It will lead to loss of livelihood and financial loss to stakeholders; it will also negatively impact on the health sector, cultural aspect and the national GDP. An example of how dengue can affect tourism is highlighted in this article which appeared on the online magazine "World Hum: Dengue Epidemic Hits Tourism in Rio".

   "Since January 2008, more that 70,000 people have been infected with dengue fever in the Brazilian state of Rio. At least 80 people have died. Now, the growing health crisis is "taking a toll on tourism" reports the International Herald Tribune. A number of foreign embassies have warned citizens about the outbreak, including the US embassy."

   Back in September of 2008, a reporter asked Dr. Kevin Palmer WHO representative in Samoa about the dengue situation in that region, this was his reply:

   "PALMER: Well, it's gotten so that it's having a major impact, not only on the health of the Pacific, but also on the economy, one of which we rely on tourism and Dengue outbreaks pretty much kills the tourism industry. So what we're saying is that it's getting worse and it's having a major impact everywhere, and it's getting so that the private industry is concerned."

ii. "Increased Cost of Health Care Delivery", ranked as <u>extreme</u> risk. This indicates an unacceptable level of risk that requires immediate controls to move this event out of the extreme range. The frequency of this event if an outbreak of dengue occurs is determined to be ***virtually certain to occur*** .It will have a ***moderate impact*** on the health sector and result in financial loss.

iii. "Increased Cost of Outbreaks Control", ranked as <u>extreme</u> risk. This indicates an unacceptable level of risk that requires immediate controls to move this event out of the extreme range. This event is expected to ***occur often*** because of increased number of outbreaks as a consequence of CV/CC and other risk factors. The impact was considered to be ***major*** because it impacts not only on health and individuals financial loss, but also because of its impact on the environment due to the chemical control measures that needs to be use in the control of an outbreak.

iv. "Work absenteeism", ranked as high risk. This level will require high priority control measures to reduce risk to an acceptable level. ***Occurs often*** but considered of ***low impact***. It could cause displacement if ill people are unable to pay their rent; it definitely causes loss of livelihood due to inability to work; and also cause financial loss and impacts on the GDP.

v. "Reduced National Production", ranked as moderate risk. Some control will be required to move this risk scenario event to lower levels. The national production will be reduced due to man-days loss to the disease, but it will be minimal, hence the classification of impact as ***low***. The probability of occurrence is estimated to be ***moderately frequent*** because most people experiencing dengue are unable to work and to contribute to the national production.

vi. "School Absenteeism", ranked as moderate risk. Some control will be required to move this risk scenario event to lower levels. This scenario risk event is classified as of ***low impact*** because it only produces temporal displacement from school, and the length of displacement with classical dengue is such, that students are able to make up. The occurrence is ***moderately frequent*** because dengue is endemic in Belize and is expected to occur every year throughout the year.

vii. "Personal Income Loss", ranked as high risk. This level will require high priority control measures to reduce risk to an acceptable level. Occurs every time that an adult becomes ill with dengue or DHF. The impact is considered to be ***low*** but it is expected to ***occur often***. It can produce displacement due to inability to pay for the rent, often patients are unable to pay for medical care, there is financial and livelihood loss and the national GDP are negatively affected. The risk assessment keys were used to interpret the ranking of each risk scenario event. (Annex B, Table 8B)

ADAPTATION AND RISK CONTROL

One of the principles of Agenda 21 and the United Nation Framework Convention on Climate change (UNFCCC) states:

"The parties should take precautionary measures to anticipate, prevent or minimize the causes of climate change and mitigate its adverse effects. Where there are threats of serious or irreversible damage, lack of full scientific certainty shall not be used as a reason for postponing such measures, taking into account that policies and measures to deal with climate change should be cost-effective so as to ensure global benefits at the lowest possible cost".

The IPCC defines adaptation as "the adjustment in natural or human systems in response to actual or expected climatic stimuli or their effects, which moderates harm or exploits beneficial opportunities". It is also referred to as: Adjustment to reduce vulnerability or actions taken to reduce impact of climate change.

When considering the adaptation and risk control measures, thought was given to existing political, social, economic, health and environmental plans, in order to avoid duplication of efforts and waste of resources. Efforts were made to identify adaptation measures that are effective in reducing the risk and are cost effective. Existing autonomous adaptations have been identified and encourage where applicable, in addition to reactive and proactive adaptation measures.

The risk scenarios events are listed according to the ranking assign to each in the previous section:

Increased cost of health care delivery	extreme risk
Increased cost of outbreak control	extreme risk
Work absenteeism	high risk
Personal income loss	high risk
Reduced national production	moderate risk
School absenteeism	moderate risk
Cancelled tourist visits	moderate risk

All risk scenarios events ranked either as moderate risk or higher, this implies that actions are required to reduce the vulnerability or potential impact. Those ranked as extreme and high risk demands more urgent action to reduce vulnerability and to minimize future potential impacts. In the absence of an effective dengue vaccine, the following adaptation measures are recommended to address the "Increase cost to health care delivery" risk scenario event.

- Improve national diagnostic capability and dengue management, especially for DHF/FSS.
- Implement an effective, sustainable, community based vector control program.
- Incorporate dengue prevention in the natural science curricula.
- Incorporate environmental sanitation as a permanent topic in schools' PTA agenda.
- Train and equip regional rapid response teams for the control of dengue epidemics.
- Enforce the environmental and public health laws.

"Increased cost of outbreak control". In addition to those recommendations for increase cost of health care delivery, efforts should be made to shift the emphasis from chemical control to environmental modification. Resources presently used in chemical control can be utilized in targeted health education and community support. The assumption here is that the community will be willing to put up with the nuisance mosquitoes which are not the target of vector control. Nuisance mosquitoes share habitats with dengue vectors, but could also reproduce in other habitats not targeted in peri-domiciliary sanitation activities.

