



MDGF 1656

**Strengthening the Philippines
Institutional Capacity to Adapt
to Climate Change**

Health Sector

Book I

Final Report

April 27, 2011

**Institute of Health Policy and
Development Studies**

**National Institutes of Health
UP Manila**



**MDGF 1656: Conduct of Climate Change Vulnerability
and Impact Assessment Framework,
Development of a Monitoring and Evaluation
Framework/System, and Compendium of Good and
Innovative Climate Change Adaptation Practices
(Health Sector)
Book I**

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Table of Contents

Table of Contents	IV
List of Tables and Figures	VI
Acronyms and Abbreviations Used	VIII
Executive Summary	X
I. INTRODUCTION	1
Health Millennium Development Goals	3
Project Objectives	4
II. CONCEPTUAL AND PROCESS FRAMEWORK OF THE HEALTH SECTOR STUDY	6
A. Concepts and Terminologies	6
B. Review of Literature	8
The Challenge of Climate Change	8
The Philippines and Climate Change	9
Climate Change Vulnerability and Assessment	10
Effects of Climate Change on Health	11
Monitoring and Evaluation of Climate Change	16
Adaptation Practices in Climate Change	17
C. Limitations of the Health Sector Study	17
D. Project Methods and Validation Sites	18
E. Climate scenarios from PAG-ASA	20
III. RESULTS OF THE STUDY	21
A. Vulnerability, Adaptability and Impact Assessment Tools	21
Vulnerability and Adaptation Framework	21
Potential Vulnerabilities In Relation To Climate Change in the Philippine Health Sector	22
Burden of Disease	24
Breteau Index for predicting Dengue outbreaks	33
Vulnerability Maps to precisely locate vulnerability hotspots	35
B. Climate Change and Health Impact Modeling	44
Climate Change and Health Impact Modeling: Statistical Models	44
1. Statistical Modeling Process: Estimating the current distribution and burden of climate-sensitive diseases	56

a. Disease Impact Modeling and Projected Disease Impacts in 2020 and 2050 and Socioeconomic Impact	56
b. A Time Series Analysis of the Effect of Climate Change on the Incidence of Dengue in the National Capital Region, 1995-2007	66
2. Estimating the future potential health impacts attributable to climate change	84
C. Outputs of the V&A Tools	89
1. Projected 2020 and 2050 Cases of Selected Diseases	89
2. Cost Implications of Disease Impacts in 2020 and 2050	95
D. Compendium of Good and Innovative Climate Change Adaptation Practices	106
1. Adaptation Options Derived from Literature Review	107
2. Field documented Innovative Climate Change Adaptation Options for the Health Sector	120
3. Prioritized Adaptation Options	122
E. Integrated Monitoring and Evaluation Framework (IM&EF)	127
How the framework was formed	128
Validation of the proposed CCA M&E framework and system for the health sector	130
PIDS as the Centerpiece of the Integrated M&E Framework	135
Vulnerability assessment and its link to the M&E framework	141
Indicators for the proposed M&E framework	147
Reconfiguring the existing reporting system for PIDS	152
IV. CONCLUSIONS	154
V. RECOMMENDATIONS	157
VI. BIBLIOGRAPHY	162

List of Tables and Figures

Tables

Table 1 Vulnerability Map Dataset Requirements	36
Table 2 Model specifications of disease cases as responses to climate change variables	57
Table 3 Availability of Disease and Weather Data, Palawan, Rizal, Pangasinan, and NCR.....	61
Table 4 Sample Coefficient Table	64
Table 5 Incidence of Infectious Diseases, National Capital Region, 1993 to 2007	67
Table 6 ARIMA Model Parameters to Predict the Number of Dengue Cases, 1995-2007.....	73
Table 7 Summary of p-values for Predicting the Number of Dengue Cases using Climate Factors....	80
Table 8 Number of cases predicted by minimum temperature	80
Table 9 Projected Climate Change Data in 2020 and 2050	89
Table 10 Dengue Cases Projection, 2020	90
Table 11 Dengue Cases Projection, 2050	91
Table 12 Cholera Cases Projection, 2020	91
Table 13 Cholera Cases Projection, 2050	92
Table 14 Malaria Cases Projection, 2020.....	92
Table 15 Malaria Cases Projection, 2050.....	93
Table 16 Projected Dengue Costs (PhP), NCR, 2020.....	97
Table 17 Projected Dengue Costs (PhP), NCR, 2050.....	98
Table 18 Cost of Preventive Measures of Dengue, NCR, 2020.	99
Table 19 Cost of Preventive Measures of Dengue, NCR, 2050.	99
Table 20 Net savings from preventing Dengue.....	100
Table 21 Projected Cost (PhP) of Malaria Cases, Palawan, 2020	101
Table 22 Projected Cost (PhP) of Malaria Prevention, 2020, Palawan	102
Table 23 Projected Costs of Malaria, Palawan, 2050.....	102
Table 24 Cost Analysis Projections of Malaria Control Strategies, Palawan, 2050.....	103
Table 25 Net savings from preventive measures for malaria.	104
Table 26 Income Classification of Provinces	104
Table 27 Percentages of Disease Costs Over Provincial Annual Income.....	105
Table 28 Types of Adaptation to Climate Change	109
Table 29 Examples of Primary and Secondary Adaptation Measures to Reduce Health Impacts.....	110
Table 30 Adaptation Options to Reduce the Potential Health Impacts of Climate Change.....	110
Table 31 Health Sector Vulnerabilities to Climate Change-related diseases, 2011	114
Table 32 Adaptations to Climate Change-related Diseases in Palawan, Pangasinan and Rizal, 2011	115
Table 33 Adaptation Evaluation Decision Matrix	124
Table 34 Adaptation Evaluation Decision Matrix based on Literature	126
Table 35 Climate Change M&E Dashboard Indicators	131

Table 36 Matrix showing the Climate Change and Health V&A Assessment Flowchart.....	143
Table 37 Matrix table showing the monitoring and evaluation principles, responsible actors and levels, relevant tools and indicators to be collected	145

Figures

Figure 1 The Philippine Climate Change Response Framework.....	2
Figure 2 Health Sector Climate Change Vulnerability and Adaptation Framework.....	24
Figure 3 The Breteau Index	34
Figure 4 Flood and landslide prone areas in Pangasinan	38
Figure 5 Pangasinan Provincial and Municipal boundaries rendered over the forest cover shapefile .	39
Figure 6 Sample Maps of Rizal Province in Acetate platform.....	41
Figure 7 Vulnerability to Summer Temperature	42
Figure 8 Vulnerability to high rainfall and flood	43
Figure 9 Conceptual Framework for Disease Impact Modeling.....	46
Figure 10 Graphical Representation of Disease Impacts vs. Rainfall	50
Figure 11 Matrix Showing the Correlations of Independent Variables	53
Figure 12 Matrix Showing the R-square Value	53
Figure 13 ANOVA Matrix.....	54
Figure 14 Coefficients Matrix	55
Figure 15 Dengue Cases, Projected Cases and CC Indicators.....	58
Figure 16 Malaria Cases, Projected Values and CC Indicators.....	58
Figure 17 Cholera Cases, Projected Values and CC Indicators.....	59
Figure 18 Leptospirosis Cases and CC Indicators	59
Figure 19 Typhoid Cases and CC Indicators.....	60
Figure 20 Malaria Incidence: National Capital Region, 1993-2009	69
Figure 21 Dengue Incidence: National Capital Region, 1993-2007.....	69
Figure 22 Cholera Incidence: National Capital Region, 1992-2009.....	70
Figure 23 Leptospirosis Incidence: National Capital Region, 1996-2009.....	70
Figure 24 Weather Elements and Dengue Incidence: National Capital Region, 1993-2007.....	72
Figure 25 Time Series Models of the Numbers of Dengue Cases	82
Figure 26 Integrated M&E Framework.....	127
Figure 27 Proposed modification of PIDSR reporting system in the light of Climate Change.....	153

Acronyms and Abbreviations Used

AEFI – Adverse Event Following Immunization
AHA – Aquino Health Agenda
BHS – Barangay Health Station
CC – Climate Change
CCA – Climate Change Adaptation
CHAWF – The five sectors executing the MDGF 1656 project, namely, Coastal, Health, Agriculture, Water, and Forestry/Biodiversity
CHD – Centers for Health Development; the regional offices of DOH
CHO – City Health Office
CIMSiM – Computational Intelligence, Modeling and Simulation
COSMIC – Computer Software Management and Information Center
CRR – Climate Risk Reduction
DA – Department of Agriculture
DALY – Disability Adjusted Life Years
DENR – Department of Environment and Natural Resources
DENSIM – Dengue Simulation Model
DILG – Department of Interior and Local Government
DOH – Department of Health
DOST – Department of Science and Technology
DRR – Disaster Risk Reduction
DTI – Department of Trade and Industry
FASPO – Foreign-Assisted and Special Projects Office (under the DENR)
FHSIS – Field Health Service Information System
FMB – Forests management Bureau
GIS – Geographical Information System
HadCM2 – Hadley Center Climate Model 2
HEMS – Health Emergency Management Service
HIV – AIDS – Health Immunodeficiency Virus – Acquired Immune Deficiency Syndrome
IDO – Infectious Disease Office (under the DOH – NCDPC)
IHPDS – Institute of Health Policy and Development Studies (under the NIH)
IMS – Information Management Service
IPCC – Inter-governmental Panel on Climate Change
LGU – Local Government Unit
MARA / ARMA – Mapping Malaria Risk in Africa / Atlas du Risque de la Malaria en Afrique
M&E – Monitoring and Evaluation
MDGF – Millennium Development Goal Fund
MESU – Municipal Epidemiologic Surveillance Unit
MHO – Municipal Health Office
MIASMA – Modeling Framework for the Health Impact Assessment of Man-Induced Atmospheric Changes
NCDPC – National Center for Disease Prevention and Control (under the DOH)
NEC – National Epidemiology Center (under the DOH)
NEDA – National Economic Development Authority
NESSS – National Epidemiologic Sentinel Surveillance System
NFSCC – National Framework Strategy for Climate Change
NIH – National Institutes of Health
PAGASA – Philippine Atmospheric, Geophysical and Astronomical Services Administration (under the DOST)
PESU – Provincial Epidemiologic Surveillance Unit
PHO – Provincial Health Office

PIDSR – Philippine Integrated Disease Surveillance and Response
REECS – Resources, Environment, and Economics Center for Studies, Inc.
RESU – Regional Epidemiologic Surveillance Unit
RHU – Rural Health Unit
SARS – Severe Acute Respiratory Syndrome
UNDP – United Nations Development Program
UP Manila – University of the Philippines Manila
UPM – CPH - University of the Philippines Manila – College of Public Health
V&A – Vulnerability and Adaptation
WHO – World Health Organization

EXECUTIVE SUMMARY

It is now widely accepted that the earth is warming, due to the emissions of greenhouse gases as a consequence of human activity. There is also evidence that current trends in energy use, development and population growth will lead to continuing – and more severe – climate change. According to WHO, climate change puts at risk the basic determinants of health: clean air and water, sufficient food and adequate shelter. Climate change moreover exacerbates challenges to infectious disease control. Many of the major causes of death are highly climate sensitive especially in relation to temperature and rainfall, including cholera and the diarrheal diseases, as well as diseases including malaria, dengue and other infections that are vector borne (WHO, 2009).

As such, climate change now regarded as a significant and emerging threat to public health (WHO, 2003). In addition, the latest document by the Intergovernmental Panel on Climate Change (IPCC), reports that there is overwhelming evidence that human activities are causing changes in the global climate and these have dire implications on human health. Climate change is already contributing to the global burden of disease and this contribution is expected to grow even more unless governments take specific actions to address the impacts of climate change on health (WHO, 2009).

Health is a focus reflecting the combined impacts of climate change on the physical environment, ecosystems, the economic environment and society. Long-term changes in world climate may affect many requisites of good health – sufficient food, safe and adequate drinking water, and secure dwelling. The current large-scale social and environmental changes mean that we must assign a much higher priority to population health in the policy debate on climate change (IDS, 2006).

Climate change will affect human health and well-being through a variety of mechanisms. Climate change can adversely impact the availability of fresh water supplies, and the efficiency of local sewerage systems. It is also likely to affect food security. Cereal yields are expected to increase at high and mid latitudes but decrease at lower latitudes. Changes in food production are likely to significantly affect health in Africa. In addition, the distribution and seasonal transmission of several vector-borne infectious diseases (such as malaria, dengue and schistosomiasis) may be affected by climate change. Altered distribution of some vector species may be among the early signs of climate change that may affect health. A change in world climate could increase the frequency and severity of extreme weather events. The impacts on health of natural disasters are considerable – the

number of people killed, injured or made homeless from such causes is increasing alarmingly. The vulnerability of people living in risk-prone areas is an important contributor to disaster casualties and damage. An increase in heatwaves (and possibly air pollution) will be a problem in urban areas, where excess mortality and morbidity is currently observed during hot weather episodes (IDS, 2006).

Climate change is a huge threat to all aspects of human development and achievement of the Millennium Development Goals for poverty reduction. Until recently, donor agencies, national and local layers of government, and non-governmental organizations have paid little attention to the risks and uncertainties associated with climate change (IDS, 2006).

Stakeholders at all levels are increasingly engaging with the question of how to tackle the impacts of climate change on development in poorer nations. There are growing efforts to reduce negative impacts and seize opportunities by integrating climate change adaptation into development planning, programmes and budgeting, a process known as mainstreaming. Such a co-ordinated, integrated approach to adaptation is imperative in order to deal with the scale and urgency of dealing with climate change impacts.

Out of the eight Millennium Development Goals (MDGs), four directly affect the health sector. These include MDG 1: Eradicate extreme poverty and hunger, MDG 4: Reduce child mortality, MDG 5: Improve maternal health and MDG 6: Combat HIV/AIDS, malaria and other diseases. In the Philippines, MDG 5 has been identified as the most likely not to be achieved target as the decrease of maternal deaths has been decreasing too slowly to meet targets. Due to poor maternal health, child health is also in jeopardy unless effective programs are in place. Since climate change has been identified to exacerbate the effects of poor health, ineffective mitigation and adaptation are expected make maternal and child health more fragile. Moreover, climate change is also expected to exacerbate vector borne diseases such as malaria, dengue and leptospirosis. Related MDG goals especially MDGs 4, 5 and 6 can be achieved by devising meaningful climate change adaptation strategies that may be advanced by the results of this project.

Project Objectives

Generally, this project aimed to:

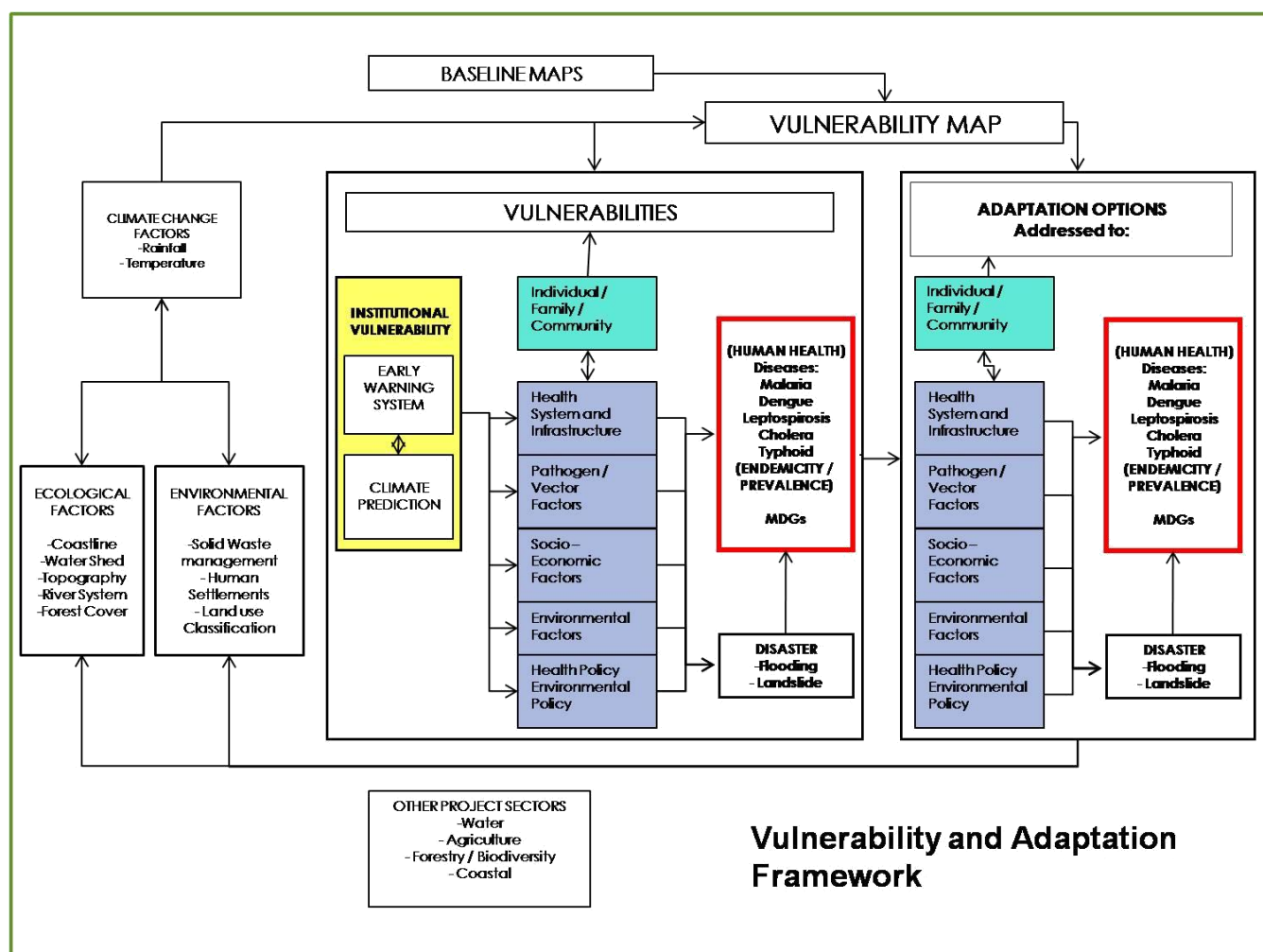
- develop a conceptual framework in the conduct of a vulnerability assessment and impact modeling for the Public Health Sector;

- develop the climate change vulnerability assessment framework for the Philippine health sector;
- develop climate change monitoring and evaluation framework/system; and
- document good and innovative practices on climate change adaptation applicable to the Health to be presented as a compendium of climate change adaptation best practices in the Philippine Health sector.

This final report covers project outputs of the Health Sector component on development of vulnerability assessment framework, including impact modeling and socioeconomic projections. We discuss background literature that informed work on the development of evolving frameworks. Results of the first and second consultative Round Table Discussion (RTD) are presented to show comments on previous work that contributed to vulnerability and adaptation framework development (See Book 2, Appendices B and D for matrices). Adaptation best practices derived from literature and field visits are also summarized together with an evolving list of literature that was reviewed for the project See Book 3. Finally methods used in impact modeling for climate change and health are discussed. A discussion on the approaches to mentoring colleagues from the Department of Health on the conduct of the V&A and Climate Change socio-economic impact evaluation is included in the final report. Proposed training materials are also included (See Book 4).

The project analyzed the relationship of incidences of selected climate-sensitive diseases specifically, Malaria, Dengue, Leptospirosis, Cholera and Typhoid to changes in certain climatic parameters. The project also looks into the current preparedness of health services and systems in the event that an increase in disease magnitude or trend change is observed. Project results include a description of the potential vulnerability or weaknesses of the health sector in terms of adapting to the effects of climate change to the health determinants. Project outcomes will ultimately assist in preparing the Health Sector to effectively address the effects of Climate Change by coming up with a Vulnerability Assessment Framework for the Health Sector, A Climate Change Monitoring and Evaluation Framework for the Health Sector and a Compendium of applicable Climate Change Adaptation Practices for the Health Sector.

The final project report is contained in four (4) books. Book 1 contains the main project report; while the report annexes are in book 2. The third book contains the compendium of best climate change adaptation practices and book four presents the training manuals that contain step by step procedures on how to utilize the V&A framework and the integrated M&E framework.