"Work absenteeism". It could cause displacement if ill people are unable to pay their rent; it definitely causes loss of livelihood due to inability to work; and also cause financial loss and impacts on the GDP. The core of the problem here is loss to the employer and loss to the employee including self employed whenever a person becomes ill with dengue (and other incapacitating diseases). All employers should insure their employees with SSB for employment benefits and/or with private or public (NHI) health insurance companies in order to guarantee health care to employees and fast recovery.

Self employed individuals should be allowed to pay SSOB for employment benefits and the worker should pay health insurance with a private or public insurance company.

"Personal income loss". The recommendation for work absenteeism applies to this risk scenario event.

"Reduced national production". Access to quality health care will accelerate recovery and expedite the return of laborers to the workplace. No specific action is required for this risk event.

"School absenteeism". The educational system could play an important roll in the implementation of a national sustainable and affordable dengue control program. The schools have a captive audience that if exposed to well targeted health information, could produce permanent behavior modifications for good. The activities in which schools could participate have been listed above.

"Cancelled tourist visits". The proposed adaptation measures for increase cost to health care delivery and absenteeism, addresses the risk to the tourism industry. This industry however, can play an important role in the implementation of those strategies. Hotel accreditation requirements could include environmental sanitation practices for the vectors of disease, including dengue vector. Since some municipalities are receiving a portion of the tourism tax from the BTA, proper control of empty lots could be a condition for access to those funds. The municipalities will not loose funds since the clean up cost will be recovered from lot owners.

The recommendation is made for the MOH to share these findings and recommendations with other stakeholders in order to create awareness and to elicit their support for the implementation of a sustainable cost-effective, community based control program. Control activities, where feasible, should be mainstreamed into the sectoral planning process.

The main limitation for the completion of this study was the access to or lack of quality data. Dengue appears to have fallen through the cracks. Cases are being diagnosed in the private sector but not reported to the epidemiology unit; cases diagnosed in the public sector, specially the outpatient services, appears to be only partially reported. Some annual reports are for laboratory confirmed cases only, others is a combination of suspected and confirmed cases; there are years where there is no data while anecdotally, cases did occur. Dengue is not only an urban disease, it is more so a domestic disease; transmission takes place around and within the homes, it is therefore important to collect data that provides with information about the environment where transmission is occurring. Since subjects who have experienced an episode of dengue are more at risk of developing DHF, it is necessary to have data on whom, where and when, has experienced dengue. There is the need to revise the health information system in order to see to what extent relevant data is been collected to monitor control activities and disease status, distribution and trend. Information provided by the regular health information system should be complemented by field studies in order to collect data that is not captured by the system or that it is not cost effective to do so.

The Third National Communication report should build on this study in terms of the analysis of vulnerability and climate change impact on health. The data that such analysis requires is not routinely collected by the system, hence the need to design and implement cohort, case control and cress-sectional studies that could allow for multivariate analysis and modeling for dengue and socio-economic, environmental and climatic risk factors.

FINDINGS

In describing the findings of this assessment exercise, the consultant was guided by the objectives of the study and the scope of work.

Objective 1: "Describe the present level of risk for dengue and DHF in Belize"

The section dealing with present vulnerability provides an in-depth description of the present level of risk of dengue and DHF in Belize. The entire country displays the environmental, socioeconomic, biological, climatic and demographic requirements for the effective transmission of dengue to occur on a sustainable basis. The conditions also exist for a major outbreak of DHF to take place, especially among children. Based on the standard used by WHOM to categorize countries with active dengue transmission, Belize is categorized as "Group B". These are countries with low to moderate risk of transmission.

Objective 2: "Project the future occurrence of dengue based on present risk levels and expected population growth, in the absence of climate change."

Based on the present incidence of dengue and the projected population growth for the years 2020 and 2050, the expected number of cases is 391 and 550 respectively. The assumption is that with the exception of population growth, all other risk factors, including climatic, remain unchanged.

Objective 3: "Utilizing selected socioeconomic and climatic scenario, project the future impact of dengue and DHF in Belize."

Reports from the National Meteorological Services, based on mathematical modeling, and using historical climate data for Belize, projects changes in climate parameters, including rainfall. The analysis of rainfall data for the Tower Hill weather station for the 1983-2005 period, shows an increase in the number of wet days (See annex F, fig F1), but a decrease in the very wet days precipitation (VWD). This suggests that the average intensity per day of rainfall may be lower, but the total number of rainy days per year will increase. With respect to dry days, there is a decreasing trend in the number of consecutive dry days. See annex F, Fig F2.

Increase urbanization, increase population density, increase extreme climate event due to climate change, increase length of rainy season, the circulation of all virus serotypes and existence of large number of people who have already experienced an episode of dengue, will no doubt significantly increase the likelihood of dengue transmission. As a result of expected climatic and socioeconomic changes, more frequent and intense outbreaks of dengue and DHF are expected.

Objective 4: “Recommend adaptation strategies to cope with potential impact.”

- Improve national diagnostic capability and dengue management, especially for DHF/FSS.
- Implement an effective, sustainable, community based vector control program.
- Elicit the educational system to incorporate dengue prevention in the natural science curricula.
- Incorporate environmental sanitation as a permanent topic in schools’ PTA agenda.
- Enforce the environmental and public health laws.
- Promote and reinforce changes in human behavior through health communication and health promotion strategies, which include specific target audiences from the school curricula to mass media participation, among others, to reach most of the population and affect the society as a whole.
- Promote and strengthen entomological surveillance capability at the local level, to determine *Aedes aegypti* distribution and level of infestation, to detect areas of new infestation, and to support local level societies in taking necessary actions to prevent further spread of the mosquito.
- Strengthen the epidemiological surveillance system for early detection of dengue cases and rapid implementation of transmission control measures to reduce transmission and prevent the occurrence of epidemics.
- Train and equip regional rapid response teams for the control of dengue epidemics.
- Encourage employers to insure employees with SSB for employment benefits and with private and public (NHI) health insurance companies in order to guarantee health care to employees.
- Encourage the self employed worker to make use of the SSB “voluntary contribution program” and to seek health insurance coverage in the private or public health (NHI) sectors.
- Encourage the tourism industry and Public Health to do the following: a) incorporate good environmental sanitation practices into the existing requirements for hotel accreditation. b) attach to the tourism tax funds that municipalities receive at present, requirements for proper sanitary control of parks, cemeteries, drainage and empty house lots.

CONCLUSIONS

Based on available incidence data for the period 1995-2007, it can be safely said that dengue fever is endemic in Belize. Furthermore, the circulation of four serotypes of dengue viruses and the endemnicity of the disease creates the conditions for dengue hemorrhagic fever to occur.

The present level of risk in rural areas of the country as determined by the recent entomological survey is unacceptable requiring immediate action on the part of the competent authorities.

In light of the natural history of dengue and the prevailing epidemiological conditions in Belize, it is likely that future outbreaks of the disease will occur.

The projected climate variability and climate change, particularly the projected increase of extreme events such as droughts, prolonged rainy seasons and increase temperature, will exacerbate the potential for major outbreaks of dengue to occur, particularly DHF.

Proactive adaptation measures most be taken, within the context of the recommendation of this study, in order to reduce the risk and minimize the potential impact of climate change and dengue.

Information to monitor implementation of control measures and to assess impact on risk reduction and disease frequency is insufficient and inconsistent.

The implementation of a community based vector control program should be more sustainable and cost-effective than the centralized chemical based control strategy. The present cost of dengue control activities are not readily available, given that expenditure is controlled at the regional levels and there is cross financing of programmatic areas such as malaria control and public health activities; supply acquisition is also integrated. Determination of the present cost of dengue control activities to facilitate cost benefit analysis is feasible, but it requires a timeframe that was not available to this study.

RECOMMENDATIONS

Efforts should be made to review the proposed adaptation measures with stakeholders, including those outside of the health sector, and to develop an implementation plan. It should be kept in mind that UNDP, UNEP, GEF and other agencies are committed to finance the additional cost of implementing adaptation measures that are above and beyond the cost of regular control activities.

The planning unit should, in coordination with the regions, develop a template to generate periodic standardized financial reports by programs and program sub-components. This type of information is critical to evaluate cost-benefit and cost-effectiveness of program strategies, and to prioritize activities.

As an initial step in the process of strengthening the dengue control program in Belize, a comprehensive program evaluation exercise should be conducted. This evaluation should among other things, identify the strengths and weaknesses of the program, develop vision and mission statements, and recommend organizational structure, training and resources necessary to implement the new strategy.

With the support of the planning unit, efforts should be made to develop and implement a dengue control research plan within the existing program. This field research plan should aimed at complementing information gathered by the health information system, and generating data necessary to conduct analytical studies linking dengue occurrence to potential risk factors. The plan should also include cross sectional surveys aimed at collecting data on risk factors distribution and serological prevalence of dengue as a means of validation the clinical diagnosis of the disease.

The MOH may wish to approach the Climate change Center to request support for the development of research protocols to collect relevant data for modeling. Dr. D. Chadee, coinvestigator in the project “Climate Change Impact on Dengue: the Caribbean Experience” has developed the expertise in cohort and case control studies related to dengue in the Caribbean, and has expressed his willingness to assist Belize in the development of research protocols. Dr. Chadee is a professor in the department of Life Sciences, University of the West Indies, St. Augustine, Trinidad and Tobago.

Annexes

Annex A

Table 1A. Hazard Frequency/Probability Rating

Hazard	**Very unlikely to Happen**	**Occasional Occurrence**	**Moderately Frequent**	**Occurs Often**	**Virtually to Occur**
Cancelled Tourism Visits		X			
Increase cost of health care delivery					X
Increase cost of outbreaks control				X	
Work absenteeism				X	
Reduced national production			X		
School absenteeism			X		
Personal income loss				X	

The potential risk to the community of a given CV/CC hazard is the probability and severity of that hazard.

Table 2A: Direct Impact Rating for “Cancelled tourist visits”

Impact / Severity	Social Factors			Economic Factors				Environmental Factors			
	Displacement	Health	Loss of livelihood	Cultural Aspects	Property Loss	Financial Loss	GDP Impact	Air	Water	Land	Eco-systems
Very Low				X							
Low			X								
Moderate		x				x	x				
Major											
Extreme											

Table 3A: Direct Impact Rating for “Increase cost of Health Care Delivery”

Impact / Severity	Social Factors			Economic Factors				Environmental Factors			
	Displacement	Health	Loss of livelihood	Cultural Aspects	Property Loss	Financial Loss	GDP Impact	Air	Water	Land	Eco-systems
Very Low											
Low											
Moderate		x				x					
Major											
Extreme											

Table 4A: Direct Impact Rating for “Increase cost of Outbreaks Control”

Impact / Severity	Social Factors			Economic Factors				Environmental Factors			
	Displacement	Health	Loss of livelihood	Cultural Aspects	Property Loss	Financial Loss	GDP Impact	Air	Water	Land	Eco-systems
Very Low											
Low								x	x		x
Moderate						x					
Major		x									
Extreme											

Table 5A: Direct Impact Rating for “Work absenteeism”