Health Sector Climate Change Vulnerability and Adaptation Framework

Vulnerability assessment. Vulnerability to climate change-related diseases is a function of several factors. These factors are classified into individual/family/community, health systems and infrastructure, pathogen/vector factors, socio-economic factors, environmental factors, and health/environmental policy. Specific indicators in each factor define the degree of vulnerability of human population to the climate change-related diseases. The vulnerabilities to climate change-related diseases are summarized in the following matrix indicating only the highly vulnerable sector of the population.

Vulnerabilities to Climate Change-related diseases

Vulnerability Indicator	Dengue	Malaria	Leptospirosis	Cholera	Typhoid
Individual, family, community	Young and old ages that are exposed outdoor activities during dawn and dusk with poor sanitary practices and facilities, low immune system, poor hygienic practices, no access to sanitary water, and lack of health facilities are highly vulnerable	All ages with poor sanitary practices and facilities, low immune system, poor hygienic practices, no access to sanitary water, lack of health facilities are highly vulnerable.	All ages, families, communities exposed in flood-prone areas where population of rats and animals are high are highly vulnerable.	All ages where water systems are easily contaminated with septic waste leakages during floods are highly vulnerable.	All ages foods and water taken are spoiled and contaminated are highly vulnerable.
health systems and infrastructure	Highly vulnerable are those that have no access to clinics and hospitals and drug stores including other important medical facilities.				
pathogen/ vector factors	Communities and households environment that have no proper sanitation, no waste management system, presence of canals and water bodies that are habitat of pathogens and vectors are highly vulnerable				
socio-economic factors	Highly vulnerable are the poor sector of the population. Those that are below poverty income threshold level and cannot afford doctor's treatment as well as medicines.				
environmental factors	Highly vulnerable are communities close to bodies of stagnant water, unsanitary environment, lack of waste management system, temperature, rainfall and relative humidity favoring the growth of pathogens and vectors.				
health/ environmental policy	Highly vulnerable are communities and families not covered by policies on the regular monitoring and treatment of diseases and maintenance of a sanitary environment.				

Mapping each of the vulnerable indicators and overlaying them together identifies whether an area, community, municipality or province is highly vulnerable, moderately vulnerable or with low vulnerability. The vulnerability map evolving from the overlaying of the individual maps representing the different vulnerability indicators guides the local government units in allocating their resources for preventions and treatments of climate change-related diseases.

Disease impact modeling. Reinforcing the vulnerable areas are the projections of potential number of disease cases through the disease impact models developed out of existing health and climate change data.

Assessment and evaluation of health and climate change data showed imperfect matching and inadequacies causing major problems in developing the models. A remedial measure adopted was to match projected climate change data from PAGASA in the four provinces with health data. The health data were also found incomplete in terms of actual cases, alert thresholds and epidemic thresholds. Also, adequate data on leptospirosis and typhoid is wanting.

The models that passed statistical screening process and used in this study are:

- a. Dengue Cases = $-1267.347 - 0.615 * \text{Monthly Rainfall} - 21.389 * \text{Maximum Temperature} + 31.442 * \text{Relative Humidity}$
- b. Cholera Cases = $8.948 + 0.026 * \text{Monthly Rainfall} - 1.681 * \text{Maximum Temperature} + 0.663 * \text{Relative Humidity}$
- c. Malaria Cases = $-218.918 - 0.089 * \text{Monthly Rainfall} + 7.605 \text{ Maximum Temperature}$

Both dengue and cholera impact models were sensitive to monthly rainfall, maximum temperature and relative humidity, whereas malaria is sensitive to monthly rainfall and maximum temperature.

The models mean that for every unit of the variables, the corresponding responses of disease cases are summarized on the table below:

Model specifications of disease cases as responses to climate change variables

Disease Cases	One unit each of the variables will increase or decrease disease per thousand cases					
	Monthly Rainfall (mm/day)		Maximum Temperature (degree centigrade)		Relative Humidity (%)	
	Increase	Decrease	Increase	Decrease	Increase	Decrease
Dengue		615		21,389	31,442	
Cholera	26			1,681	663	
Malaria		89	7,605			

Costs of Dengue. There are projected 1,735 cases of dengue in NCR in 2020. This will require a total cost of PhP7.59 Mil for diagnosis, treatment cost of PhP4.29 Mil and a total income loss of PhP2.11 Mil from families that will be affected.. The total cost of dengue will be PhP13.99 Mil. If prevention measures will be done, the cost is estimated at PhP2.8 Mil, which will give the LGU a net saving of PhP11.19 Mil.

In 2050, there will be 2128 dengue cases. the cost is PhP43.6 Mil. If preventive measures will be implemented with a cost of PhP8.11Mil, the net saving is PhP35.51 Mil.

Costs of Malaria. The potential number of cases of malaria in 2020 is 187. The total fund required (total cost for diagnosis plus the total cost of treatment) is PhP0.68 Mil. The cost of preventing malaria is PhP0.28 Mil. This will give a saving of PhP0.4 Mil for the LGU.

In 2050, there will be 185 malaria cases. This will require a total budget of PhP2.38 M for the diagnoses and treatments. The prevention cost of malaria is PhP1.0 Mil. Doing the preventive measures will save PhP1.38 Mil for the LGU.

Cost of Leptospirosis, Cholera and Typhoid. There were no cost data on the diagnoses, treatments, income losses and costs of prevention for leptospirosis, cholera, and typhoid in NCR, Palawan, Pangasinan, and Rizal. Thus, no economic analyses were done.

Adaptation Practices. The main objective of this activity were to identify policy options and measures on climate change adaptation measures on health that suit Philippine setting and the integration of these measures for national and local development planning processes. These outputs were obtained through an intensive literature review, as well as consultation with experts on the various diseases and meetings with representatives of health agencies. Validation was undertaken through the visits in 3 selected provinces namely Palawan, Rizal and Pangasinan.

Experiences with the different adaptation practices where they have been implemented were gathered through an extensive search of related literature from the internet and through presentations of experts on the various diseases. These practices are being assessed and attempts are also being made to explain successes and failures, especially the factors that contributed to them. The adaptation strategy were categorized to address the vulnerabilities identified in the V&A framework, comprising of the following: (a) individual/family/community; (b) health system and infrastructure; (c) pathogen and vector factors; (d) socio-economic factors; (e) environmental factors; and (f) health and environmental policy. The adaptation

measures must incorporate capacitating the individual, family, and/or community to analyze and adequately respond to future climate risks.

Based on consultations with health workers in Palawan, Pangasinan and Rizal, the adaptation measures that they use to prevent and control the spread of dengue, malaria, leptospirosis, cholera and typhoid are summarized in the following matrix.

Adaptations to Climate Change-related Diseases in Palawan, Pangasinan and Rizal

Adaptation Practices	Dengue	Malaria	Leptospirosis	Cholera	Typhoid
<i>Individuals and Family</i>					
Use of treated or untreated mosquito nets.	Proper use of nets at the right time and right place	Proper use of nets at the right time and right place			
Provision of screens and sealing of holes in houses	Prevent entries of mosquitoes	Prevent entries of mosquitoes			
Cleanliness of immediate household's surroundings	Removal of waters in containers inside and outside the house	Removal of breeding grounds of mosquitoes inside and outside the house by practicing proper waste disposal	Elimination of damp areas conducive for rat's habitat. Clean drainage system most often to prevent breeding grounds of rats		
Water, sanitation and good hygienic practices				Source out water for drinking that are safe or free from contamination. Sterilize water before drinking. Store foods properly avoiding contacts with probable carriers of cholera. Practice sanitation and	Same as cholera

Adaptation Practices	Dengue	Malaria	Leptospirosis	Cholera	Typhoid
				good hygiene in the family.	
Consciousness on good health maintenance	Early diagnosis and treatment of climate change-related diseases.				
Maintenance of pets at home that can reduce growth of vectors and pathogens	Breeding of larvivorous species of fish		Maintenance of cats that feed on rats		
Barangay or Community					
Presence of active barangay health workers.	Report suspected cases to hospitals for immediate diagnosis and treatment	Microscopists for malaria only for immediate diagnosis and treatment of climate change-health related diseases	Report cases of suspected infected persons for treatment	Refer cases to hospitals for diagnosis and treatment	Refer cases to hospitals for immediate diagnosis and treatment
Decanting	Spraying pesticides that are not toxic to human being		Destroy rats and breeding grounds and habitat		
Provision of a centralized clean water sources that are well protected and maintained whole year round				Spring development; Prevention of water source contamination by sealing potential entry of pathogens/vectors.	
Community ordinances: zoning and resettlement of high risk groups or informal settlers.	Resettlement in dengue-free zones.	Resettlement in malaria free zone.	Resettlement in elevated and non-flood prone areas.	Remove sources of water contamination or resettlement contaminated groups.	
Proper waste management system at community level	Removal of wastes that promote growth of pathogens/vectors; cleaning of water ways		Eliminate breeding grounds of rats	Removal of sources of contamination; location of water sources away	Prevent sources of pathogens/ vectors

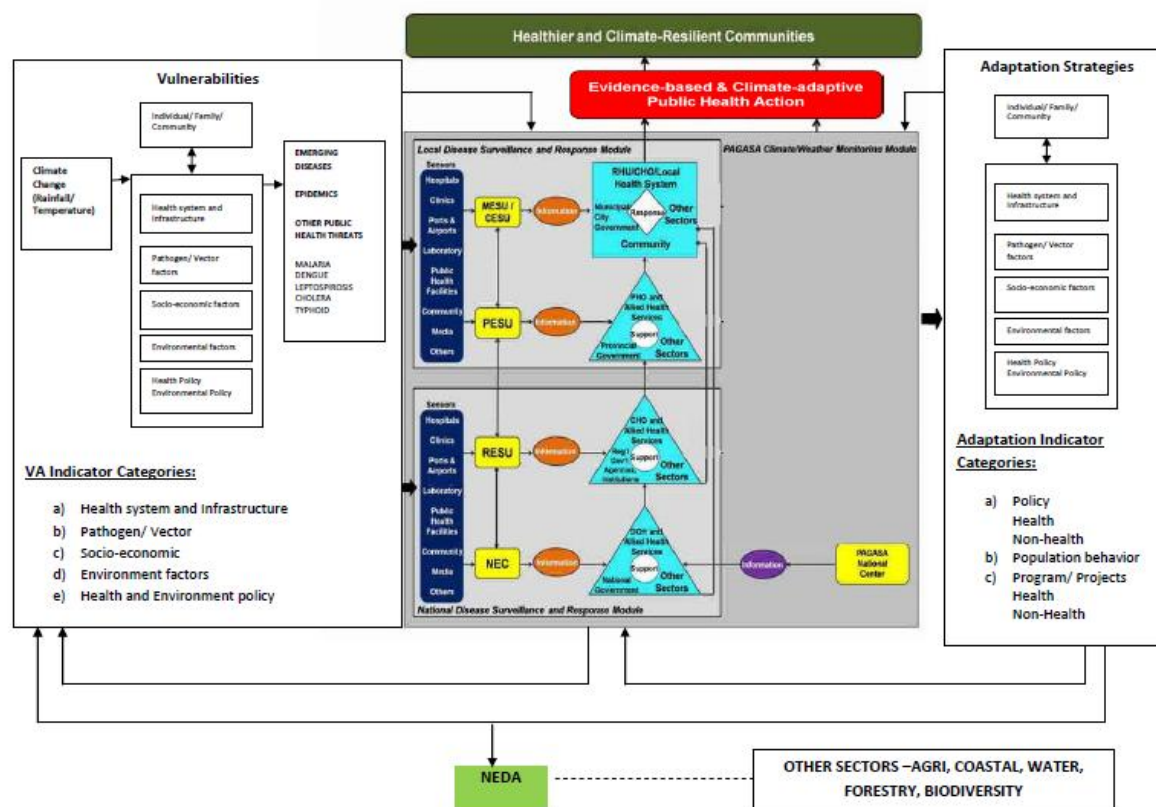
Adaptation Practices	Dengue	Malaria	Leptospirosis	Cholera	Typhoid
				from sewage/waste dumping areas. dengue	coming from waste/sewage areas.
Presence of manned and active health workers in BHCs.	Regular diagnosis, treatment and referrals/endorsement to hospitals that can treat diseases.				
Information and Education Campaign at the Community Level	Barangay Health Centers with regular information campaign activities for the barangay population regarding prevention adaptation measures of all diseases				
Health systems and infrastructure					
Presence of a network of complimentary hospitals complete with laboratory, medicines, and medical facilities within the province where costs of diagnosis and treatments are affordable.	Conduct thorough diagnoses and treatments of infected persons.				
Health care system	PhilHealth card necessary for each family				
Holistic health maintenance projects	Fourmula-1, Vaccination, PIDSR, etc.	Fourmula-1, PIDSR, malaria treatment medicines, etc.	Fourmula 1, PIDSR, leptospirosis treatment medicines	Fourmula 1, PIDSR, cholera treatment medicines	Fourmula 1, PIDSR, typhoid treatment medicines
Pathogen/vector factors					
Innovative practices to eliminate vectors and pathogens.	Solar insecticide capture and destroy		Rats trapping	Floating Toilet Device	Floating Toilet Device

Adaptation Practices	Dengue	Malaria	Leptospirosis	Cholera	Typhoid
Regular spraying of chemicals that are non- toxic to human beings to eliminate pathogens and vectors inside and outside the house.	Regular and simultaneous spraying that kills mosquitoes and other insects, fungi and other pathogens in all houses and breeding grounds in a barangay.		Regular and simultaneous decanting by barangay level.		
Elimination of growth factors and habitat.	Cleaning of water ways, streams and other water bodies, and proper sanitary practices at the household level.		Cleaning of canals; removal of rat habitat and wastes.	Avoid food spoilage by refrigeration and maintenance of clean and safe water sources.	
Socio-economic Factors					
Health subsidies in vulnerable communities or barangays.	Subsidies to all vulnerable families in the form of free or affordable health card.				
Provision of livelihood and income generating projects to increase income of vulnerable communities.	Planting, processing and marketing of medicinal plants proven to strengthen immune system; manufacture and marketing of decanting and trap gadgets; production and marketing of insect repellants; production, breeding and marketing of pets that feed on insects and rats.				
PPP for clean and safe water system				Replace old water system vulnerable to contamination	Replace old water system vulnerable to contamination.
Environmental factors					
Forestation	Planting and management of integrated forest plantations that drive away mosquitoes	Planting and management of integrated forest plantations that drive away mosquitoes	Planting of forest species that attract rats from residential areas.		
Establishment, maintenance and management of	Eliminates breeding grounds of insects, pathogens and vectors.		Eliminates breeding	Eliminates breeding grounds of insects, pathogens and vectors.	

Adaptation Practices	Dengue	Malaria	Leptospirosis	Cholera	Typhoid
sanitary landfills.			grounds of rats.		
Periodic cleaning and declogging of waterways, streams and rivers to allow waterflow continuously.	Breeding grounds of mosquitoes in stagnant water are destroyed.		Flowing streamflow prevent s deposition of wastes for rat foods .	Clean and declogged waterways also washout pathogens and vectors that live on stagnant water.	
Health/ environmental policy					
Policy on the integration of health and climate change education in primary and secondary education	Education on the prevention of dengue at home and in school .	Education on the prevention of malaria at home and in school.	Education on the prevention of leptospirosis	Education on the prevention of cholera	Education on the prevention of typhoid
Climate risk proofing policies	Adoption and implementation of adaptation measures for climate change-related health problems in all DOH projects				
Policy on mandatory coverage of population for health care system	Full coverage in highly vulnerable areas.				
Policy on Strengthened Provincial Disaster Coordinating Council	Creation of a sub-council on disease-related disaster prevention and management				
Disaster preparedness policy.	Nationwide capacity building of people on disaster preparedness brought about by climate change-related diseases.				

Monitoring and Evaluation (M&E) Framework. This is an offshoot of existing DOH-PIDSAR, NGAs, and at the international level, the UNDP-GEF-M&E, and M&E of the International Federation of Red Cross and Red Crescent Societies. These M&Es monitor climate change adaptation and climate change programs.

The schematic diagram of the Integrated M&E for health under climate change conditions is shown in the following figure.



Integrated M&E Framework

The components of the M&E framework are the climate change indicators, the vulnerability factors, PIDSAR and the adaptation measures component. These components are discussed in the major components.

Conclusions

A Vulnerability and Adaptation Impact Assessment Framework for the health sector was devised for this project and grounded the results and outputs of the study. The research team utilized this framework to test the other deliverables of the study and found that the framework works.

The categories of vulnerabilities that were culled from the review of literature and the round table discussion provided focus and specificity to the vulnerability assessment and adaptation documentation. Hence the team deems it is safe to be recommended for use in the country. While utilizable, the team avers that the framework can still be refined through

pilot tests of the framework and its parts in different areas of the country and for various usages.

The following section provides more specific conclusions from the applications of the vulnerability assessment models that were derived in the project.

1. Disease impact models for dengue, malaria, and cholera were developed out of available data from the NCR and PHOs of Palawan, Pangasinan and Rizal. The robustness of the models depend on the accuracy of the health and climate data measurements or estimations. Leptospirosis and typhoid impact models were not formulated due to inadequate data. Disease impacts for 2020 and 2050 were conducted using the projection models that passed the statistical screening process. Refinements of the models may be done as additional data on health and climate change are made available.

2. Assessment and evaluation of health data showed purely medical-related data and no climate change data. This was a major problem. A remedial measure adopted was to match climate change data from PAGASA in the NCR, Palawan, Pangasinan and Rizal. The health data were also found incomplete in leptospirosis and typhoid. Also, disease cases were not available in Palawan, Pangasinan and Rizal. This could be due to lack of real disease occurrence or with disease occurrence but no documentation. Likewise, in NCR, only disease cases were available.

The Time Series Analysis also provided important insights into the climate change and impact assessments:

3. Consistent results that the observed minimum temperatures for the current month provide the most significant positive contributions to the model to predict the number of dengue cases for any month of observation.

4. A peak of dengue incidence occurs thereafter in about a month after the start of the increase of cases. This coincides with the years when a surge of cases was experienced in NCR (as was mentioned previously: 1996, 1998, 2001, 2005 and 2006). (This is evident as crests of maximum temperature seem to frequently transpire a little earlier compared to the peaks of minimum temperature. This would be consistent with the lack of significance in estimates for dengue cases based on maximum temperature.)

Economic impact analyses were accomplished for dengue and malaria. Other diseases such as leptospirosis, cholera, and typhoid were not covered in the economic analysis due to lack of data. Rizal was not also covered because of lack of both climate change and economic data on the selected diseases.

5. The results in NCR and Palawan indicate that malaria and dengue in 2020 would require about 1% of its annual income for the diagnoses and treatments of malaria and dengue. In 2050, the allocation for funding for the same diseases would reach no less than 2% of the provincial income.

6. However, Pangasinan in 2020 would need about 18% of its income only for diagnoses and treatments of malaria and dengue. In 2050, the budget requirement for both diseases would be reduced to 4% owing to the reduced number of malaria and dengue cases, which is not attributed to preventive measures that would be implemented, but to the changes in the climate indicators. Such climate change nonetheless, may be good from the point of view of reducing disease occurrence.

7. Considering the five diseases for budgeting purposes, the provincial government may allocate in the future roughly a total of 2.5% of the income of Palawan in 2020 and 5% in 2050 assuming that the average cost requirement of each disease would more or less be the same with malaria and or dengue. On the other hand, Pangasinan would allocate roughly 45% of its income in 2020 to address the five diseases and 20% in 2050.

8. Considering the substantial savings that could be generated from applying preventive measures, the two provincial governments may consider investing on financing preventive measures to lessen the cost impacts of the diseases, thus lessen the burden of the provincial governments in addressing these diseases.

9. Provincial and municipal governments should not wait for the diseases to reach epidemic levels before they address the malaria and dengue outbreaks as well as other diseases that would emerge and be aggravated by climate change conditions. It is most certainly beneficial to prevent disease outbreaks before they even emerge.

10. Applying effective preventive measures against dengue would result in significant savings on the part of the provincial government in the amounts of PhP 10.9 M in 2020 and PhP 31.69 M in 2050.