Impact / Severity	**Social Factors**			**Economic Factors**				**Environmental Factors**			
	Displacement	Health	Loss of livelihood	Cultural Aspects	Property Loss	Financial Loss	GDP Impact	Air	Water	Land	Eco-systems
Very Low	X										
Low		x	X			x	x				
Moderate											
Major											
Extreme											

Table 6A: Direct Impact Rating for “Reduced National Production”

Impact / Severity	**Social Factors**			**Economic Factors**				**Environmental Factors**			
	Displacement	Health	Loss of livelihood	Cultural Aspects	Property Loss	Financial Loss	GDP Impact	Air	Water	Land	Eco-systems
Very Low		x					x				
Low						x					
Moderate											
Major											
Extreme											

Table 7A: Direct Impact Rating for “School Absenteeism”

Impact / Severity	**Social Factors**			**Economic Factors**				**Environmental Factors**			
	Displacement	Health	Loss of livelihood	Cultural Aspects	Property Loss	Financial Loss	GDP Impact	Air	Water	Land	Eco-systems
Very Low											
Low	X										
Moderate											
Major											
Extreme											

Table 9A: Direct Impact Rating for "Personal Income Loss"

Impact / Severity	**Social Factors**			**Economic Factors**				**Environmental Factors**			
	Displacement	Health	Loss of livelihood	Cultural Aspects	Property Loss	Financial Loss	GDP Impact	Air	Water	Land	Eco-systems
Very Low	X	x					x				
Low			X			x					
Moderate											
Major											
Extreme											

Annex B

Table 1B: Risk Assessment Matrix: Cancelled Tourist Visits

Frequency/Probability						
Impact Severity		Very Unlikely to Happen	Occasional Occurrence	Moderately frequent	Occurs Often	Virtually Certain to Occur
	Extreme					
	Major					
	Moderate		X			
	Low					
	Very low					

"Cancelled tourist visits". The frequency of this event is considered to be ***occasional*** because only moderate to large scale outbreaks reach the international media and travel warnings are issued. It will lead to loss of livelihood and financial loss to stakeholders; it will also negatively impact on the health sector, cultural aspect and the national GDP.

Table 2B: Risk Assessment Matrix: Increased Cost of Health Care Delivery

Frequency/Probability						
Impact Severity		Very Unlikely to Happen	Occasional Occurrence	Moderately frequent	Occurs Often	Virtually Certain to Occur
	Extreme					
	Major					
	Moderate					X
	Low					
	Very low					

"Increased Cost of Health Care Delivery". The frequency of this event if an outbreak of dengue occurs is determined to be ***virtually certain to occur*** .It will have a ***moderate impact*** on the health sector and result in financial loss.

Table 3B: Risk Assessment Matrix: Increased Cost of Outbreaks Control

		Frequency/Probability				
Impact Severity		Very Unlikely to Happen	Occasional Occurrence	Moderately frequent	Occurs Often	Virtually Certain to Occur
	Extreme					
	Major				X	
	Moderate					
	Low					
	Very low					

"Increased Cost of Outbreak Control". This event is expected to ***occur often*** because of increased number of outbreaks as a consequence of CV/CC and other risk factors. The impact was considered to be ***major*** because it impacts not only on health and financial loss, but also because of its impact on the environment due to the chemical control measures that needs to be use in the control of an outbreak.

Table 4B: Risk Assessment Matrix: Work Absenteeism

		Frequency/Probability				
Impact Severity		Very Unlikely to Happen	Occasional Occurrence	Moderately frequent	Occurs Often	Virtually Certain to Occur
	Extreme					
	Major					
	Moderate					
	Low				X	
	Very low					

"Work Absenteeism" ***Occurs often*** but considered of ***low impact***. It could cause displacement if ill people are unable to pay their rent; it definitely causes loss of livelihood due to inability to work; financial loss and GDP

Table 5B: Risk Assessment Matrix: Reduced National Production

	Frequency/Probability					
Impact Severity		Very Unlikely to Happen	Occasional Occurrence	Moderately frequent	Occurs Often	Virtually Certain to Occur
	Extreme					
	Major					
	Moderate					
	Low			X		
	Very low					

"Reduced National Production" The national production will be reduced due to man-days loss to the disease, but it will be minimal, hence the classification of ***impact as low***. The probability of occurrence is estimated to be ***moderately frequent*** because most people experiencing dengue are unable to work and contribute to the national production.

Table 6B: Risk Assessment Matrix: School Absenteeism

	Frequency/Probability					
Impact Severity		Very Unlikely to Happen	Occasional Occurrence	Moderately frequent	Occurs Often	Virtually Certain to Occur
	Extreme					
	Major					
	Moderate					
	Low			X		
	Very low					

"School Absenteeism". This scenario risk event is classified as of ***low impact*** because it only produces temporal displacement from school and the length of displacement with classical dengue is such that students are able to make up. The occurrence is ***moderately frequent*** because dengue is endemic in Belize and is expected to occur every year throughout the year.

Table 7B: Risk Assessment Matrix: Personal Income Loss

		Frequency/Probability				
Impact Severity		Very Unlikely to Happen	Occasional Occurrence	Moderately frequent	Occurs Often	Virtually Certain to Occur
	Extreme					
	Major					
	Moderate					
	Low				X	
	Very low					

"Personal Income Loss" Occurs every time that an adult becomes ill with dengue or DHF. The impact is considered to be low but it is expected to occur often. It can produce displacement due to inability to pay for the rent, often patients are unable to pay for medical care, there is financial and livelihood loss and the national GDP are negatively affected.

Table 8B: Risk Assessment keys.

Extreme Risk	This indicates an unacceptable level of risk that requires immediate controls to move the activity out of the extreme range
High Risk	This level will require high priority control measures to reduce risk to an acceptable level
Moderate risk	Some controls will be required to move this risk scenario event to lower levels
Low Risk	Probable no control is needed. However, depending upon stakeholder perceptions, some low level controls or other actions such as public education and awareness may be desirable.
Negligible Risk	Scenarios in this category probable do not need to be considered further.

Annex C: Table 1C: Entomological Indices by District and Village, Belize 2008

District	Village	House Index	Cont Index	Breteau Index
Corozal	Ranchito	4%	2%	4%
	Paraiso	3%	2%	3%
	Little Belize	9%	2%	9%
Orange Walk	Douglas	2%	1.4%	0.2%
	Fire Burn	0%	0%	0%
	Trial Farm	3.8%	1.3%	4.7%
Belize	Double Head Cabbage	3.9%	1.1%	3.9%
	Barrel Boom	4.2%	3.1%	4.2%
	Crooked Tree	7%	2.4%	9%
Cayo	Santa Familia	9%	6.32%	16%
	Ontario	16%	7.28%	22%
	Cristo Rey	9%	5.21%	17.14%
Stann Creek	Valley Community	0%	0%	0%
	South Stann Creek	14%	13.6%	24%
	Hope Creek	7%	3.8%	9%
Toledo	Blue Creek	4.9%	2%	4.9%
	Forest Home	4%	.9%	4%
	San Antonio	8.7%	3%	12%

17% of surveyed communities had a Breteau index below 2%. This is the threshold below which dengue transmission is unlikely.
39% had Breteau indexes between 2 and 5 per cent. This level of larvae infestation supports the maintenance of endemic dengue and low level outbreaks.

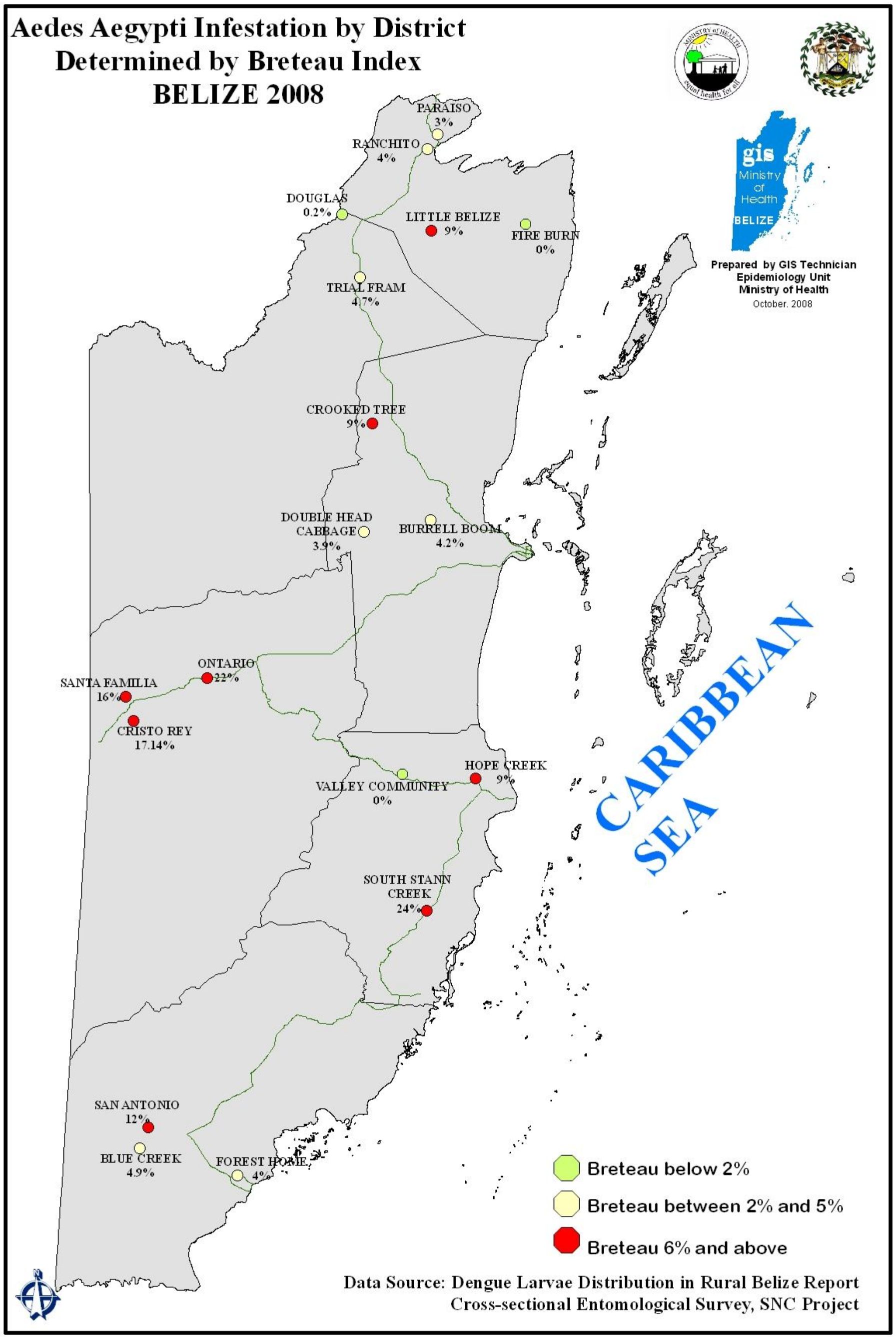
Eight communities (44%) had larvae infestation as determined by the Breteau index, between 6 and 24 per cent. The probability of dengue outbreaks is very high in these communities.