Recommendations

1. The most critical recommendation that this study provides is that there is a need to improve the data bases and information systems that feeds into climate change vulnerability and adaptation assessment for the health sector. Currently, there are no linked data between health outcomes and meteorological information. Timely disease surveillance and case finding may be triggered by accurate weather and climate information that should be provided to health and LGU managers at all levels.

Governments should engage more actively with the **scientific community, who in turn must be supported to provide easily accessible climate risk information.**

Climate risk information should put current and future climate in the perspective of national development priorities.

Information needs of different actors should be considered and communication tailored more specifically to users, including the development community

2. Another major recommendation is to create systems to strengthen mainstreaming adaptation within existing poverty alleviation policy frameworks. There is a lack of research on the extent to which climate change, and environmental issues more broadly, have been integrated within national policy and planning frameworks. National Adaptation Programmes of Action or NAPA was a project funded by the Least Development Countries Fund (LDC Fund) and commissioned by the UNFCCC to the 48 least developed countries need to be utilized for this purpose.

This is critical. Examples of efforts from Sri Lanka, Bangladesh, Tanzania, Uganda, Sudan, Mexico and Kenya are presented, highlighting a number of key issues relating to current experiences of integrating climate change into poverty reduction efforts (IDS, 2006).

As previously discussed climate change stakeholders at all levels are increasingly engaging with the question of how to tackle the impacts of climate change on development in poorer nations. There are growing efforts to reduce negative impacts and seize opportunities by integrating climate change adaptation into development planning, programmes and budgeting, a process known as mainstreaming. Such a co-ordinated, integrated approach to adaptation is imperative in order to deal with the scale and urgency of dealing with climate change impacts (IDS, 2006).

In developed countries progress on mainstreaming climate adaptation has been limited. Many countries have carried out climate change projections and impact assessments, but few have started consultation processes to look at adaptation options and identify policy responses.

The following section provides more detailed recommendations for specific research outputs:

On Impact modeling

For better disease impact modeling, the following are strongly recommended:

Improve existing database on health and climate change through standardization of health and climate change data monitoring forms and that data gathering should be localized. Since the occurrences of diseases are localized and climate change variations are also localized, there is a need to strengthen the PHO and LGU in each province on health and climate change indicators monitoring, modeling, and analysis. The reason for this is to enable the health sector for immediate response to address climate change health-related problems without waiting decisions from the national level.

Basic weather instrumentation set up containing rain gauge, thermometer, evaporation pan, relative humidity measurer, wind velocity meter may be funded out of the IRAs of each of the provinces and may be installed in the municipalities. This is important to capacitate the municipal LGUs and provincial PHOs on health and climate change concerns so that immediate adaptation measures can be implemented right where the problems are.

Intensify research on the environmental habitat of disease vectors including the climate change conditions favoring their growth and their life cycles. Determine to what extent does the vector live and in what conditions. Identify the types of vector, where they are and estimate vector population so that proper strategies to control their spread may be implemented without waiting for an outbreak. Knowing the vulnerable areas by barangay would be a significant step in controlling diseases. In modeling, there is a need to include environmental variables that favor the occurrences of disease vectors and their population in addition to the climatic factors

Vulnerability assessment at the barangay level should be mapped for effective implementation of adaptation measures.

The models are not advisable for national application due to differences in the environmental conditions and climatic change factors in each of the provinces. Averaging provincial data would result in substantial discrepancies between predicted values and actual disease

observations due to substantial inter-provincial variations on climatic and environmental conditions. The only remedy is for each province to develop its own impact models for climate change-sensitive diseases.

In order to address the threats of the climate change-related diseases, preventive measures were recommended for implementation for malaria and dengue control. Thus, the provincial governments are encouraged to fund such preventive measures to restrict the possible spread of the diseases. The effective implementation of the preventive measures will result in substantial savings from the income of the provincial government.

Other recommendations that would help the provincial governments to become more responsive in addressing the threats of climate change-related diseases include the following:

7. Conduct of studies on economic impacts of other climate change-related diseases such as leptospirosis, cholera, and typhoid in Palawan and Pangasinan.
8. Conduct of studies of economic impacts of malaria, dengue, leptospirosis, cholera, and typhoid in Rizal Province and other provinces that are vulnerable to climate change.
9. Pursue studies on the costs of other adaptation measures on health to minimize or control the impacts of climate change-related diseases.

Recommendations from time Series Analysis

10. Regarding the generalizability of the results of the models developed, though the data analysis had solely used data from cities of NCR, it would be **potentially useful to also apply the results to other LGUs elsewhere (i.e. other urban areas) where communities have experienced outbreaks of dengue in the past.** It is therefore critical that local health officials should work closely with national health authorities to coordinate efforts in mitigating the effects of a rise in temperature (i.e. recorded minimum temperature) on a possible increase in dengue cases and/or the occurrence of dengue outbreaks particularly during periods when an occurrence of an El Niño/La Niña –Southern Oscillation (ENSO) condition in the Pacific Ocean is announced and experienced.

Policy Recommendations

Policy recommendations have largely been culled from the literature as a full policy analysis for climate change and health was not feasible within the project. International experiences

so far highlight a number of barriers and opportunities to mainstreaming climate change adaptation in developing countries. These are focused around information, institutions, inclusion, incentives and international finance, and result in a number of recommendations for national governments (IDS, 2006).

The following section contains those recommendations deemed appropriate for the Philippines.

Recommendations for stakeholders:

A multi-stakeholder coordination committee should be established to manage national adaptation strategies, chaired by a senior ministry.

Regulatory issues should be considered from the start of the mainstreaming process.

The capacity of existing poverty reduction mechanisms is consistent with existing policy criteria, development objectives and management structures.

Policy-makers should look for policies that address current vulnerabilities and development needs, as well as potential climate risks.

Actions to address vulnerability to climate change should be pursued through social development, service provision and improved natural resource management practices.

A broad range of stakeholders should be involved in climate change policy-making, including civil society, sectoral departments and senior policy-makers.

Climate change adaptation should be informed by successful ground-level experiences in vulnerability reduction.

NGOs should play a dominant role in building awareness and capacity at the local level.

Recommendations for incentives:

Donors should provide incentives for developing country governments to take particular adaptation actions, appropriate to local contexts.





The economic case for different adaptation options should be communicated widely.

A risk-based approach to adaptation should be adopted, informed by bottom-up experiences of vulnerability and existing responses.

Approaches to disaster risk reduction and climate change adaptation should be merged in a single framework, using shared tools.

Finally, the major results of the study can be summarized into the Health Sector Climate Change Vulnerability and Adaptation Matrix which follows:

Health Sector Climate Change Vulnerability and Adaptation Matrix

Area/Sector (C, H, A, W, F)	CC Vulnerability	Socio-Economic Impact	Adaptation Option/Activities
 CHAWF Most vulnerable sectors according to IPCC Report	 Based on Climate Scenarios & Vulnerability Assessment Tool	 Social, Economic & Environmental Implications of Vulnerabilities if not addressed	 Social, Economic & Environmental Implications of Vulnerabilities if not addressed
HEALTH	<u>Climate Sensitive Diseases Projections</u> <ul style="list-style-type: none"> • Malaria is projected to have 258 new cases by 2020, and 308 new cases by 2050. • By 2020, there will be 143 new cases of cholera. In 2050, there will be 99 new cases of cholera. • Dengue cases in NCR will amount to 2,128 by 2020, and 1,735 cases in 2050. • (No projections were made for leptospirosis and typhoid fever due to the lack of models.) <u>Individual, family, community</u> <ul style="list-style-type: none"> • Poor sanitary practices and facilities • Low immune system • Poor hygienic practices • Poor access to potable water • No access to health facilities • Exposure to vectors, 	Malaria <ul style="list-style-type: none"> • For every unit of monthly rainfall, malaria will be reduced by 89 per 1,000 cases. Cholera <ul style="list-style-type: none"> • For every unit of monthly rainfall, cholera cases will increase by 26 per 1,000 cases. • For every unit of maximum temperature, cholera cases will be increased by nearly 8 cases. <ul style="list-style-type: none"> • For every unit of maximum temperature, cholera cases will decline by almost 2 cases. • For every unit of relative humidity, cholera cases will increase by 662 per 1,000 cases. Dengue <ul style="list-style-type: none"> • For every unit of 	<ul style="list-style-type: none"> • Construction of climate resistant houses • Ensure adequate supply of potable water: SODIS, SCW System • Regular house-spraying • Provision of insecticide-treated bed nets in Malaria endemic areas • Improve household sanitation • Floating Toilet Device

Area/Sector (C, H, A, W, F)	CC Vulnerability	Socio-Economic Impact	Adaptation Option/Activities
	contaminated water and food <ul style="list-style-type: none"> Do not have climate change resistant shelters Live in disaster prone areas i.e. flood plains or watershed slopes 	monthly rainfall, dengue cases will decline by 615 per 1,000 cases. <ul style="list-style-type: none"> In NCR, for every 1° C increase in recorded minimum temperature, an expected 233 cases of dengue is predicted to occur. For every unit of maximum temperature, dengue will decrease by about 21 cases. For every unit of relative humidity, dengue cases will rise by about 31 cases. By 2020, the total cost of diagnosis & treatment of dengue and malaria as a percentage of annual provincial income will be 0.15% for Palawan, and 7.21% for Pangasinan. By 2050, the total cost of diagnosis & treatment of dengue and malaria as a percentage of annual provincial income will be 0.53% for Palawan, and 18.03% for Pangasinan. 	
	<u>Health Systems and Infrastructure</u> <ul style="list-style-type: none"> Inequitable distribution of health system factors i.e. clinics, hospitals, pharmacies and human resources for health (HRH) that lead to population's lack of access to quality basic health services Health information system not related to climate change leads to difficulty in monitoring climate change related illnesses Disease prevention and health promotion systems weak Inability to respond properly & quickly to emergency/disaster situations 		<ul style="list-style-type: none"> Implementation of education campaigns to eliminate breeding sites Adoption of a risk-based approach to adaptation Improved disease monitoring and surveillance systems Early case detection and improved case management
	<u>Pathogen/vector factors</u> <ul style="list-style-type: none"> Poor sanitation facilities and systems Solid waste management systems below standard Presence of vector habitats (e.g. canals and bodies of water) 	<ul style="list-style-type: none"> For every 1°C increase in temperature, the mosquito population increases ten-fold (east African highlands, 2009) Increased bite rate of 	<ul style="list-style-type: none"> Release of sterile male vectors Introduction of larvivorous fish in natural and artificial ponds and wetlands

Area/Sector (C, H, A, W, F)	CC Vulnerability	Socio-Economic Impact	Adaptation Option/Activities
	<u>Socio-economic factors</u> <ul style="list-style-type: none"> Below poverty threshold level Unable to afford or sustain recommended treatment 	mosquitoes with increased temperature <ul style="list-style-type: none"> Contamination of water sources the potential impacts of climate change would be US\$5–19 million by 2050 in terms of loss of public safety, increased vector- and waterborne diseases, and 	<ul style="list-style-type: none"> Provision of a National disaster insurance fund
	<u>Environmental factors</u> <ul style="list-style-type: none"> Human proximity to vector habitats (e.g. canals, bodies of water) Temperature, rainfall and relative humidity favors vector and pathogen growth 	<ul style="list-style-type: none"> increased malnutrition from food shortages during extreme events (Fiji, WHO 2003) 	<ul style="list-style-type: none"> Integrated water management Weather forecasting and early warning systems Water disinfection through the use of solar power (e.g. SCW System, SODIS) Integrated environmental management
	<u>Health/environmental policy</u> <ul style="list-style-type: none"> Lack of policies on regular monitoring and treatment of diseases Lack of policies on maintenance of a sanitary environment Lack of effective policies on Weak implementation of existing policies on disease control. 		<ul style="list-style-type: none"> Ban on precarious residential placements Land zoning restrictions based on hydrological and risk assessment studies Establishment of a multi-stakeholder coordination committee to manage national adaptation strategies Use of radio and television for information dissemination Mainstreaming of Climate Change into government policies

I. INTRODUCTION

It is now widely accepted that the earth is warming, due to the emissions of greenhouse gases as a consequence of human activity. There is also evidence that current trends in energy use, development and population growth will lead to continuing – and more severe – climate change. According to WHO, climate change puts at risk the basic determinants of health: clean air and water, sufficient food and adequate shelter. Climate change moreover exacerbates challenges to infectious disease control. Many of the major causes of death are highly climate sensitive especially in relation to temperature and rainfall, including cholera and the diarrheal diseases, as well as diseases including malaria, dengue and other infections that are vector borne (WHO, 2009).

As such, climate change now regarded as a significant and emerging threat to public health (WHO, 2003). In addition, the latest document by the Intergovernmental Panel on Climate Change (IPCC), reports that there is overwhelming evidence that human activities are causing changes in the global climate and these have dire implications on human health. Climate change is already contributing to the global burden of disease and this contribution is expected to grow even more unless governments take specific actions to address the impacts of climate change on health (WHO, 2009).

Health is a focus reflecting the combined impacts of climate change on the physical environment, ecosystems, the economic environment and society. Long-term changes in world climate may affect many requisites of good health – sufficient food, safe and adequate drinking water, and secure dwelling. The current large-scale social and environmental changes mean that we must assign a much higher priority to population health in the policy debate on climate change (IDS, 2006).

Climate change will affect human health and well-being through a variety of mechanisms. Climate change can adversely impact the availability of fresh water supplies, and the efficiency of local sewerage systems. It is also likely to affect food security. Cereal yields are expected to increase at high and mid latitudes but decrease at lower latitudes. Changes in food production are likely to significantly affect health in Africa. In addition, the distribution and seasonal transmission of several vector-borne infectious diseases (such as malaria, dengue and schistosomiasis) may be affected by climate change. Altered distribution of some vector species may be among the early signs of climate change that may affect health. A change in world climate could increase the frequency and severity of extreme weather events. The impacts on health of natural disasters are considerable – the number of people killed, injured or made homeless from such causes is increasing

alarmingly. The vulnerability of people living in risk-prone areas is an important contributor to disaster casualties and damage. An increase in heatwaves (and possibly air pollution) will be a problem in urban areas, where excess mortality and morbidity is currently observed during hot weather episodes (IDS, 2006).

The effects of Climate Change have always been linked to recent disasters in the Philippines. Catastrophic phenomena such as El Niño, La Niña, and severe flooding have taken numerous lives and destroyed properties. Consequently, these events have enlightened our country and the international community into recognizing that Climate Change is real and now and thus should be demystified with appropriate attention.

From the time climate change has taken the limelight in the world stage, much effort and financial resources have already been spent and channeled worldwide. In the Philippines, the government has already started putting up action plans, mitigation and adaptation strategies to address the impacts of climate change. However, even with all these efforts, not much focus has been given to the health sector as evidenced by the inadequacy of available research and literature on the climate change and health and the inadequacy of action plans to address climate change impacts on health directly.

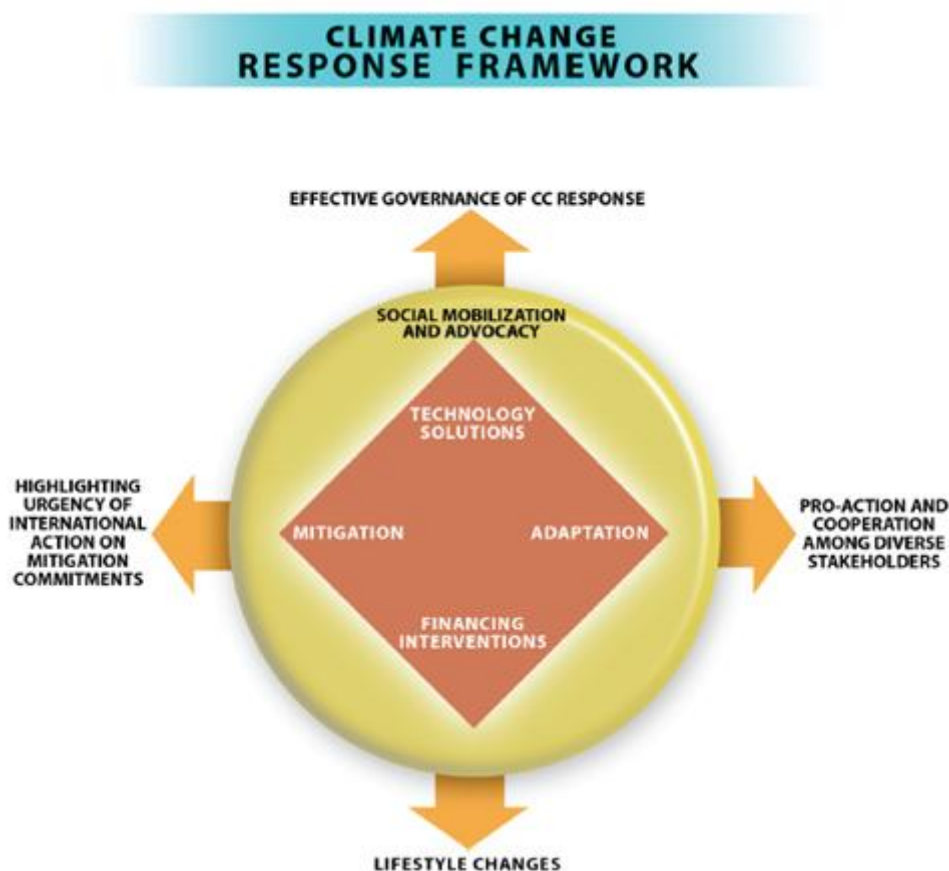


Figure 1 The Philippine Climate Change Response Framework

(Source: Presidential Task Force on Climate Change)

The Department of Health of the Philippines has started laying out plans in addressing the aforementioned concerns on climate change and health in accordance with the Philippine Climate change Response Framework as shown in Figure 1. A national policy on Climate Change mitigation and adaptation has already been enacted. However, the mitigation and adaptation strategies that will effectively address climate change needs to be integrated and multi-sectoral while being culturally relevant and appropriate to the resource availability within the different regions. This is also the case in other nations of the world. Hence, the United Nations and Government of Spain implemented a joint program in the country that was aimed at strengthening the Philippines' institutional capacity to adapt to climate change. This program focused on five priority sectors including Coastal, **Health**, Agriculture, Water, and Forestry/Biodiversity (CHAWF). The program sought to mainstream climate risk adaptation into key national & local development planning & regulatory processes, enhance capacities of key partners and communities to undertake climate resilient development, and test integrated adaptation approaches with up scaling potential. The program brought together GOP and UN partners over a period of 3 years to complete the country's knowledge base and strengthen institutional capacities to manage climate change risks. The University of the Philippines Manila, through the Institute of Health Policy and Development Studies, was one of the UP units that were commissioned to undertake the present study to represent the health sector.

Health Millennium Development Goals

Climate change is a huge threat to all aspects of human development and achievement of the Millennium Development Goals for poverty reduction. Until recently, donor agencies, national and local layers of government, and non-governmental organizations have paid little attention to the risks and uncertainties associated with climate change (IDS, 2006).

Now, however, players at all levels are increasingly engaging with the question of how to tackle the impacts of climate change on development in poorer nations. There are growing efforts to reduce negative impacts and seize opportunities by integrating climate change adaptation into development planning, programmes and budgeting, a process known as mainstreaming. Such a coordinated, integrated approach to adaptation is imperative in order to deal with the scale and urgency of dealing with climate change impacts.

In developed countries progress on mainstreaming climate adaptation has been limited. Many countries have carried out climate change projections and impact assessments, but few have started consultation processes to look at adaptation options and identify policy responses.

In developing countries, the mainstreaming process is also in its early stages. Small island developing states have made good progress, with Caribbean countries among the first to start work on adaptation. The Pacific islands have received considerable support and through the World Bank a number of initiatives have begun.

Crucially, there has been little progress in mainstreaming adaptation within existing poverty alleviation policy frameworks. There is a lack of research on the extent to which climate change, and environmental issues more broadly, have been integrated within PRSPs. This is critical. Examples of efforts from Sri Lanka, Bangladesh, Tanzania, Uganda, Sudan, Mexico and Kenya are presented, highlighting a number of key issues relating to current experiences of integrating climate change into poverty reduction efforts.