Annex D: Table 1D: Type of Containers and Productivity by District, Belize 2008

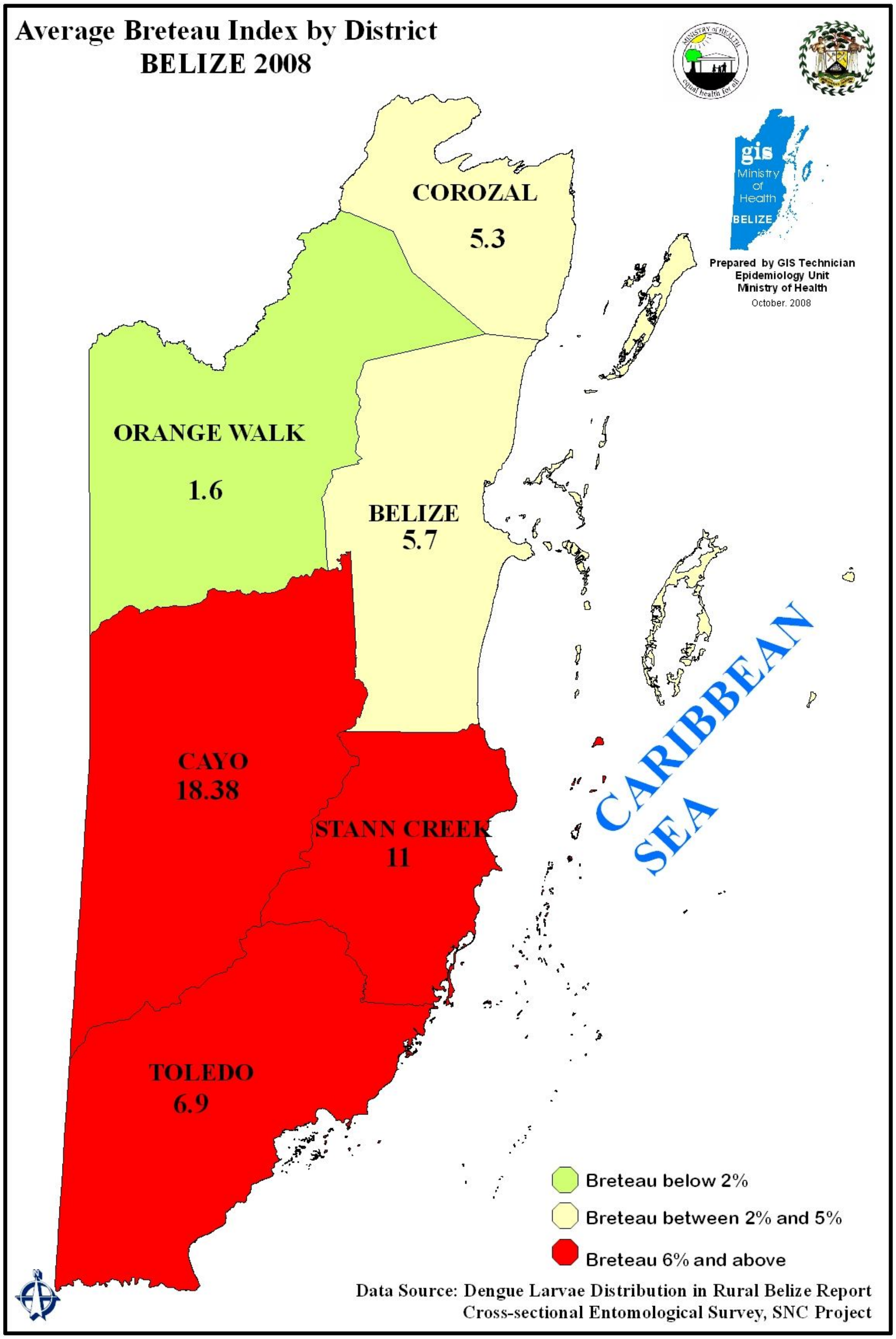
District	Village	# Cisterns	% Wet	% Positive	# Drums	% Wet	% Positive	# Vase	% Wet	% Positive	# Bucket	% Wet	% Positive	# Tires	% Wet	% Positive	# Bottles	% Wet	% Positive	# Watering Pan	% Wet	% Positive
Corozal	Ranchito	50	78	3	25	56	14	22	68	0	109	26	0	25	28	14	276	0	0	27	100	0
	Paraiso	57	89	0	25	72	11	13	31	25	80	29	0	20	25	0	377	0	0	27	96	0
	Little Belize	175	92	0	43	70	0	7	71	0	68	40	0	51	22	55	0	0	0	151	91	4
Orange Walk	Douglas	24	88	0	15	67	0	9	33	0	80	30	0	29	7	50	588	.51	0	55	87	0
	Fire burn	17	94	0	11	73	0	0	0	0	21	33	0	9	22	0	177	0	0	20	100	0
	Trial Farm	70	98	3	79	53	5	51	51	4	309	39	.84	81	21	0	998	9	0	214	95	0
Belize	Barrel Boom	64	94	0	55	65	8	59	0	0	106	28	10	20	5	100	155	13	0	12	92	0
	Double Head Cabbage	62	97	0	58	76	7	10	0	0	121	34	0	9	33	0	9	89	0	16	94	0
	Crooked Tree	92	95	2	82	60	6	0	0	0	133	32	5	0	0	0	98	10	10	52	60	3
Cayo	Santa Familia	5	100	0	32	100	12	68	4	33	145	65	2	60	50	27	112	4	0	69	90	0
	Ontario	0	0	0	29	86	28	32	6	0	58	69	3	12	58	0	78	17	8	60	100	2
	Cristo Rey	29	97	0	30	97	0	55	4	0	77	39	3	17	59	50	47	64	0	73	97	4
Stann Creek	Hope Creek	11	91	50	88	44	0	63	0	0	145	25	3	18	11	0	982	13	0	11	36	0
	South Stann Creek	12	83	20	88	66	21	294	2	29	147	23	12	51	22	18	756	3	0	15	80	0
	Valley Community	3	100	0	20	70	0	187	1	0	40	48	0	10	20	0	283	10	0	8	100	0
Toledo	Blue Creek	5	100	0	8	63	0	8	25	0	41	22	0	10	50	20	203	27	0	44	68	3
	Forest Home	8	75	0	18	50	0	42	10	0	60	42	0	52	13	14	392	38	0	31	52	6
	San Antonio	11	64	0	33	70	9	60	18	0	191	51	5	58	48	11	408	51	2	102	50	0

The green columns contain the actual number of containers. The orange columns contain the percentage of containers that were wet and the yellow columns contain the percentage of wet containers that had larvae. Drums and tires appear as the most productive containers.

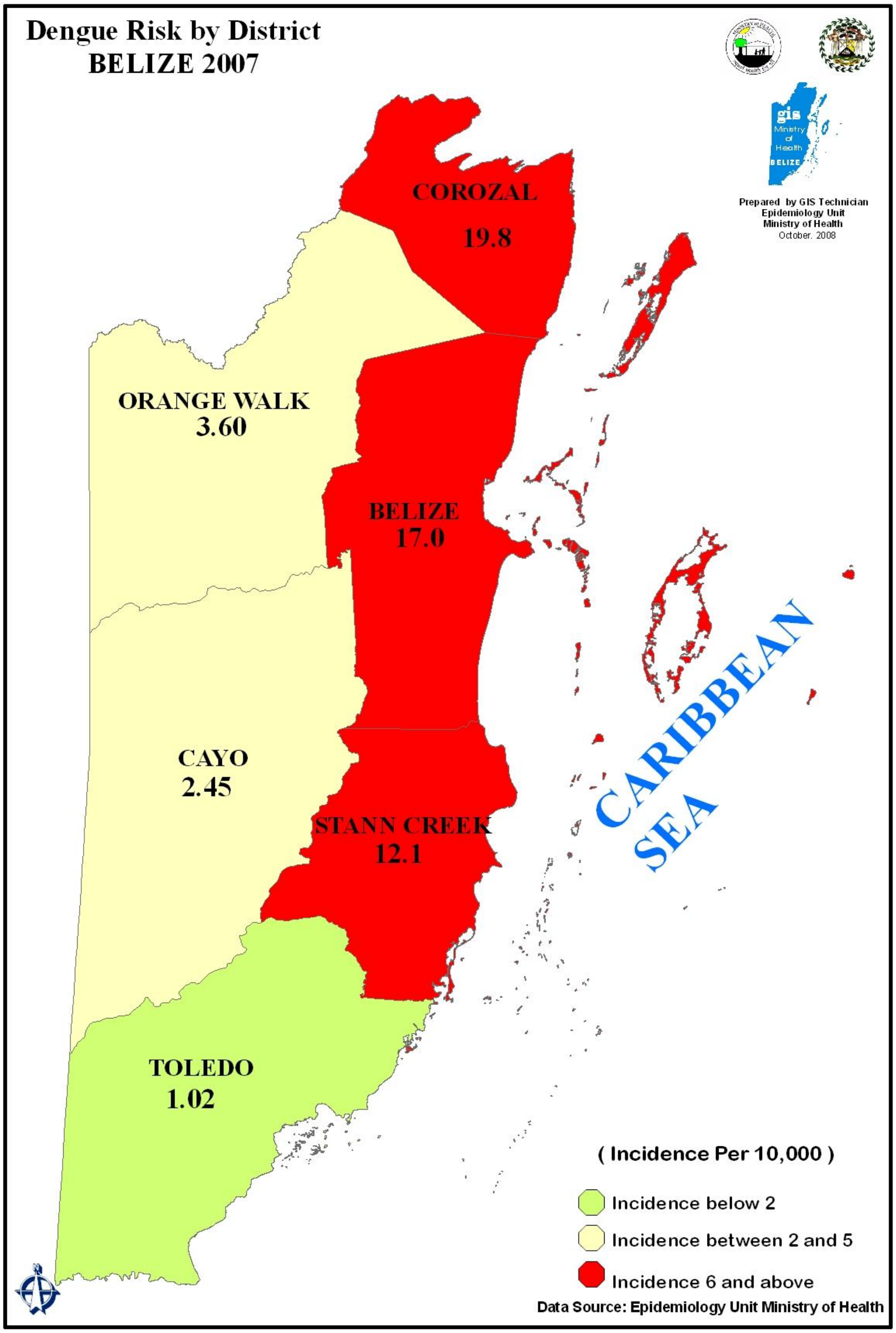
Annex E
Map 1E: *Aedes aegypti* Infestation by District, determined by Breteau Index – Belize 2008