Out of the eight Millennium Development Goals (MDGs), four directly affect the health sector. These include MDG 1: Eradicate extreme poverty and hunger, MDG 4: Reduce child mortality, MDG 5: Improve maternal health and MDG 6: Combat HIV/AIDS, malaria and other diseases. In the Philippines, MDG 5 has been identified as the most likely not to be achieved target as the decrease of maternal deaths has been decreasing too slowly to meet targets. Due to poor maternal health, child health is also in jeopardy unless effective programs are in place. Since climate change has been identified to exacerbate the effects of poor health, ineffective mitigation and adaptation are expected make maternal and child health more fragile. Moreover, climate change is also expected to exacerbate vector borne diseases such as malaria, dengue and leptospirosis. Related MDG goals especially MDGs 4, 5 and 6 can be achieved by devising meaningful climate change adaptation strategies that may be advanced by the results of this project.

Project Objectives

Generally, this project aimed to:

1. develop a conceptual framework in the conduct of a vulnerability assessment and impact modeling for the Public Health Sector;
2. develop the climate change vulnerability assessment framework for the Philippine health sector;

3. develop climate change monitoring and evaluation framework/system; and
4. document good and innovative practices on climate change adaptation applicable to the Health to be presented as a compendium of climate change adaptation best practices in the Philippine Health sector.

This final report covers project outputs of the Health Sector component on development of vulnerability assessment framework, including impact modeling and socioeconomic projections. We discuss background literature that informed work on the development of evolving frameworks. Results of the first and second consultative Round Table Discussion (RTD) are presented to show comments on previous work that contributed to vulnerability and adaptation framework development (See Book 2, Appendices B and D for matrices). Adaptation best practices derived from literature and field visits are also summarized together with an evolving list of literature that was reviewed for the project (See Book 3). Finally methods used in impact modeling for climate change and health are discussed. A discussion on the approaches to mentoring colleagues from the Department of Health on the conduct of the V&A and Climate Change socio-economic impact evaluation is included in the final report. Proposed training materials are also included (See Book 4).

The project analyzed the relationship of incidences of selected climate-sensitive diseases specifically, Malaria, Dengue, Leptospirosis, Cholera and Typhoid to changes in certain climatic parameters. The project also looks into the current preparedness of health services and systems in the event that an increase in disease magnitude or trend change is observed. Project results include a description of the potential vulnerability or weaknesses of the health sector in terms of adapting to the effects of climate change to the health determinants. Project outcomes will ultimately assist in preparing the Health Sector to effectively address the effects of Climate Change by coming up with a Vulnerability Assessment Framework for the Health Sector, A Climate Change Monitoring and Evaluation Framework for the Health Sector and a Compendium of applicable Climate Change Adaptation Practices for the Health Sector.

The final project report is contained in four (4) books. Book 1 contains the main project report; while the report annexes are in Book 2. The third book contains the compendium of best climate change adaptation practices and book four presents the training manuals that contain step by step procedures on how to utilize the V&A framework and the integrated M&E framework.

II. CONCEPTUAL AND PROCESS FRAMEWORK OF THE HEALTH SECTOR STUDY

A. Concepts and Terminologies

The World Health Organization (WHO) reports that climatic changes over recent decades have probably already affected some health outcomes. The World Health Report 2002 says that climate change was estimated to be responsible in year 2000 for approximately 2.4% of worldwide diarrhea, and 6% of malaria in some middle-income countries. The first detectable changes in human health may well be alterations in the geographic range (latitude and altitude) and seasonality of certain infectious diseases – including vector-borne infections such as malaria and dengue fever, and food-borne infections which normally peak in the warmer months. Warmer average temperatures combined with increased climatic variability would alter the pattern of exposure to thermal extremes and resultant health impacts (WHO, 2002).

The Intergovernmental Panel on Climate Change (IPCC) concluded that overall, climate change is projected to increase threats to human health, particularly in lower income populations and predominantly within tropical/subtropical countries. Three broad categories of health impacts are associated with climatic conditions: (1) impacts that are directly related to weather/climate; (2) impacts that result from environmental changes that occur in response to climatic change; and (3) impacts resulting from consequences of climate-induced economic dislocation, environmental decline, and conflict. The first two categories are often referred to as climate-sensitive diseases; these include changes in the frequency and intensity of thermal extremes and extreme weather events (i.e., floods and droughts) that directly affect population health, and indirect impacts that occur through changes in the range and intensity of infectious diseases and food- and waterborne diseases and changes in the prevalence of diseases associated with air pollutants and aeroallergens (McCarthy et al, 2001).

Vulnerability is defined by the IPCC as “the degree, to which a system is susceptible to, or unable to cope with, adverse effects of climate change, including climate variability and extremes. Vulnerability is a function of the character, magnitude, and rate of climate change and variation to which a system is exposed, its sensitivity, and its adaptive capacity” (McCarthy et al., 2001).

This project subscribes to the following notion: **the greater the exposure or sensitivity to the effects of climate change, the greater the vulnerability; the greater the adaptive capacity, the lower the vulnerability.** An assessment of vulnerability must consider all these components to be comprehensive. An **impact** of climate change is typically the effect of climate change. **Biophysical systems** can undergo change in terms of productivity, quality, or affect population (in specific numbers or ranges). For **societal systems**, impact can be measured as change in value (e.g., gain or loss of income) or in morbidity, mortality, or other measure of well-being (Parry and Carter, 1998).

The **vulnerability of human health** to climate change is a function of three components namely; sensitivity, exposure, and adaptation:

- Sensitivity, which includes the extent to which health or nature or social systems on which health outcomes depend, are sensitive to changes in weather and climate (exposure–response relationship). Sensitivity to climate change may also be determined by the characteristics of the population, such as its level of development and demographic structure;
- Exposure to weather or climate-related hazard, including the character, magnitude and rate of climate variation; and
- Adaptation measures and actions in place to reduce the burden of a specific adverse health outcome (the adaptation baseline). The effectiveness of adaptation measures are determined in part by the exposure–response relationship.

Populations, subgroups and systems that cannot or will not adapt are more vulnerable, and may be similar to those that are more susceptible to weather and climate changes. Understanding a population's capacity to adapt to new climate conditions is crucial to realistically assessing the potential health effects of climate change. In general, the **vulnerability of a population to a health risk depends on factors such as population density, level of economic development, food availability, income level and distribution, local environmental conditions, health status, and the quality and availability of health care.** These factors are not uniformly distributed across a region or country or across time, and differ based on geography, demography and socio-economic factors. **Effectively targeting prevention or adaptation strategies requires understanding which demographic or geographical subpopulations may be most at risk and when that risk is likely to increase.** Thus, individual, community and geographical factors determine vulnerability.

The cause-and-effect chain from climate change due to changing disease patterns can be extremely complex and includes many non-climatic factors, such as distribution of income, provision of medical care, and access to adequate nutrition, clean water and sanitation. Therefore, the severity of impacts actually experienced will be determined not only by changes in climate but also by concurrent changes in non-climatic factors and by the adaptation measures implemented to reduce negative impacts.

B. Review of Literature

The review of related literature started from reviewing previous documents that chronicled the results of previous Climate Change studies in the Philippines. The most prominent of these was the second Communication Report, which was used as the springboard of this current project. Few other reports on Climate Change and Health were similarly perused to situate the project in the process of crafting the vulnerability and assessment framework.

The Challenge of Climate Change

UN Secretary-General Ban Ki-Moon and UNEP Executive Director Achim Steiner described climate change as “the defining challenge of our generation.” Climate change is a change in the statistical distribution of weather over periods of time that range from decades to millions of years. It can be a change in the average weather or a change in the distribution of weather events around an average (for example, greater or fewer extreme weather events). Climate change may be limited to a specific region, or may occur across the whole Earth. It can be caused by recurring, often cyclical climate patterns such as El Niño-Southern Oscillation (ENSO), or come in the form of more singular events such as the Dust Bowl (NOAA, 2007).

The climate is changing because of the way people live these days, especially in richer, economically developed countries. The power plants that generate energy to provide us with electricity and to heat our homes, the cars and planes that we travel in, the factories that produce the goods we buy, the farms that grow our food – all these play a part in changing the climate by giving off what are known as ‘greenhouse gases’. Climate change has long-since ceased to be a scientific mystery, and is no longer just a trivial environmental concern. It is no longer relevant to discuss whether or not our climate is changing, but rather, how fast changes will occur (European Commission, 2009).

The Kyoto Protocol is an international agreement linked to the United Nations Framework Convention on Climate Change. The major feature of the Kyoto Protocol is that it sets binding targets for 37 industrialized countries and the European community for reducing greenhouse gas (GHG) emissions. These amount to an average of five per cent against 1990 levels over the five-year period 2008-2012. Under the Treaty, countries must meet their targets primarily through national measures. However, the Kyoto Protocol offers them an additional means of meeting their targets by way of three market-based mechanisms, namely:

- Emissions trading – known as “the carbon market”
- Clean Development Mechanism (CDM)
- Joint Implementation (JI).

The mechanisms help stimulate green investment and help Parties meet their emission targets in a cost-effective way. Under the Protocol, countries’ actual emissions have to be monitored and precise records have to be kept of the trades carried out.

The Philippines and Climate Change

Climate change is occurring in the Philippines as evidenced by trends of certain climatic parameters observed by PAGASA for decades. Temperature spikes and warming have been noted in the northern and southern parts of the country. Moreover, it was noted that the regions with the highest temperature spikes also experienced drought. Precipitation trends are largest (10%) during the 20th century (PTFCC, 2007). Hotter days and nights have been experienced by people. Since the 1980s, extreme weather events occurred more frequently. These include fatal typhoons, flash floods, landslides, El Nino and La Nina, drought, and even forest fires. The detrimentally affected sectors which require the most attention include agriculture, fresh water, coastal and marine resources, and health (PTFCC, 2007).

Typhoon Ondoy devastated Metro Manila as 334 mm of rain flooded the NCR in just six hours compared to the 1967 typhoon that brought the same area 334 mm of rain in 24 hours (PAGASA spokesman Nathaniel Cruz on TS Ondoy). Continuous media coverage, post typhoon, where victims of the disaster recounted that they were not prepared for the disaster, and that there was no warning, noted that most of all help came from the government and came a bit late. Students were stranded in their schools. Workers became stranded in their workplaces. Government offices and functions were put to a halt for they were also stranded. People already in the streets for home or for someplace else were caught in the dilemma of whether or not brave the rising flood waters and return home or to just hold their ground, hoping that the waters would eventually subside. The victims, in

general had one thing in common: everyone was caught off-guard, unprepared and unaware that such a catastrophe was even possible.

Consequently, outbreaks of various diseases most notably leptospirosis, dengue fever, and influenza were reported. Aside from being unprepared physically, mentally, emotionally, financially, and structurally, the people were also unprepared and unaware in terms of knowledge on the transmission and management of these diseases. As a result, more lives were lost. Additionally, one of the great needs during the Ondoy and Pepeng onslaught was the provision of all types of medicines most especially for those who were left with no choice but to transfer to crowded evacuation centers.

Climate Change Vulnerability and Assessment

Potential health impact of climate variability and change requires understanding of both the vulnerability of a population and its capacity to respond to new conditions. **Vulnerability is defined as the degree to which individuals and systems are susceptible to or unable to cope with the adverse effects of climate change, including climate variability and extremes.** Both vulnerability and adaptation need to be understood to ensure effective risk management of the current and potential effects of climate variability and change.

The vulnerability of human health to climate change is a function of sensitivity, which includes the extent to which health, or the natural or social systems on which health outcomes depend, are sensitive to changes in weather and climate (the exposure–response relationship) and the characteristics of the population, such as the level of development and its demographic structure; the exposure to the weather or climate-related hazard, including the character, magnitude and rate of climate variation; and the adaptation measures and actions in place to reduce the burden of a specific adverse health outcome (the adaptation baseline), the effectiveness of which determines in part the exposure–response relationship.

Adaptation includes the strategies, policies and measures undertaken now and in the future to reduce potential adverse health effects. **Adaptive capacity** describes the general ability of institutions, systems and individuals to adjust to potential damages, to take advantage of opportunities and to cope with consequences. The primary goal of building adaptive capacity is to reduce future vulnerability to climate variability and change.

Higher temperatures also alter the geographical distribution of species that transmit disease. For example, outbreaks of dengue and yellow fever, transmitted by mosquitoes, increase in warmer temperatures.

Approaches to assessing the potential effects of climate variability and change on human health vary depending on the outcome of interest. Conventional environmental health impact assessment is based on the toxicological risk assessment model that addresses population exposure to environmental agents, such as chemicals in soil, water or air. Most diseases associated with environmental exposure have many causal factors, which may be interrelated. These multiple, interrelated causal factors, as well as relevant feedback mechanisms, need to be addressed in investigating complex associations between disease and exposure, because they may limit the predictability of the health outcome.

Effects of Climate Change on Health

Climate sensitive diseases include heat-related diseases, water borne diseases, diseases from urban air pollution, and diseases related to extreme weathers such as flood, droughts, windstorms and fires. Climate change may also alter the distribution of vector species. This depends on whether conditions are favorable or unfavorable for them to breed and continue their reproductive cycle. Temperature can also influence the reproduction and maturation rate of the infective agent within the vector organism and the survival rate of the vector organism, thereby further influencing disease transmission.

Changes in climate that can affect the potential transmission of vector-borne infectious diseases include *temperature, humidity, altered rainfall, soil moisture and rising sea level*. Determining how these factors may affect the risk of vector-borne diseases is complex. The factors responsible for determining the incidence and geographical distribution of vector-borne diseases are complex and involve many demographic and societal as well as climatic factors. Transmission requires that the reservoir host, a competent vector and the pathogen be present in an area at the same time and in adequate numbers to maintain transmission (Sari Kovats, 2003). Among the vector borne diseases that are climate change sensitive are dengue, malaria and leptospirosis.

A. Dengue

Dengue is the most common mosquito-borne viral disease of humans that in recent years has become a major international public health concern. The geographical spread of both the mosquito vectors and the viruses has led to the global resurgence of epidemic dengue fever and emergence of dengue hemorrhagic fever (dengue/DHF) in the past 25 years with the development of hyperendemicity in many urban centers of the tropics.

Dengue is a disease caused by any one of four closely related dengue viruses (DENV 1, DENV 2, DENV 3, or DENV 4). The viruses are transmitted to humans by the bite

of an infected mosquito. In the Western Hemisphere, the *Aedes aegypti* mosquito is the most important transmitter or vector of dengue viruses, although a 2001 outbreak in Hawaii was transmitted by *Aedes albopictus*. It is estimated that there are over 100 million cases of dengue worldwide each year.

Dengue is transmitted to people by the bite of an *Aedes* mosquito that is infected with a dengue virus. The mosquito becomes infected with dengue virus when it bites a person who has dengue virus in their blood. The person can either have symptoms of dengue fever or DHF, or they may have no symptoms. After about one week, the mosquito can then transmit the virus while biting a healthy person. Dengue cannot be spread directly from person to person.

The principal symptoms of dengue fever are high fever, severe headache, severe pain behind the eyes, joint pain, muscle and bone pain, rash, and mild bleeding (e.g., nose or gums bleed, easy bruising). Generally, younger children and those with their first dengue infection have a milder illness than older children and adults.

There is no specific medication for treatment of a dengue infection. Persons who think they have dengue should use analgesics (pain relievers) with acetaminophen and avoid those containing aspirin. They should also rest, drink plenty of fluids, and consult a physician. If they feel worse (e.g., develop vomiting and severe abdominal pain) in the first 24 hours after the fever declines, they should go immediately to the hospital for evaluation.

Outbreaks of dengue occur primarily in areas where *Ae. aegypti* (sometimes also *Ae. albopictus*) mosquitoes live. This includes most tropical urban areas of the world. Dengue viruses may be introduced into areas by travelers who become infected while visiting other areas of the tropics where dengue commonly exists. *Aedes aegypti* and other mosquitoes have a complex life-cycle with dramatic changes in shape, function, and habitat. Female mosquitoes lay their eggs on the inner, wet walls of containers with water. Larvae hatch when water inundates the eggs as a result of rains or the addition of water by people. In the following days, the larvae will feed on microorganisms and particulate organic matter, shedding their skins three times to be able to grow from first to fourth instars. When the larva has acquired enough energy and size and is in the fourth instar, metamorphosis is triggered, changing the larva into a pupa. Pupae do not feed; they just change in form until the body of the adult, flying mosquito is formed. Then, the newly formed adult emerges from the water after breaking the pupal skin. The entire life cycle lasts 8-10 days at room temperature, depending on the level of feeding. Thus, there is an aquatic phase (larvae, pupae) and a terrestrial phase (eggs, adults) in the *Aedes Aegypti* life-cycle (CDC, 2009).

B. Malaria

Malaria is a serious and sometimes fatal disease caused by a parasite that commonly infects a certain type of mosquito which feeds on humans. People who get malaria are typically very sick with high fevers, shaking chills, and flu-like illness. Four kinds of malaria parasites can infect humans: *Plasmodium falciparum*, *P. vivax*, *P. ovale*, and *P. malariae*. Infection with *P. falciparum*, if not promptly treated, may lead to death. Although malaria can be a deadly disease, illness and death from malaria can usually be prevented.

People get malaria by being bitten by an infective female *Anopheles* mosquito. Only *Anopheles* mosquitoes can transmit malaria and they must have been infected through a previous blood meal taken on an infected person. When a mosquito bites an infected person, a small amount of blood is taken in which contains microscopic malaria parasites. About 1 week later, when the mosquito takes its next blood meal, these parasites mix with the mosquito's saliva and are injected into the person being bitten.

Most cases occur in people who live in countries with malaria transmission. People from countries with no malaria can become infected when they travel to countries with malaria or through a blood transfusion (although this is very rare). Also, an infected mother can transmit malaria to her infant before or during delivery.

Symptoms of malaria include fever and flu-like illness, including shaking chills, headache, muscle aches, and tiredness. Nausea, vomiting, and diarrhea may also occur. Malaria may cause anemia and jaundice (yellow coloring of the skin and eyes) because of the loss of red blood cells. While most people, at the beginning of the disease, have seemingly benign symptoms like fever, sweats, chills, headaches, malaise, muscles aches, nausea and vomiting, at the outset, malaria can very rapidly become a severe and life-threatening disease. Infection with one type of malaria, *Plasmodium falciparum*, if not promptly treated, may cause kidney failure, seizures, mental confusion, coma, and death.

For most people, symptoms begin 10 days to 4 weeks after infection, although a person may feel ill as early as 7 days or as late as 1 year later. Two kinds of malaria, *P. vivax* and *P. ovale*, can occur again (relapsing malaria). In *P. vivax* and *P. ovale* infections, some parasites can remain dormant in the liver for several months up to about 4 years after a person is bitten by an infected mosquito. When these parasites come out of hibernation and begin invading red blood cells ("relapse"), the person will become sick.

Malaria requires two hosts to complete its life cycle. The process starts when a mosquito, infected with malaria sporozoites, releases them into a human host during feeding. The sporozoites travel through the bloodstream into the liver, infecting the cells. The sporozoites mature into schizonts, which explode and release merozoites. The merozoites latch onto the nearest red blood cell and infect it. Inside the infected red blood cell,

trophozoites develop into schizonts and explode, releasing more merozoites or in some species, develop into male and female gametocytes, where they infect the next mosquito. These gametocytes reproduce, creating zygotes, which grow into ookinets. The ookinets attach themselves to the stomach wall of the mosquito, becoming oocysts. These oocysts grow and explode, releasing sporozoites, which get into the salivary glands of the mosquito.

C. Leptospirosis

Leptospirosis, on the other hand, is a bacterial disease that affects humans and animals. It is caused by bacteria of the genus *Leptospira*. In humans it causes a wide range of symptoms, and some infected persons may have no symptoms at all. Symptoms of leptospirosis include high fever, severe headache, chills, muscle aches, and vomiting, and may include jaundice (yellow skin and eyes), red eyes, abdominal pain, diarrhea, or a rash. If the disease is not treated, the patient could develop kidney damage, meningitis (inflammation of the membrane around the brain and spinal cord), liver failure, and respiratory distress. Leptospirosis cases may be fatal.

Outbreaks of leptospirosis are usually caused by exposure to water contaminated with the urine of infected animals. Many different kinds of animals carry the bacterium; they may become sick but sometimes have no symptoms. *Leptospira* organisms have been found in cattle, pigs, horses, dogs, rodents, and wild animals. Humans become infected through contact with water, food, or soil containing urine from these infected animals. This may happen by swallowing contaminated food or water or through skin contact, especially with mucosal surfaces, such as the eyes or nose, or with broken skin. The disease is not known to be spread from person to person.

Leptospirosis occurs worldwide but is most common in temperate or tropical climates. It is an occupational hazard for many people who work outdoors or with animals, for example, farmers, sewer workers, veterinarians, fish workers, dairy farmers, or military personnel.

Leptospirosis is treated with antibiotics, such as doxycycline or penicillin, which should be given early in the course of the disease. Intravenous antibiotics may be required for persons with more severe symptoms. Persons with symptoms suggestive of leptospirosis should contact a health care provider. The risk of acquiring leptospirosis can be greatly reduced by not swimming or wading in water that might be contaminated with animal urine. Protective clothing or footwear should be worn by those exposed to contaminated water or soil because of their job or recreational activities.

Cholera and typhoid are water borne diseases usually associated with post disaster events. The causative organisms are ever present in the environment but cause much harm

when sanitary conditions deteriorate and when human immune mechanisms weaken as a result of disaster exposure. In this project, these two diseases were also considered as important climate sensitive illnesses that were included in the study.

D. Cholera

Cholera is an acute, diarrheal illness caused by infection of the intestine with the bacterium *Vibrio cholerae*. Outbreaks are frequently associated with large populations affected by disasters and are subjected to poor sanitary conditions such as in evacuation centers. The infection is often mild or without symptoms, but sometimes it can be severe. Approximately one in 20 infected persons has severe disease characterized by profuse watery diarrhea, vomiting, and leg cramps. In these persons, rapid loss of body fluids leads to dehydration and shock. Without treatment, death can occur within hours.

It is acquired by the ingestion of water or food contaminated with the cholera bacterium. In an epidemic, the source of the contamination is usually the feces of an infected person. The disease can spread rapidly in areas with inadequate treatment of sewage and drinking water.

Cholera can be simply and successfully treated by immediate replacement of the fluid and salts lost through diarrhea. Patients can be treated with oral rehydration solution, a prepackaged mixture of sugar and salts to be mixed with water and drunk in large amounts. This solution is used throughout the world to treat diarrhea. Severe cases also require intravenous fluid replacement. With prompt rehydration, fewer than 1% of cholera patients die.

E. Typhoid Fever

Typhoid fever, caused by the pathogen *Salmonella typhi*, is a systemic disease with manifestations varying from mild illness with low-grade fever to severe clinical disease with abdominal discomfort and complications. The disease may be accompanied by onset of sustained fever, severe headache, malaise, anorexia, relative bradycardia, splenomegaly, nonproductive cough in the early stage of the illness, and constipation in adults. It is transmitted through the ingestion of food or beverages contaminated with *Salmonella typhi* bacteria from an infected person. The incubation period usually lasts 8-14 days, with a range of 3-60 days. The severity of the disease depends on the virulence of the strain, quantity of inoculums ingested, duration of illness before adequate treatment, age and previous vaccination. A small number of individuals continue to be asymptomatic carriers of the bacteria even after recovery, hence making them sources of infection.

Monitoring and Evaluation of Climate Change

Because of concerns with the growing threat of global climate change from increasing concentrations of greenhouse gases (GHG) in the atmosphere, more than 176 countries have become Parties to the U.N. Framework Convention on Climate Change (FCCC) (UNEP/WMO, 1992). The FCCC was entered into force on March 21, 1994, and the Parties to the FCCC adopted the Kyoto Protocol for continuing the implementation of the FCCC in December 1997 (UNFCCC, 1997). The Protocol requires developed countries to reduce their aggregate emissions by at least 5.2% below 1990 levels by 2008 to 2012.

Monitoring and evaluation of climate change mitigation projects is needed to accurately determine the net GHG, and other, benefits and costs, and to ensure that the global climate is protected and that country obligations are met. It provides feedback regarding the implementation of the climate change program or project to managers as well as to decision makers.

The conduct of monitoring may have a range of objectives, among which include the need to:

1. Establish a baseline by gathering information on the basic site characteristics prior to development or to establish current conditions;
2. Establish long term trends;
3. Estimate inherent variation within the environment, which can be compared with the variation observed in another specific area;
4. Make comparisons between different situations (for example, pre-development and post development; upstream and downstream; at different distances from a source) to detect changes; and
5. Make comparisons against a standard or target level.

Some of the suggested criteria in determining indicators for monitoring include the following:

1. legal, political, economic, ecologic relevance;
2. sensitivity to human activity;
3. measurable
4. predictable
5. appropriate
6. cost-effective
7. sensitive and specific
8. attainable

Adaptation Practices in Climate Change

Adaptation to climate change is already taking place, but on a limited basis. Societies have a long record of adapting to the impacts of weather and climate through a range of practices that include crop diversification, irrigation, water management, disaster risk management, and insurance. But climate change poses novel risks often outside the range of experience, such as impacts related to drought, heat waves, and accelerated glacier retreat and hurricane intensity.

Adaptation measures that also consider climate change are being implemented, on a limited basis, in both developed and developing countries. These measures are undertaken by a range of public and private actors through policies, investments in infrastructure and technologies, and behavioral change. Examples of adaptations to observed changes in climate include partial drainage of the Tsho Rolpa glacial lake (Nepal); changes in livelihood strategies in response to permafrost melt by the Inuit in Nunavut (Canada); and increased use of artificial snow-making by the Alpine ski industry (Europe, Australia and North America). A limited but growing set of adaptation measures also explicitly considers scenarios of future climate change. Examples include consideration of sea-level rise in design of infrastructure such as the Confederation Bridge (Canada) and in coastal zone management (United States and the Netherlands).

Adaptation measures within societies need to be integrated across sectors. Health adaptation is dependent on water, forest, agricultural and habitation adaptation strategies as health effects of climate change will emanate from various sectors. Hence a broad of adaptation measures were reviewed and analyzed in this study.

C. Limitations of the Health Sector Study

The results of this study are constrained by several factors mostly pertaining to availability of local data and information linking climate change to health outcomes in the Philippines. First, the review of literature mostly yielded international information sources on climate change and health as research on this topic has been sparse. Second, review of records on selected disease patterns specifically, malaria, dengue, leptospirosis, cholera and typhoid, revealed that trend data that covers at least ten years or more are not reliable as there is data for some years while for other years, these are not reliably collected anymore. Moreover changes in data collection i.e. change from Field Health Information System (FHIS) to Philippine Integrated Disease Surveillance Reports (PIDSR) have created some artifacts that affected disease trend analysis especially as we linked this analysis to meteorological data. The quality of data significantly affected the precision of projection

results. Hence much of the disease projections were based on assumptions that the project team had to utilize.

Third, coordination of agencies in producing data needed for this project was quite challenging. While NEDA had initially assured the project team that arrangements have already been made with DOH and PAG-ASA regarding the need to make data available for this study, the project team had to devise special arrangements and rely on past friendships and contact to derive essential data for the project.

Lastly, due to time and resource constraints, only three validation sites were chosen to test the derived health sector V&A Framework. While these study sites were carefully chosen to be representative of climate vulnerable areas in the whole country, generalization of the study results to the whole country cannot be done. More extensive application of the health V&A tools and models need to be accomplished.

D. Project Methods and Validation Sites

The health sector project team utilized a descriptive-analytic design in the conduct of this study. Current climate change vulnerability of three selected project sites were assessed using the evolving vulnerability and adaptation framework of the project. Then, adaptation and mitigation practices observed in three selected project validation sites namely Pangasinan, Palawan and Rizal provinces were identified and described. These practices were later analyzed to determine their feasibility and effectiveness to adapt to the changing climate and mitigate climate change selected sensitive health problems in these areas. Furthermore, these practices were compared to what are already known effective adaptation strategies so that they may be integrated into adaptation strategy recommendations that would be later offered to local governments.

An extensive review of literature was accomplished to situate the project in the beginning. In addition, the literature review revealed what is already known in the science of climate change and its impact on health including examples of effective vulnerability assessment and adaptation planning in many countries around the world. Results of this review also were used in the documentation of best practices in health sector adaptation strategies to cope with climate change. These were later annotated to be put together to compose the compendium of climate change best practices in the health sector.

Data collection consisted of gathering meteorological data from national and local PAGASA units as well as getting information on target diseases also from national and local health units. Epidemiologic information describing the distribution of diseases by population affected and location were also derived. Hence data collection was mostly achieved through

the analysis of secondary data that were routinely collected by PAGASA, DOH and provincial and municipal health units. These data were vital for the disease and alert threshold modeling as well as for projections of disease prevalence and economic burden based on PAGASA climate projections for 2020 and 2050. Secondary data from previous studies were utilized to project climate change impacts on health as well as their costs. Hence, most assumptions were robust as they were grounded by previous study results.

The validation sites were selected to cover a wide variance of geographic and development factors namely topography, population density and development. In Pangasinan, Alaminos and Bolinao were selected to represent coastal rural areas with recorded cases of Typhoid and Cholera after being hit by typhoons. In Palawan, the municipality of Brooke's Point was chosen to represent coastal, rural areas with a persistently high prevalence of malaria while Quezon is a typical upland, rural area also with high malaria prevalence. Rural areas typically have lower population densities compared to urban areas. The municipalities of Tanay and Teresa in Rizal typified upland areas with high population densities in urbanization transition. They are referred to as "rurban" in this report. These areas have high prevalence of dengue cases almost all year round and also reported cases of Leptospirosis after typhoon Ondoy.

The health sector project team conducted two national consultation round table discussions (RTDs). The first RTD aimed to present project approaches and the initial vulnerability and adaptation framework crafted from the review of literature. That consultation elicited comments and suggestions to improve the framework and fine tune the study approaches. The second RTD was utilized to elicit comments on preliminary project results and to determine their acceptability to project key stakeholders. At this time, the vulnerability and assessment framework for the health sector was finalized. Moreover, the various best practice adaptation strategies that were documented were presented and discussed.

Validation of the vulnerability and adaptation (V&A) framework was done in the three aforementioned validation sites through site visits. Meetings with the provincial and municipal health teams were conducted. The V&A framework was presented to the municipal health team, the municipal executives and planners as well as to the provincial health team and provincial health executives and planners. Comments and recommendations to improve the framework were elicited. Discussions to determine the implementability of the framework and to elicit best practices from the validation sites were likewise conducted. Discussions were sometimes preceded by key informant interviews with key stakeholders like the chief meteorologic officer of satellite PAGASA offices, municipal health officers, provincial health staff and in Rizal a longtime sanitary inspector (See Book 2, Appendix J for list of respondents.)

After extensive consultation with key project stakeholders, the final report was drafted and prepared for presentation. Several presentations have been made to the Climate change commission as well as to the LGU 3i summits held in Albay, Iloilo and Davao.

E. Climate scenarios from PAG-ASA

Climate data from PAG-ASA was made available to include temperature and rainfall measurements for 2010, 2020 and 2050 (See Book 2, Appendix I). These climate scenarios were supposed to provide information so that predicted epidemiologic and socio-economic impact of climate change could be described.

These data show that in 2020 and 2050, the minimum and maximum temperatures will be higher and rainfall will increase. This is attributed to the earth that is warming due to emissions of greenhouse gases caused by human activity. Current trends in energy use, unsustainable development and population growth are already held responsible for continuing – and more severe – climate change. The changing climate will inevitably affect the basic requirements for maintaining health: clean air and water, sufficient food and adequate shelter.

Climate change also brings new challenges to the control of infectious diseases. Many of the major killers are highly climate sensitive as regards temperature and rainfall, including cholera and the diarrheal diseases, as well as infectious diseases including malaria, dengue, leptospirosis and others spread by vectors. Results of the study show the forecasted prevalence of selected diseases based on models that were constructed based on available data.

Ultimately, **climate change threatens to slow, halt or reverses the progress that the global public health community is now making against many of the aforementioned diseases.** With effective health sector adaptation strategies, the spread of these targeted health problems may be effectively curbed and ultimately contribute to the attainment of MDGs directly attributable to health.

III. RESULTS OF THE STUDY

A. Vulnerability, Adaptability and Impact Assessment Tools

The project developed tools namely: 1) Vulnerability and Adaptation (V&A) framework; or adopted appropriate tools such as 2) the burden of disease, 3) Breteau Index and 4) Vulnerability Maps, 5) climate change, health and socio-economic impact models and 6) the ecologic epidemiologic model to determine the impact of predicted climactic changes on selected diseases. The project also devised a 6) Adaptation Assessment Tool to evaluate possible climate change adaptation options. A variety of methods and tools are available to assess climate change vulnerability and adaptation in the health sector. Both quantitative and qualitative approaches may be used to assess potential health impacts of climate change. The three key issues to be addressed are: (1) estimating the current distribution and burden of climate-sensitive diseases; (2) estimating the future health impacts attributable to climate change including their costs to society; and (3) identifying current and future adaptation options to reduce the burden of disease. These tools and their outputs as a result of their application to the validation sites are discussed in the following section.

Vulnerability and Adaptation Framework

The schematic diagram of the vulnerability and adaptation framework is shown in Figure 2. The inputs to vulnerability assessment are baseline maps, climate change data, ecological factors, environmental factors, individual/family/community characteristics, health system and infrastructure, pathogen/vector factors, socio-economic factors, institutional factors, and health/environmental policies. The integration of all these factors defines the vulnerabilities of the people to climate change-related diseases. Highly vulnerable populations such as infants, children and mothers as well as people with compromised immunities will most likely be affected. Extreme rainfall events that will lead to flooding and landslide may cause or further aggravate incidence of diseases. Institutional capabilities for early warning systems and weather predictions can either mitigate or exacerbate climate change vulnerabilities of populations.

Vulnerabilities are grouped according to several categories. The first category identifies who are vulnerable whether they are individuals, families or communities. The ability to precisely identify who are vulnerable and where they are improves the capability of society to protect them through specific adaptation measures. Secondly, there are health system and infrastructure vulnerabilities that will determine how well people can access

health services from health promotion, to disease prevention, treatment and rehabilitation. This also involves determining the sustainability of appropriate health care measures to maintain human health. The third category refers directly to vector and pathogen factors including their density, virulence, and capability to spread climate sensitive diseases. The next set of vulnerabilities covers socio-economic and environmental factors separately. Incomes, educational status, habitat locations and environmental quality will determine whether vulnerabilities are heightened or mitigated. Finally, health and other policies will determine whether vulnerabilities are reduced by effective and efficient interventions in the public or institutional policy arenas.

The following vulnerabilities were identified by respondents in the field site visits as well as from the two RTDs conducted:

Potential Vulnerabilities In Relation To Climate Change in the Philippine Health Sector

1. Individual /Family /Community

- Extreme age (e.g., very young and old segment of the population)
- Individual susceptibility (e.g., immune system, genetic predisposition, pre-existing diseases)
- Presence of indigenous population/communities
- Access to safe water supply
- Access to sanitation facilities
- Access to healthcare / health insurance
- Health related behavior (hygiene practices)
- Occupational factors
- Type of dwelling
- Location of residential areas (upland, coastal, rural, urban)
- Ability to respond promptly to urgent and long-term impacts of Climate Change

2. Health System and Infrastructure

- Accessibility
- Facilities and human resource capabilities
- Laboratory facilities
- Ability to respond to emergency and disasters
- Emergency preparedness plan / Disaster Management Plan
- Monitoring and disease surveillance capacity
- Referral system and networking with other healthcare facilities
- Database system
- Forecasting and risk assessment capabilities re health impacts of climate change
- Risk communication capabilities

- Level of local and national support

3. *Pathogen /Vector Factors*

- Pathogen/Vector reproduction
- Presence of breeding sites
- Location of breeding sites vis a vis community sites
- Preventive technology (e.g. vaccines, vector control, etc.)

4. *Socio – Economic Factors*

- Income level
- Education level
- Access to healthcare facilities
- Coverage of health insurance (may also be considered as individual/ family factor)
- Allocation of resources (local and national) to address vulnerability to CC (e.g. health system and health infrastructure)
- Social safety nets (e.g. in Albay public schools are redesigned to be evacuation center-ready facilities)

5. *Environmental Factors*

- Domestic wastewater management practices
- Solid waste management practices
- Level of water pollution
- Level of soil and land pollution
- Population density
- Susceptibility to flooding and landslides
- Degradation of watershed areas
- Environmental sanitation conditions
- Human settlement conditions and locations
- Implementation of zoning and land-use policies

6. *Health/Environmental Policy*

- Adequacy
- Relevance of existing health and environmental policy
- Level of implementation of environmental health programs (provide incentive system for good implementation)

Applications of adaptation options to reduce disease impacts will reduce the vulnerability of the affected population thus rendering them disease-resilient. Adaptation options need to be designed to precisely address specific vulnerability categories. If successful, climate change impact on the identified target climate-sensitive diseases can be significantly reduced. Hence, climate change vulnerability will likewise be reduced.

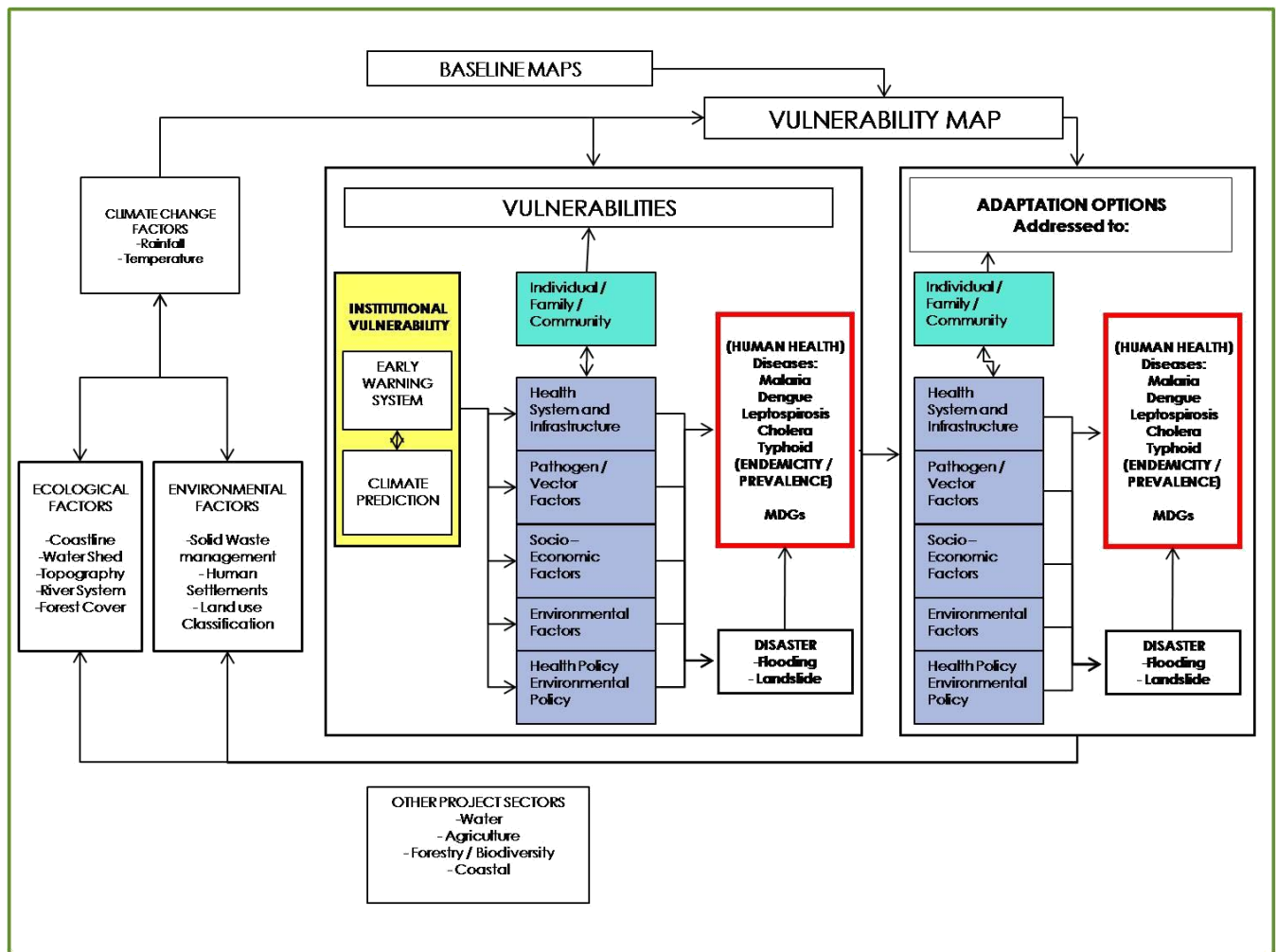


Figure 2 Health Sector Climate Change Vulnerability and Adaptation Framework

Burden of Disease

Disability Adjusted Life Year or DALYs is a common metric of BOD study. It is used to aggregate and summarize the data and information on mortality and non-fatal health outcomes and thus permit comparisons of the impact of various health-related conditions. As DALY can also be used in cost-effectiveness analyses, they greatly facilitate the joint assessment of the magnitude of health problems with the array of interventions-and their costs-that are available to address these problems. Measures from DALYs provide a way to compare the magnitude of fatal and non-fatal health problems. (Murray JL and Lopez AD, 1996)

The Global Burden of Disease Study in 1992 commissioned by the World Bank and the World Health Organization was basically conducted to provide an objective comparable

assessment of health status, based on what was then known about the occurrence of disease and injury throughout the world. The study was the first implementation of the burden of disease concept at the global and regional levels. It demonstrated that BOD approach is feasible. The large numbers of National Burden of Disease studies that have followed also indicate the demand for such comprehensive views of health problems. (Murray JL and Lopez AD, 1996)

This research project adopted the methodology of the Global Burden of Disease project to attain a more objective result and to ensure that the results of the study are comparable with other studies using the same methodology.