Map 2E: Average Breteau Index by District – Belize 2008

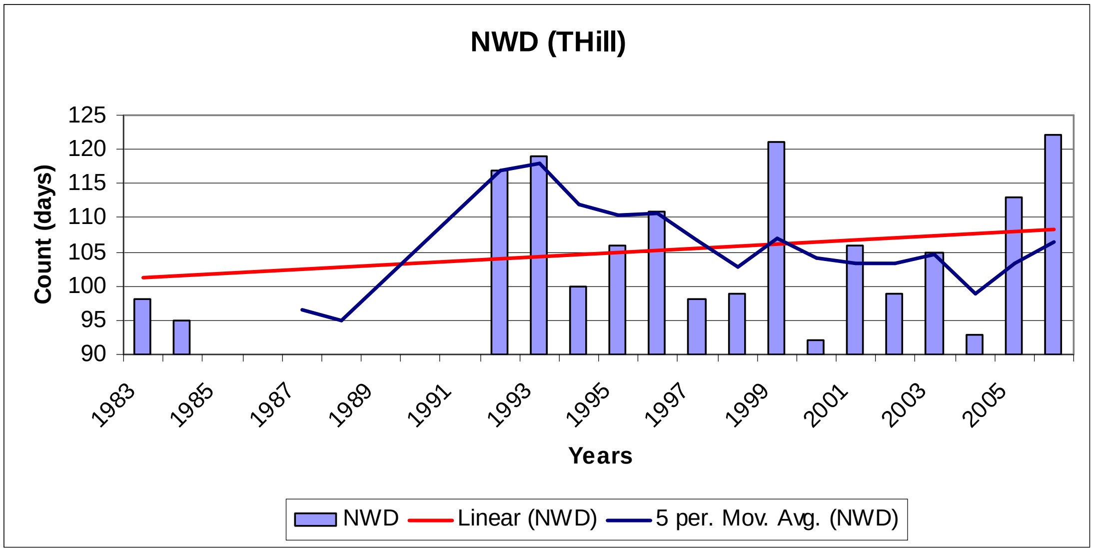


Map 3E: Dengue Risk by District Belize - 2007



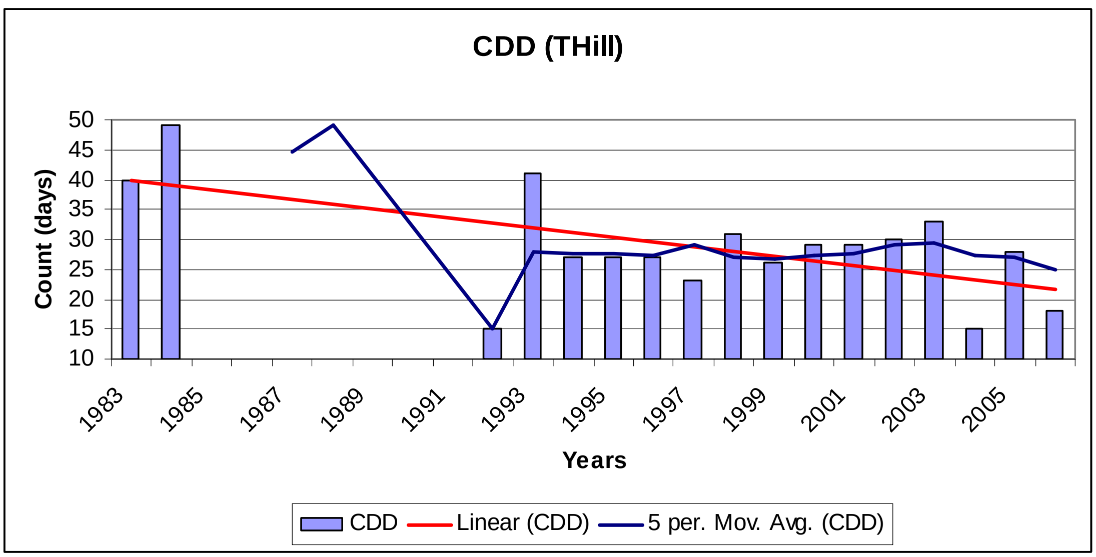
Annex F:

Figure F1: Number of wet days



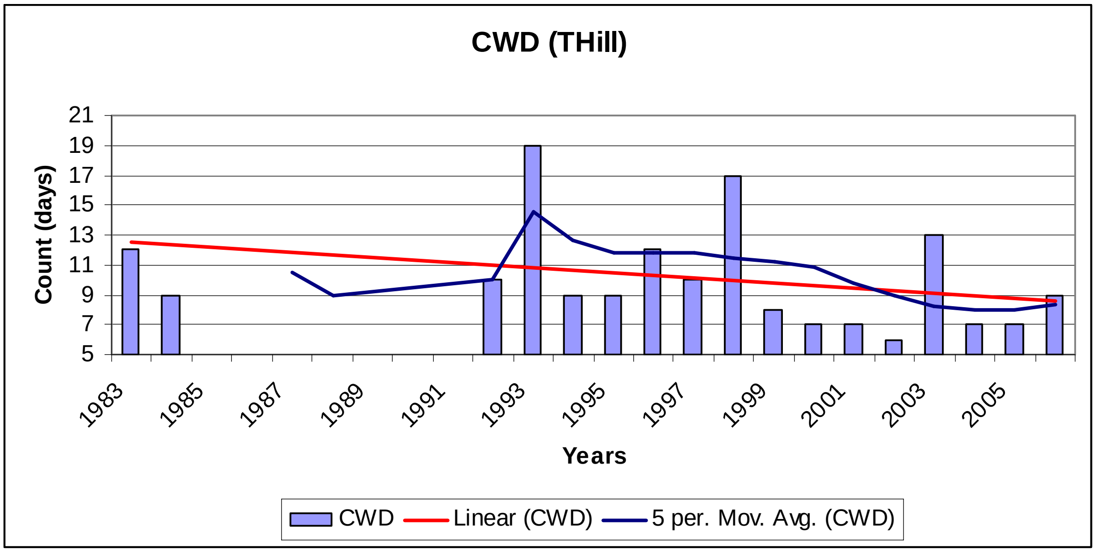
i) Linear trend analysis shows an increase in number of wet days.

Figure F2: Maximum number of consecutive dry days



i. Linear trend indicates a decrease in the consecutive dry days.

Figure F3. Maximum number of consecutive wet days



i. Indications are that consecutive wet days are decreasing.

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