The Burden of disease concept as discussed by Murray and Lopez addresses the usual limitations of available information on magnitude of health problems. Health information is usually provided to decision makers by disease advocates wherein this link between advocacy and epidemiological estimation can raise doubts about the objectivity of the conclusions. In particular, advocates, often unintentionally, tend to overestimate the magnitude of their specific health concerns. International datasets which are based on similar diagnostic and reporting procedures fail to incorporate comparable information on nonfatal health outcomes as they are almost exclusively focused on mortality. With the absence of plausible information on disability and other indicators of morbidity which contributed to the neglect of these problems in national and international health policy debate, the team considered adopting the burden of disease concept in this project.

In the past, most of the assessments of relative importance of different diseases are based on how many deaths they cause. This method has its merits as death is a clear event and most countries routinely records the data required in their vital statistical systems. However, closer scrutiny show that mortality analysis has loopholes because there are no consistent estimates of adult mortality in many developing countries and the available mortality estimates are generally confined to infancy and childhood. There are also many non-fatal conditions which are responsible for great loss of 'healthy life'. Disability has not been included in estimating the burden as it is considered a problem only in societies that have undergone epidemiological transition (*World Development Report, 1993*).

With the expanding role of cost-effectiveness in health care planning, the need for more comprehensive measurement of burden of disease has become more urgent. Thus, there is an urgent need for a process through which every disease or health problem would be evaluated objectively so that health programs which do not have strong and able advocates will not be ignored.

Christopher Murray et al have developed a new approach to quantify the burden of disease which was used by WHO and World Bank to estimate the Global Burden of Disease (GBD). This indicator, the Disability Adjusted Life Year (DALY) extends the concept of premature death (Potential years of life lost PYLL) to include equivalent years of “healthy life lost because of illness and disability (years lived with disability YLD) (Schopper D, et al, 2000).

Four concepts were proposed by Murray et al in developing a burden of disease index. The first one is that **any health outcome that represents a loss of welfare should be included in an indicator of health status**. If a society is willing to devote resources, money, manpower or other resources in the prevention, cure or rehabilitation of a certain illness or outcome, then that health outcome must be included in the total estimated burden. There is no use considering health outcomes which society is not willing to pay for.

Secondly, the **characteristics of individuals affected by a certain outcome to be included in the associated burden of disease should be restricted to sex and age**. This concept primarily addresses the issue of what is common to all individuals and communities. The third concept which is **treating like outcomes as like, a BOD index should be able to achieve comparability across different communities and within communities**. Treating like as like means that the premature death of an individual in a rich country or poor area would mean the same anywhere else in the world, thus, giving an egalitarian flavor to the index.

The fourth concept proposed by Murray et al is that **time is the unit for the burden of disease**. Making use of time as a unit of measure would solve the problem of combining both morbidity and mortality into one summary index. It is also a more politically-correct choice of unit of measure than money, when dealing with public health.

The DALY as a measure of the burden of disease was developed with the aforementioned concepts in mind. While the calculation of the DALY is based on the standard expected years of life lost (YLL) on model life tables, the value of time lived at different ages is captured in calculating the DALYs using an exponential function which reflects the dependence of the young and elderly on adults. The time lived with disability is made comparable with the time lost due to premature mortality. For this, six classes of severity of disability have been defined and each class was assigned a disability weight between 0 to 1. Considering that the DALY measures the future loss, a social discount rate of three percent has been applied. Details of assumptions used in DALY estimation were summarized in Global comparative assessments in the health sector edited by CJL Murray and AD Lopez (1996).

Existing Indices used as Basis for Formulating DALYs

Four different methods of estimating time lost due to premature death were explored by Murray et al:

1. Potential years of life lost (PYLL) – calculated by subtracting the age at time of death from a potential life expectancy. The products of each death are then added in order to come-up with the PYLL for the population. This would have been a good basis for the DALY formula, however, the major disadvantage of this method is shown when dealing with the older age groups especially so if the life expectancy at birth for that particular country is low. It would appear that deaths that are over this potential life expectancy do not contribute to the overall burden.

2. Period expected years of life lost – Instead of using an arbitrary potential limit to life, this method uses the local period life expectancy at each stage. In this system, all deaths contribute to the estimated burden. However, since different communities may have different local period life expectancies at each age thus varying reference standards, and since life expectancies change over a period of time, comparability among communities and within communities over time may be problematic.

3. Cohort expected years of life lost- this is similar to the period expected years of life lost except that the estimated cohort life expectancies are used instead of the local period life expectancy. Similar problems as in 'period expected years of life lost' are also encountered in using this method. Cohorts in different communities will also have different life expectancies, thus the reference standards will also vary.

4. Standard expected years of life lost – in this method, an ideal standard for life expectancy is adapted. As in the two previous measures, deaths from all ages, in this method contribute to the estimated total burden of the disease. With the use of an ideal standard, comparability among communities becomes possible. The standard age used in this method is the Japanese women's life expectancy of 82.5 years which is the highest in the world. The use of the highest attained life expectancy is also an effective way of promoting the egalitarian notion since everybody is given equal weights.

The standard years of life lost was used as the basis for the formulation of the DALY because it ensures comparison among communities, takes into account all age groups and treats all communities quite fairly.

In addition to the basic formula discussed above, several components have been added to the DALY. Such components have triggered so much discussion when the DALYs concept was espoused, either because of the very idea of the component itself or the manner by which such components were measured. These are disability weighting, discounting, and age weighting.

Disability-Adjusted Life Years

In 1993, the World Bank developed the Disability-Adjusted Life Years (DALY) as a principal summary measure of population health (Murray CJL, 1996). The reason behind this was that mortality data becomes less sensitive indicators of change when deaths become rare (Schopper D, et al, 2000). Also mortality data do not adequately represent a population's health status as they disregard widely prevalent, severely disabling but non-fatal diseases. The DALY is being groomed as an objective measure that can be used in priority setting (Mathers CD, et al, 2000), (Murray CJL, 1996). It combines life years lost due to premature death with life years lost due to living in a disabled state allowing the burden of disease to be measured as the gap between the current health status and an ideal situation where people live to old age free of disease and disability (Lopez AD, 2000). DALY can be computed using the formula:

$$DALY=YLL+YLD$$

Where:

DALY = Disability-Adjusted Life Years

YLL = Years of Life Lost or amount of time in years lost due to premature death from a specific disease

YLD = Years Lived with Disability or the period of time someone has to live suffering from a disability brought about by a specific disease

There are different formulae to compute the Years of Life Lost (YLL) and Years Lived with Disability (YLD) attributable to a specific disease or condition. These formulae will be discussed in more detail in subsequent sections.

For computations of Years of Life Lost (YLL), Murray used the standard expected years of life lost method (SEYLL). This is denoted by the formula:

$$SEYLL = \sum_{x=0}^l d_x e_x^*$$

Where:

SEYLL = standard expected years of life lost method

x= age at death

d= number of deaths in the population at each age

e_x^* = expectation of life at each age x based on some ideal standard

SEYLLs were used because deaths at all ages contribute to the disease burden. Also, deaths at the same age in all communities contribute equally to the disease burden thus like outcomes are treated as like.

Disability-Adjusted Life Years (DALY) is a variant of the Quality-Adjusted Life Years (QALY) but differs due to its standardized assumptions (Andrews G, Sanderson K and Beard J, 1998). Discounting is applied because people give higher value to their present health compared to their future health (Andrews G, Sanderson K and Beard J, 1998). Discounting is the practice of valuing the same thing in the future as less (or more) valuable if one were to get it in the present (Murray CJL, 1996). Since discounting health benefits is highly controversial among policy planners, a low positive rate of 3 percent was used in the DALY computations (Murray CJL, 1996). This low rate was used to account for uncertainty that increases with time and reduce the problems of excessive sacrifice. While this rate was selected arbitrarily, it was deemed acceptable for those who argue for and against discounting after considering arguments from both sides

Age weighting was also introduced. This is denoted by the general formula:

$$Ce^{-\beta a}$$

Where:

β =parameter of the age weighting function

a = age

C = constant

As most societies would choose to save the young to middle-aged individuals compared to the very young and the very old, age weighting was applied in the computations (Andrews G, Sanderson K and Beard J, 1998). Arguments, such as the human capital

approach, where net producers are given a bigger role in contributing to the social welfare, and welfare interdependence gives justification for the use of age weights. The formula above, which introduces a continuous age weighting function that can be mathematically manipulated, conforms to the age weighting pattern desired. Only a narrow range of β and C, approximately ranging from 0.03 to 0.05, provides age patterns consistent with the arguments already presented. A β of 0.04 was chosen after consultations with the advisory board. The fact that choosing β was arbitrary was not deemed too much an issue because sensitivity analysis showed that the results were basically insensitive to the choice of β . The important issue was the presence of non-uniform age weights. Discounting and age weighting were applied per age group.

Methods for Disability-Adjusted Life Years Studies

The methods utilized in previous burden of disease studies can be subdivided into two parts: methods for estimating Years of Life Lost (YLL) and methods for estimating Years Lived with Disability (YLD). As these two components of burden of illness are different from each other, the methods utilized to collect these data are naturally different from each other. The following section reviews the methods utilized by studies that estimated burden of disease.

Methods for Estimating Mortality Data (Years of Life Lost)

Years of Life Lost (YLL) is the component of Disability-Adjusted Life Years (DALY) which summarizes mortality data for a specific disease or condition. It computes years lost due to premature death using the standard expected years of life lost method (SEYLL) with the application of age-weighting and discounting (Murray CJL, 1996). It can be computed using the following formula:

$$YLLs = \frac{KC e^{ra}}{(r + \beta)^2} \left[e^{-(r+\beta)(L+a)} \left[-(r + \beta)(L + a) - 1 \right] - e^{-(r+\beta)a} \left[-(r + \beta)a - 1 \right] \right] + \frac{1-K}{r} (1 - e^{-rL})$$

Where:

r = discount rate for future years; 3% was used

β = parameter of the age weighting function, where 0.04 was used

K = age-weighting modulation factor, which was equal to 1

C = constant, set at 0.1658 due to $\beta=0.04$

a = age at death

L = standard expectation of life at age a

YLLs compute years of life lost from a disease as the difference between the current health status and an ideal situation where people live to old age free of disease and disability (Lopez AD, 2000). Murray and Lopez used the life expectancy at birth of Japanese women in the computation of YLL (Murray CJL, 1996). This was done on grounds of equity so that deaths in rich and poor countries will be valued equally. However, Williams argued that this should not be the case as the practice inadvertently applies an equity weight greater than one to each year lost in a country where life expectancy at a given age is less than the standard (Williams A, 1999). He suggested using actual life expectancies for the country in the calculations.

The Global Burden of Disease Study started in 1992 with the first results published in 1994 (Murray CJL and Lopez AD^a, 1994). In the original version of the DALY, causes of mortality were classified into three big groups: Group I included communicable, perinatal and maternal conditions, Group II was non-communicable diseases, and Group III was injuries. Mortality estimates were arrived at using three methods. In areas where there is good vital registration, they used the deaths as coded by the registration system according to the ninth revision of the International Classification of Diseases (ICD9). In China and India where there is no complete vital registration system, data from sample registration systems were used after adjusting for underreporting. Model-derived estimates of cause-of-death patterns based on total age-specific mortality were the second source of estimates. The relationship between Groups I, II, and III, and total mortality for each age group was examined using indirect techniques developed by Preston. The third source of estimates was built from disease experts on regional epidemiology patterns for specific diseases. These specialists gave assessments of incidence, prevalence, remission and case fatality rates based on review of available data for each disease. Estimates were then subjected to internal consistency checks using DISMOD, a competing-risks computer model (Murray CJL and Lopez AD^a, 1996). DISMOD uses general population based parameters and disease specific inputs to check internal consistency of estimates. In the computation of YLL, life expectancy of 82.5 for females and 80 for males were used in the computation. Age-weights were applied with an age-weighting modulation factor of 0.04 and a discount rate of 3% was used for future years. These methods were basically the same used for the second set of DALY estimates published in 1996 (Murray CJL and Lopez AD^a, 1996). One difference was that nutritional disorders were properly classified in Group I. Nutritional disorders were classified as non-communicable diseases in the earlier estimates.

Other than the Global Burden of Disease Study, two other studies tried to estimate burden of disease in their respective countries using DALY. Schopper and others (Schopper D, et al, 2000) tried to estimate burden of disease in Geneva. They used the national mortality database to estimate mortality (Schopper D, et al, 2000). Deaths were recoded according to ICD 9 as Switzerland still uses ICD 8. Life expectancies, age-weights, and discounting rates for future years used were the same with the GBD. On the other hand, Mathers and others attempted to estimate DALYs for Australia (Mathers CD, et al, 2001) (Mathers CD, et al, 2000). They made several revisions for YLL computation to make the results more applicable for Australia. First, the difference in life expectancies of females from male is 4.2, greater than 2.5 used in GBD. Another alteration from the GBD was the non-usage of age-weighting. However, a discount rate of 3% for future years was still used.

Methods for Estimating Disability Data (Years Lived with Disability)

Years Lived with Disability (YLD) is defined as the time lived in health states worse than perfect health (Murray CJL, 1996). This is weighted by a preference weight for each health state. This can be computed as follows:

$$YLDs = D \left\{ \frac{KC e^{ra}}{(r + \beta)^2} \left[e^{-(r+\beta)(L+a)} \left[-(r + \beta)(L + a) - 1 \right] - e^{-(r+\beta)a} + \frac{1-K}{r} (1 - e^{-rL}) \right] \right\}$$

Where:

r = discount rate for future years; 3% was used

β = parameter of the age weighting function, where 0.04 was used

K = age-weighting modulation factor, which was equal to 1

C = constant, set at 0.1658 due to β=0.04

a = age at onset of disability

L = duration of disability

D = disability weight

Because data on disability is not as readily available as mortality data, methods used for the estimation of YLD are more complicated. The methods used for the original YLD's in 1992 were as follows: First, disability was defined into four domains namely, procreation, occupation, education, and recreation (Murray CJL, 1996). Then, six classes of disability were arbitrarily identified based on word definitions related to activities of daily living,

instrumental activities of daily living, and the four domains. Probabilities of transition from disease to major disabling sequelae were estimated using available literature and expert panels. And finally, a panel of public health practitioners was asked to choose the severity weight for each of the six classes using a rating scale method. However, important criticisms against this approach were raised in scientific meetings and country applications, which prompted the authors to revise some of the methods. In the 1996 estimations, revisions were already made which included shifting away from defining disability class in terms of the four domains used earlier and having a more deliberative process of choosing weights for any of the disabling sequelae using the person trade-off approach (Murray CJL and Lopez AD^b, 1996).

Having developed the disability weights, the GBD made it easier for succeeding studies to estimate disability. Schopper and others indirectly estimated YLD through data published by Murray (Schopper D, et al, 2000). They used YLD/YLL ratios calculated for health conditions in Established Market Economies (EME) to estimate YLD in Geneva when this ratio is <10. When the ratio is >10, primary data on incidence, age of onset, duration, and degree of disability for EME countries as published in Global Burden of Disease Study (GBD) were used. Mathers and others, in the Australian Burden of Disease Study used incidence rates directly available for some conditions directly from disease registration systems or epidemiologic studies (Mathers CD, et al, 2001) (Mathers CD, et al, 2000) For conditions when only prevalence was available, they used the computer program DISMOD to model incidence. For disability weights, they used actual or derived weights from GBD and Dutch disability weights. They used the Dutch disability weights as much as possible as it was more applicable for Australia. A major revision was that weights were adjusted for co-morbidity unlike in the GBD and the Dutch Study.

The GBD group made the computations for DALY easier by providing a worksheet (attached) that computes for DALYs provided certain data points are entered. These data points are: (1) the number of incident cases (2) average age at onset of the disability (3) expected duration of the disability (4) the disability weights (5) number of deaths and (6) life expectancy at age of death.

Breteau Index for predicting Dengue outbreaks

The Breteau index has been linked with the transmission level of the dengue fever and can be used as a warning indicator of this disease (Wei-Chun et al, 2008). The index is measured in terms of the number of containers positive for mosquito larvae per 100 houses

inspected. This is generally considered to be the best of the commonly used indices (such as the House Index or the Container Index), since it combines dwellings and containers and is more qualitative besides having epidemiological significance

○ Density Level	○ 1	○ 2	○ 3	○ 4	○ 5	○ 6	○ 7	○ 8	○ 9
○ Breteau Index	○ 1 - 4	○ 5 - 9	○ 10 - 19	○ 20 - 34	○ 35 - 49	○ 50 - 78	○ 78 - 99	○ 100 - 199	○ \geq 200

Figure 3 The Breteau Index

As shown in Figure 3 when the Breteau index is above 50 (i.e. density level >6), *it is regarded as highly dangerous* in terms of transmission of the disease according to the definition provided by the WHO; above 20 (i.e. density level >4), *it is considered to be sensitive, meaning that a dengue fever epidemic could break out anytime*; under 5 (i.e. density level <2), *this means that the disease will not be transmitted*.

The formulae used for this index include:

$$\text{Stage 1} - Y_{it} = f(TEM_{it}, WET_{it}, RAIN_{it-1}, Y_{it-1})$$

$$\text{Stage 2} - NDEN_{it} = g(Y^*_{it}, POP_{it})$$

Where:

Y_{it} is the density level in county i at time t ,

Y_{it-1} is the one-period lagged density level in county i ,

TEM_{it} is the temperature in Celsius in county i at time t ,

WET_{it} is the humidity in county i at time t ,

$RAIN_{it-1}$ is the one-period lagged rainfall in county i at time t ,

$NDEN_{it}$ is the number of people infected with dengue fever in county i at time t ,

*Y^*_{it} is the estimated density level in county i at time t from equation (1),*

POP_{it} is the population in county i at time t .

The Breteau index is a very practical tool that can be used either at the barangay, municipal or provincial levels to reliably predict a dengue or malaria outbreak. The sanitary inspector or the midwife can be trained to use this index and give weekly reports to the rural health nurse or doctor. This will be a simple but reliable surveillance tool that will give the health authorities some time to control an imminent outbreak.

The index can be complemented with policy pronouncements that will compel adherence to disease prevention behavior i.e. regular decanting and destruction of mosquito breeding sites. Similar successful policies have been implemented in Malaysia where urban dengue outbreaks were prevented with strict policy implementation.

Vulnerability Maps to precisely locate vulnerability hotspots

The vulnerability map is a visual representation of vulnerable areas or “hotspots”. It is designed to provide national and local planners with a visual reference for areas that are more vulnerable to the changes in the environment, including the health sector, brought about by climate change.

Vulnerability map is part of the impact model that is at the center of vulnerability assessment. Although the vulnerability map is at the center, not all of the factors or variables identified in the model can be effectively rendered in the map. These other factors and variables would only clutter the map and make it less understandable.

In coming up with the vulnerability map, the project team initially decided to use available mapping software technology (i.e., ArcGIS) as tool to build such. Computer-aided mapping technologies have been observed by the team as common to all the three (3) provincial validation sites of the project in terms of mapping capabilities. However, during the course of gathering the necessary datasets that could be rendered in ArcGIS for the project, a number of limitations were encountered.

Limitations to the Vulnerability Maps

The following limitations have been encountered by the project team in coming up with computer-aided vulnerability maps:

- **Unavailability of information/data** - One of the difficulties encountered by the team in its effort to gather datasets and shapefiles (GIS filetype) was the unavailability of

information or data itself. It is not absolutely necessary that the data or information be in a shapefile or geo-referenced (i.e. longitude and latitude readings). It is sufficient that the data could be linked to a geographic area. For example, the open pit dumpsites data that the team was able to gather was not geo-referenced but with a specific barangay-level address, the team will be able to mark this on the map. This becomes an important piece of information for planners. However, a number of vital data sets were dropped from the list because they were either not being collected or not available for dissemination during the visit. This limits the analysis that could be done at the province and municipality level when assessing for vulnerabilities to diseases. Table 1 presents the dataset requirements identified by the project team.

Most often, the team was able to find a map that shows the data needed in building the vulnerability map, however, the data is in picture format (*.jpg or *.bmp). These cannot be rendered or manipulated in the mapping software (ArcGIS) being used by the team. Such predicament posed serious limitations on the team's ability to electronically render, analyze and present the different data sets in a vulnerability map.

Table 1 Vulnerability Map Dataset Requirements

Variables/Datasets	Agency Involved
<ul style="list-style-type: none"> • Rainfall • Temp (Max, Min, Mean) • Relative Humidity • Number of Weather Stations and Locations 	PAGASA-DOST
<ul style="list-style-type: none"> • Prevalence and Incidence of Diseases • Age/Sex-Specific Morbidity/Mortality Data • Address of Health Facilities/Coordinates if available (Longitude and Latitude of health facilities from Barangay health units to tertiary hospitals) 	DOH (NCDPC, IMS) DOH – PHAP (Hospital Licensing) DOH-IMS (Information Management Office)
<ul style="list-style-type: none"> • Population Information • Low Density/High Density Population (geographical locations) 	NSO

Variables/Datasets	Agency Involved
• Topographic Maps	NAMRIA - DENR
• Forest Cover	FMB - DENR
• Watershed and Water Networks	DENR / DA
• Disaster Preparedness Index of Provinces, Municipalities	DND / DILG / PNRC
• Human Settlement Information	DILG
• Geohazard Maps	NAMRIA / MGB
• Rodent/Mosquito Population	Research Institute for Tropical Medicine (RITM)
• Landfill Information	DENR - NSWMC
• Road Networks	DPWH – Central Office or from Planning Offices of each Province
• Safe Water Access	NSO

- **Data Sources** - The datasets and shapefiles that the team has been able to gather so far has been mostly sourced through official channels. However in order to facilitate the initial discussion for the project, some information were gathered through unofficial channels.

There were also instances wherein the needed shapefiles are already available; however, securing these data is another issue. What is being shared for the project is just a portion or just the picture format of it.

- **Incompatibility of existing map formats for use in ArcView** - The official maps from NAMRIA are currently rendered in AUTOCAD. Although they are currently in the process of converting these files to shapefiles, the file format for ArcGIS, this is a long and tedious process. It would take the team approximately 50 weeks to convert the AUTOCAD files for Palawan which is composed of 50 map sheets or files at a rate of 1 week: 1 map sheet. This is the shortest time estimate given to the team by the NAMRIA if the AUTOCAD file were “clean” or needed fewer adjustments. But there is no assurance that the Palawan files are clean.

According to NAMRIA, among the three focus areas, Palawan is the least priority when it comes to conversion because it is not a “geohazard area” unlike Pangasinan and Rizal where some of the map sheets have been converted to shapefiles. This is a special concern for the team because, even if shapefiles are available, they are not complete that would allow for a comprehensive analysis of the province. To illustrate, Figure 4 shows the flood and landslide prone areas in Pangasinan based on available NAMRIA maps. It can be seen that two large chunks of Pangasinan (Dagupan City and Infanta areas) cannot be rendered on the map.

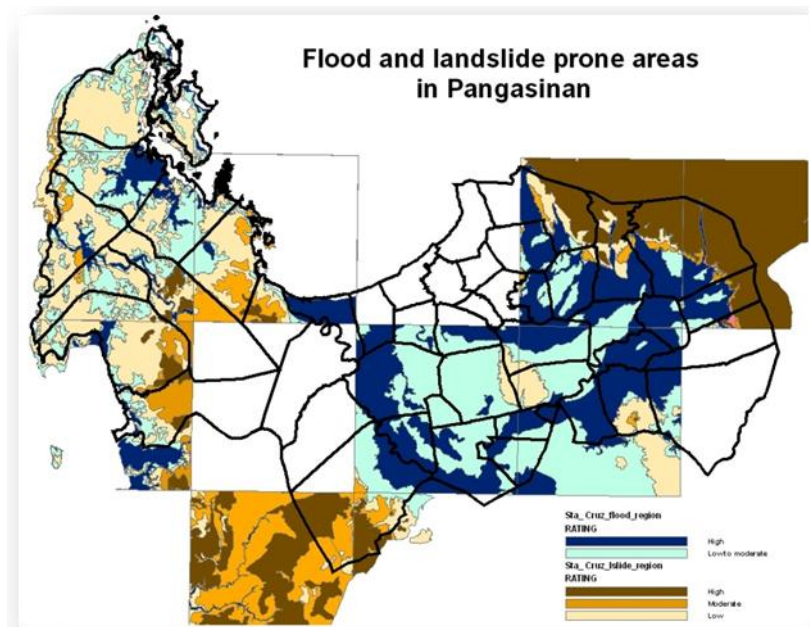


Figure 4 Flood and landslide prone areas in Pangasinan

- **“Misalignment” of some maps to NAMRIA maps.** The team has been able to get shapefiles but, when rendered on ArcGIS, they are misaligned. This is particularly true for the provincial and municipality boundary files, which shows the administrative boundaries of the different municipalities and provinces. As can be seen in Figure 5, the boundary shapefiles are “misaligned” when super-imposed over the NAMRIA-produced shapefiles, such as the forest cover map. Technically, this could be fixed by manually adjusting the boundary files. But this will never be fully aligned with the NAMRIA-based files.

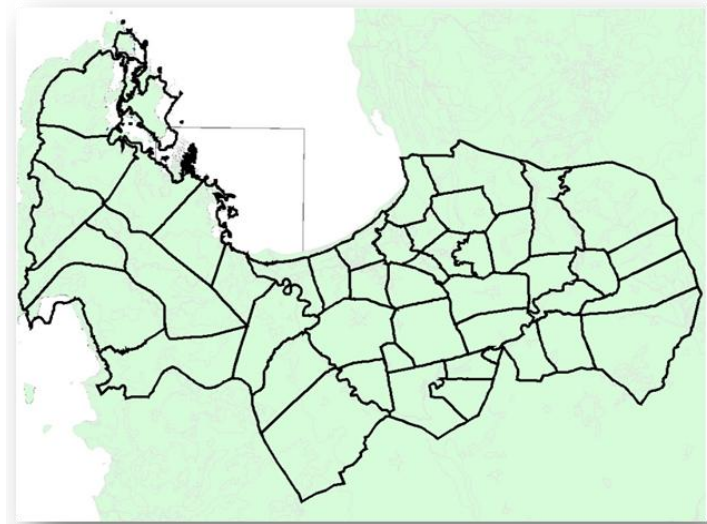


Figure 5 Pangasinan Provincial and Municipal boundaries rendered over the forest cover shapefile

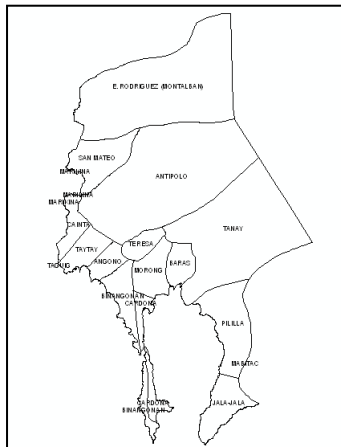
- **No available digitized barangay boundary maps.** The team also has difficulty in securing digitized barangay maps. Such limitation poses a problem since, ideally, incidences of the diseases should be mapped out in a specific location at the barangay level in order to come up with a more evidence-based analysis of its demographic or environmental characteristics.
- **Use of mapping software tool only at the national and provincial level.** Mapping software technologies are only available and being used for planning activities at the national and provincial level. Although there are few cities and municipalities in the country which are also using mapping software technologies, however, their use is only limited to purposes such as tax mapping and development planning. And since there is now a paradigm shift in terms of planning hierarchy from *top down* into *bottom up*, it is important to also equip these local planning offices (i.e. municipalities) with the necessary tools to guide them and carry their respective mandates in addressing issues in their own localities.

Alternative Method for the Vulnerability Mapping

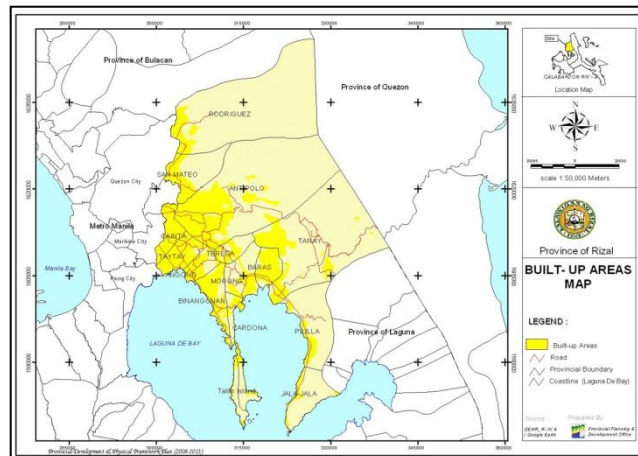
Ideally, the vulnerability map being envisioned by the team should be rendered and analyzed electronically. The use of Geographic Information System (GIS) software such as ArcGIS allows the team more room for modeling the vulnerability assessment. But given the

limitations presented above, the team has decided to shift to a more traditional method of rendering, analyzing and presenting the vulnerability maps. A more manual methodology allows the team to integrate data in different formats (shapefiles, pictures, print outs) into a common platform – acetates or similar materials. This conventional method hopes to also address the issue of technical readiness in using ArcGIS software of some municipalities in the study area. Through the use of acetates and overlay of the various variable layers (or maps) being considered in this study, local planners and decision makers will be able to participate in the planning process and at the same time appreciate the visual presentation of the vulnerabilities in their respective jurisdictions.

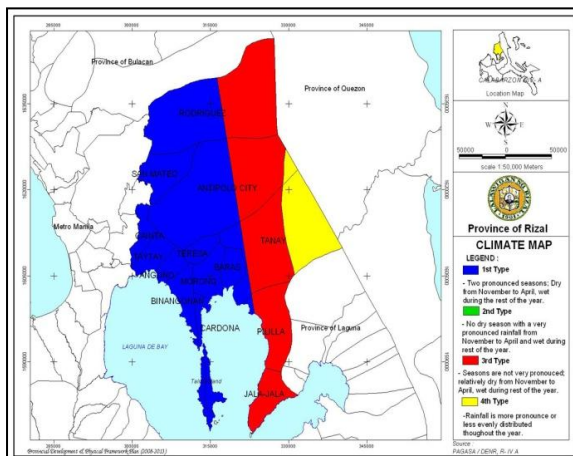
For instance, local planners could overlay the political boundary map (Acetate 1 in Figure 6) together with other maps/layers such as built-up areas (Acetate 2), flood prone areas (Acetate 4), and solid waste disposal (Acetate 5) in order to see the locations that are vulnerable to, say, leptospirosis. Or they can further analyze why incidences of leptospirosis are high to some areas by looking at the demographic and environmental conditions in these areas. One factor could be that these areas are the same areas that are flood prone or where landfills or dumpsites are located.



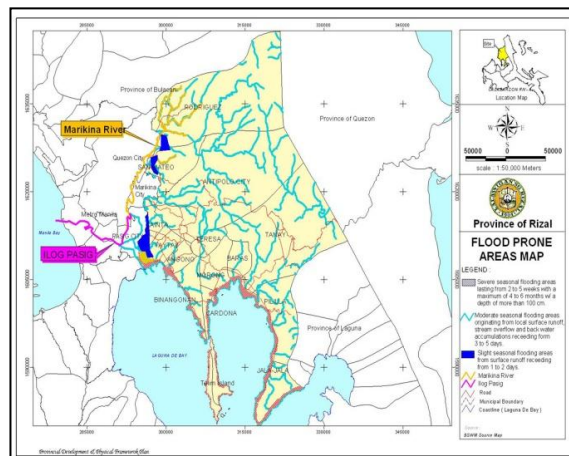
Acetate 1: Political Boundary Map



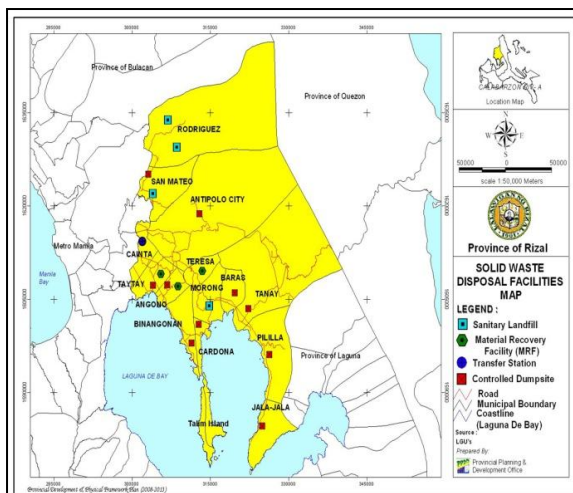
Acetate 2: Built-up Areas Map



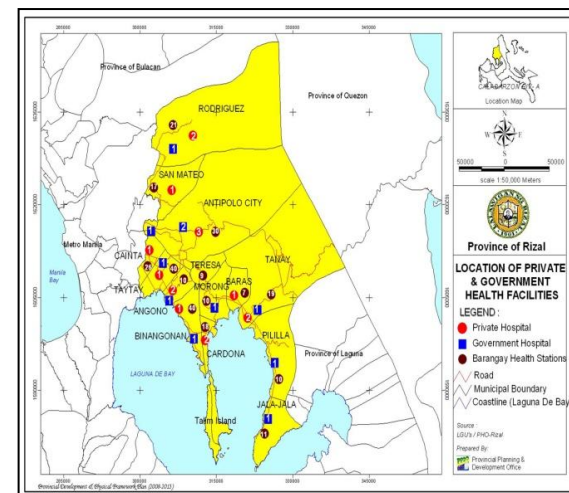
Acetate 3: Climate Map



Acetate 4: Flood Prone Areas Map



Acetate 5: Solid Waste Disposal Map



Acetate 6: Health Facilities Map

Figure 6 Sample Maps of Rizal Province in Acetate platform

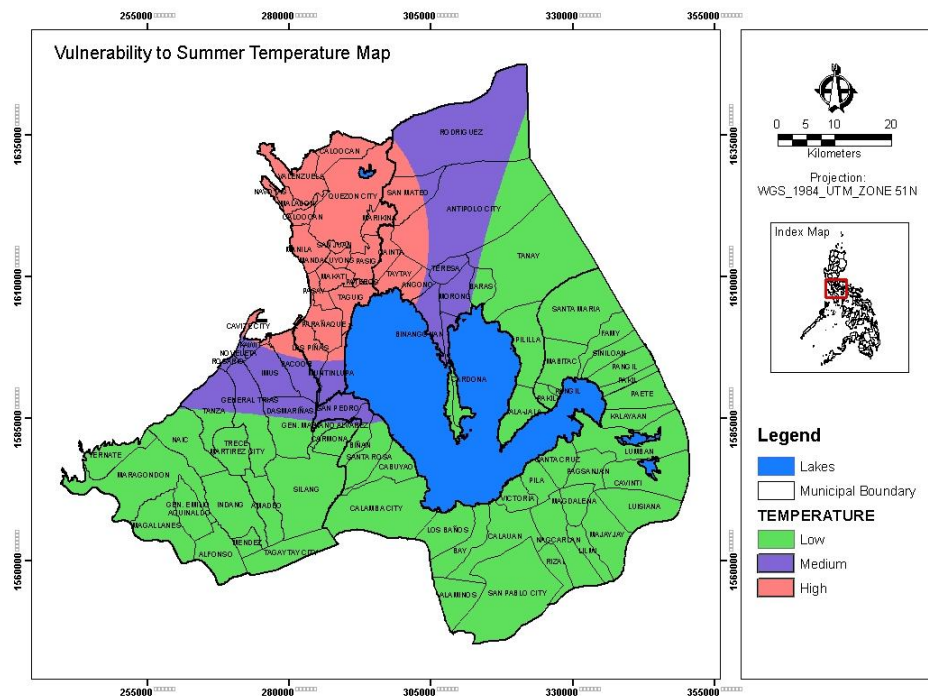


Figure 7 Vulnerability to Summer Temperature

Figure 7 shows the temperature vulnerability map of Laguna Lake Basin. The provinces located here are the National Capital Region (Metro Manila), Rizal province, Laguna province and Cavite province. The provinces are further subdivided into municipalities. The temperature vulnerability map was drawn by taking spot readings of temperature in different places and plotting the temperature readings, then interpolated to come up with the temperature map as shown above. Most of the built-up areas such as those located in NCR are the hottest places. Those still covered with vegetations such as those located in Rizal, Laguna and Cavite are a bit cooler and areas between NCR and Rizal which are populated between the hottest and coolest part of the basin have moderate temperature.

Transforming this to vulnerability map makes the provinces/municipalities that are colored green with low vulnerability, NCR with high vulnerability and part of Rizal with medium vulnerability.

Taking into account disease occurrence in the different places in the Laguna Lake Basin, areas in NCR close to the lake where the temperature is high causing drying down of stream waters to stagnant level is conducive to dengue growth. This makes such areas highly vulnerable to dengue. On the other hand, areas in Laguna where stream waters are still flowing even during the summer season are considered less variable to dengue.

Superimposing a map of water systems (sealed and open/unsealed) of the different municipalities in the basin to the temperature map defines the vulnerability to cholera. Communities with open or unsealed water systems are highly vulnerable to cholera due to water contamination.

Figure 8 shows the vulnerability of the basin to high rainfall and flood. The map shows the areas that were flooded during Typhoon Milenyo. The highly vulnerable areas are those colored with blue. Most of the areas around the lake have the highest vulnerability while areas outside are less vulnerable to flood.

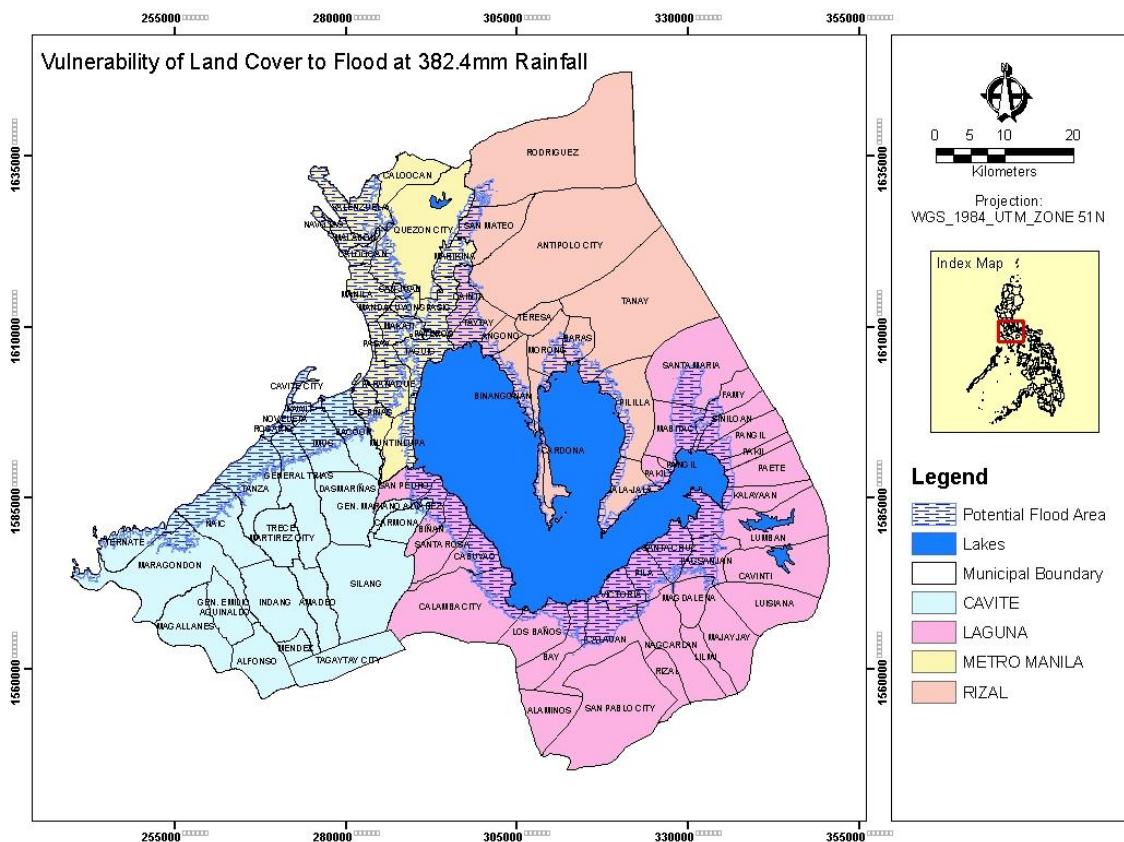


Figure 8 Vulnerability to high rainfall and flood

Considering leptospirosis, the flood-prone areas are potential sources of leptospirosis. These areas therefore are highly vulnerable to leptospirosis. The same areas are also vulnerable to cholera especially communities where their water systems are not sealed type.

The uplands in the basin are less vulnerable to leptospirosis because such areas are not reached by flood waters.

Mapping and superimposing a health infrastructure map with the flood prone map, temperature map and other environmental attribute maps will change the vulnerability of the areas to diseases in the basin.

The importance of vulnerability maps is that it could be used as a tool for planning investments for infrastructure, resettlement, reforestation, and so on. Moreover, planning officers could also be guided further on what specific measures and strategies to introduce to target/address climate change vulnerabilities.

B. Climate Change and Health Impact Modeling

There are two approaches to modeling the health impact of climate change. The first uses a time series analysis to determine the effect of climate change on Dengue utilizing data from the NCR. The second method uses a combination of statistical methods to project future cases of selected diseases as well as alert and epidemic thresholds.

Climate Change and Health Impact Modeling: Statistical Models

Disease impact modeling is one of the tools that can be used by planners of the LGU, DOH, and NEDA to enable them to predict scenarios of health situation in the country under climate change, thus, making the Philippines' health sector resilient. The capacity of the planners to determine future outcome of climate change impact on health would enable the government to implement effective climate change impact adaptation strategies.

Disease impact models are important tools in predicting the future effects of rainfall, temperature, population of disease vectors, and changes in the environmental conditions to the growth and incidence of diseases that impact on human health.

The general aim of developing disease impact models for selected climate change-related diseases is to craft simple models that planners of the LGU, DOH and NEDA can use to minimize the risks of having disease outbreaks in the future under a climate change scenario.

Specifically, the modeling effort sought to:

- a. Assess and evaluate the availability and adequacy of disease and climate change data for modeling purposes in NCR, Palawan, Rizal, and Pangasinan;

- b. Determine which of the climate change indicators or factors contribute to the increase or decrease of disease cases.
- c. Develop a methodology for disease impact modeling; and
- d. Project the impacts of climate change to diseases under different climate change scenarios in 2020 and 2050.

Disease Impact Modeling

Disease impact modeling is one of the tools that can be used by planners of the LGU, DOH, and NEDA to enable them to predict scenarios of health situation in the country under climate change, thus, making the Philippines' health sector resilient. The capacity of the planners to see future outcome of climate change impact on health would enable the government to implement effective climate change impact adaptation strategies.

The general objective of this effort was to develop disease impact models for selected climate change-related diseases that can be used by planners of the LGU, DOH and NEDA to minimize the risks of having diseases in the future under a climate change scenario.

The specific objectives of disease impact modeling were to:

- a. assess and evaluate the availability and adequacy of disease and climate change data for modeling purposes in NCR, Palawan, Rizal, and Pangasinan;
- b. determine which of the climate change indicators or factors contribute to the increase or decrease of disease cases, alert and epidemic thresholds;
- c. develop a methodology for disease impact modeling; and
- d. project the impacts of climate change to diseases under different climate change scenarios in 2020 and 2050.

Conceptual Framework

The methodology used in this study is based on the following conceptual framework (Figure 9):

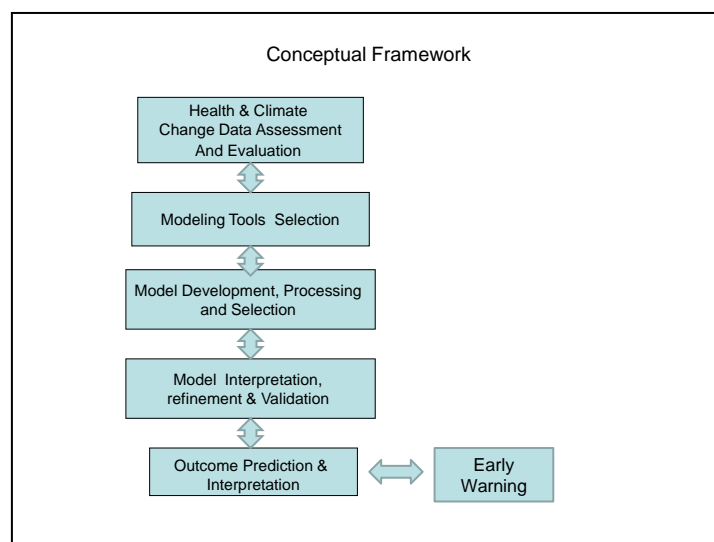


Figure 9 Conceptual Framework for Disease Impact Modeling

The framework shows six interactive components. These are:

a) Health and climate change assessment and evaluation

True, accurate, and adequate health and climate change data are important in modeling. It is necessary that both health data and climate change data are observed and recorded at the same place and at the same time. It is also imperative to use true data, which refers to validated disease data which have passed through scientific diagnosis approach. Use of suspected disease occurrence would cause error in the modeling.

Adequacy refers to the optimum number of observations that could be used in modeling. As a rule of thumb, use of more observations or data distributed in different climate change conditions is better, resulting in clear pattern or trend. The optimum number of observations could be established using proven statistical methods.

b) Modeling tools selection

Depending on resource availability, planners can use any of the two general modeling – the graphical method and the automated computed-based system.

The graphical method is highly appropriate in rural areas where the economic condition is not favorable. Its usefulness is significant to households which are at the frontline of disease impact adaptation. Thus, graphical disease impact models could be done at the barangay level where households would directly benefit from it.

Computer-based system is appropriate in urban areas that are economically well-off and could afford sustainability of a computer-based system. This method therefore is expensive compared to graphical method but it is fast for processing data and model development.

c) Model development, processing, and selection

Model development refers to forming alternative models. Using graphical method, this is simply drawing the disease data with climate change data one at a time. Model processing is more appropriate in the computer system where health and climate change data are processed together to form a model. Model selection is selecting the best model from a list of developed alternative models using standard selection criteria that are mostly statistical in nature.

d) Model interpretation, refinement and validation

After screening the alternative models and selecting the best one, the elements of the best model needs to be interpreted to establish its strengths through statistical tests. The relevant statistical tests are F-test, T-test and Chi-square test with corresponding significance levels. Model refinement refers to further improving the model by increasing or decreasing the data used in its formation and processing again resulting in better statistical test results. After selecting or refining the data, further validation strengthens the stability of the model. Validation requires testing the model with real health and climate change data and statistically testing its significance.

e) Outcome prediction and interpretation

Outcome prediction refers to using the best model in predicting disease magnitude or indicator given predicted climate change data. Outcome interpretation refers to analyzing the predicted values, formulating policies and actions that need to be implemented in the field to lessen potential adverse impacts of diseases to people in the locality. In outcome prediction, there are precautionary measures to bear in mind. These are the limitations of the model usually defined by the range of conditions where it was developed, its statistical accuracy, and the planners who are using it.

f) Early warning

The very reason for developing disease impact models is to enable LGU, DOH and NEDA planners prepare governance systems in addressing disease impacts of

climate change to health that would occur in the future. In particular, knowing what lies ahead in terms of the climate change conditions through the predicted results using the models serves as an early warning to the general public, allowing them to plan out how to prepare themselves during a climate change scenario.

Limitations of Disease Impact Modeling

There are several limitations of the modeling process in this study. These are:

- a. Non-availability of perfectly matched real time health and CC data

The available health data and CC data were not real time and perfectly matched data. While the health data were actual cases, the CC data were projected to where the locations of the diseases were observed. The CC data therefore were not taken at the place when the disease was diagnosed and recorded.

- b. Health data do not reflect start and finish time of diagnoses as well as that of treatment.

The health data provided were actual disease cases recorded during a given day of the month. There were no data saying that such particular disease case had the shortest or longest time (number of days) from diagnosis to cure.

- c. No lag time data on disease occurrence.

An ideal recording of disease cases vis-a-vis climate change indicators shows the real time of disease occurrence starting from the first time of diagnosis where symptoms were observed brought about by a change in temperature or rainfall or relative humidity to the time when the disease was cured. This recording was not available during the conduct of the study. Thus, integrating lag time variable to the modeling was not possible because of lack of data.

- d. Incomplete health data

The data provided by the Provincial Health Office in Palawan, Pangasinan and Rizal derived from their disease surveillance data were incomplete. Some have disease cases, some were alert thresholds and some were epidemic thresholds.

Modeling tools

There are two general tools used for impact modeling, the graphical approach and mathematical or statistical modeling, which can be used depending on the availability of resources and existence of personnel who can operate the system. These tools require software and hardware support and information resources such as disease and climate change data.

Graphical Modeling

This tool is the easiest, the least cost method, and could be easily understood by non-college graduate. It requires only the following:

- a. Graphing paper
- b. Ruler calibrated in mm and cm
- c. Colored pens

Because of its simplicity to use and being the cheapest among the available tools, it could easily be performed by local planners at the municipal level whether in the health sector or the local government units. This is simply done by graphing the dependent parameter with the independent parameter. The dependent parameter is at the y-axis while the independent parameter is at the x-axis. This method does not require any computer.

Because it is the cheapest tool, even local planners at the Barangay level could prepare their disease impact models to guide them in the adaptation of the communities to potential disease impacts of climate change.

Limitation of the graphical method

This tool is only applicable for two variables, namely the dependent variable (e.g. dengue cases) and the independent variable (e.g. rainfall). If a disease is affected by two or more climate change variables, impact modeling through graphical form is not appropriate especially when simultaneous treatment of the contributing climate change factors and when proofs of significance are necessary. This is where mathematical or statistical modeling is more useful.

Procedure of graphical modeling

The steps to follow in using graphical method are shown below,

- a. Draw the y-axis. This is the vertical line
- b. Draw the x-axis. This is the horizontal line

- c. Plot the observations given the readings in the y-axis and in the x-axis
- d. Connect the outer most points inside the plot –region. This represents the maximum observed values.
- e. Connect the inner most points (close to the x-axis) inside the plot- region. This represents the minimum observed values.
- f. The area bounded by the maximum and the minimum observed values define the region of potential disease occurrence region.

The process is illustrated in Figure 10.

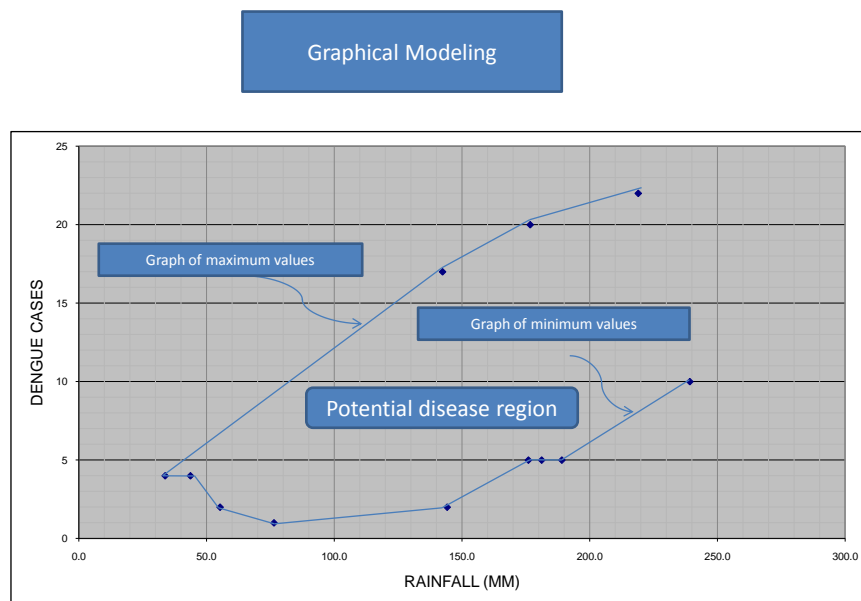


Figure 10 Graphical Representation of Disease Impacts vs. Rainfall

If there are several climate change factors, the planner may decide whether to place all the graphs of the diseases and climate change factors in one graphing paper or each in separate graphing paper for clarity.

Mathematical or statistical modeling tool

This tool is best applicable when there are more than two independent variables and one dependent variable depending on available hardware and software. This requires the use of the following hardware support:

- a. Personal computer and peripherals

- b. Software: SPSS or any statistical software that can process linear and curvilinear regression
- c. Weather data such as rainfall, temperature, and relative humidity
- d. Environmental parameters (existence of stagnant water bodies, moist-areas, garbage areas, canals, water containers in households' surroundings, disease vector habitat)

For disease and climate change data with negatively or positively sloping linear trend, EXCEL can be used. Its applications in impact modeling for climate change impact on health are limited by the following constraints:

- a. Useful only for disease observations that have linear relationships with the independent variable (weather parameters). There are diseases and climate change data with non-linear relationships;
- b. Limited to one dependent (any disease unit) and one independent variable (say, rainfall or temperature); and
- c. It approximates trends; accuracy is dependent on the goodness of fit of the line graph considering the data or observations.

The structure of the linear regression model is shown below,

$$Y = a + b_1X_1 + b_2X_2 + b_3X_3 \quad (\text{Equation No. 1})$$

Where: y is the predicted value of the disease (units that can be used are disease cases, prevalence, alert threshold and epidemic threshold, etc.)

a – constant defining the slope of the line. This is the initial disease impact level.

b₁ – is a coefficient for independent variable X₁ (rainfall),

b₂ – is a coefficient for independent variable X₂ (temperature),

b₃ – is a coefficient for independent variable X₃ (relative humidity)

X₁ – weather parameter (rainfall)

X₂ – weather parameter (any of the minimum, maximum or mean temperature readings)

X₃ – other weather parameters (relative humidity)

The other form of the model is a curvilinear model. Curvilinear models are sometimes known as exponential or quadratic models. The form of curvilinear models is,

$$Y = a + b_1X_1^2 + b_2X_2^3 \quad (\text{Equation No. 2})$$

The power or exponent means that the climate change factor has an exponential factor.

Definition of Terms

In interpreting modeling results, there are important statistical parameters that the planners from DOH, NEDA and LGU should be familiar of. These are:

- a. Dependent variable – refers to the name of the variable to be predicted or estimated. In this study, the dependent variables are cases, prevalence, alert level, and epidemic level of dengue, malaria, leptospirosis, cholera, and typhoid specific to this study. Other diseases may be included.
- b. Independent variables – refer to the predictors of the dependent variables. Examples of the independent variables are climate change indicators such as rainfall, temperature, relative humidity, and environmental factors. These independent variables contribute to the variations of the dependent variables.
- c. Environmental factors – refer to the environmental conditions that favor the growth of disease vectors. Examples are the existence of unmanaged waste disposal area which has turned into a rat habitat, areas with stagnant water where mosquitoes live, unsanitary water systems in barangays composed of old water delivery system from source to communities where human waste disposal system infiltrates into water sources.
- d. Climate change indicators/data/parameters – refer to any of the following: rainfall, temperature (maximum, minimum, mean), and relative humidity.
- e. Vector – refers to disease carrier (could be insects, animals, and human beings). It has been reported by medical practitioners that human urine can be a source of leptospirosis. Humans or pets infected with malaria or dengue are considered vectors.
- f. Correlation value – indicates the relationship of one independent variable to the dependent variable. The higher the correlation value, the better. This means that the correlation between the independent variables and the dependent variable are stronger. A correlation value higher than 0.5 is favorable. The independent variable

therefore should be selected in impact modeling as one or among the predictors. Using an existing statistical software, the correlation table is shown in Figure 11.

Correlations						
		Alert thresholdD	Max. Temp (°C)D	Mean Temp. (°C)M	Min. Temp. (°C)M	Rainfall (mm)M
Alert thresholdD	Pearson Correlation	1	-.371	-.336	-.274	.731**
	Sig. (2-tailed)		.052	.081	.176	.000
	N	28	28	28	26	28
Max. Temp (°C)D	Pearson Correlation	-.371	1	.981**	.877**	-.067
	Sig. (2-tailed)	.052		.000	.000	.699
	N	28	36	36	34	36
Mean Temp. (°C)M	Pearson Correlation	-.336	.981**	1	.956**	.035
	Sig. (2-tailed)	.081	.000		.000	.841
	N	28	36	36	34	36
Min. Temp. (°C)M	Pearson Correlation	-.274	.877**	.956**	1	.134
	Sig. (2-tailed)	.176	.000	.000		.451
	N	26	34	34	34	34
Rainfall (mm)M	Pearson Correlation	.731**	-.067	.035	.134	1
	Sig. (2-tailed)	.000	.699	.841	.451	
	N	28	36	36	34	36

** . Correlation is significant at the 0.01 level (2-tailed).

Figure 11 Matrix Showing the Correlations of Independent Variables

- g. R^2 – is the coefficient of determination defining the goodness of fit of the regression line to the observed values. The R^2 values are given in decimal point which is converted into percent. R^2 values range from 0.1-1.0. An R^2 closer to 0.1 has a weaker goodness of fit and regression models having such R^2 values should be discarded because the models are inferior. Models having 0.5-1.0 R^2 values have stronger goodness of fit and therefore should be selected. Increases in R^2 value indicate increasing acceptability of the model. How should R^2 be interpreted? If the R^2 value of a regression model is .800 or 80%, means 80% of the predicted values are due to the independent variables and 20% are contributed by other variables not included in the model. This is therefore an error. The R^2 can also be interpreted as the accuracy of the model in predicting values. Using statistical software, the R^2 is part of the summary table shown in the following matrix (Figure 12).

Model Summary				
Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
1	.915 ^a	.836	.808	17.450

a. Predictors: (Constant), prov2, Rainfall (mm)D, prov1, Max. Temp (°C)D

Figure 12 Matrix Showing the R-square Value

- h. F-Test – is used to test the null hypothesis that variation in the independent variables does not contribute to the variation in the dependent variable. To reinforce the importance of the F-value, a significance level is also established. As a rule of thumb, an F-value of greater than 2.0 with a significance level of 1-5% indicates that the null hypothesis is rejected. This means that any variation in the independent variables does contribute to the variation of the dependent variable. In this situation, the model is accepted. On the other hand if the F-value is less than 2.0, the independent variables do not contribute to the variation in the dependent variable. The model therefore is rejected. Using statistical software, the F-value is found in the ANOVA matrix (Figure 13).

ANOVA^a

Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	35819.046	4	8954.762	29.407	.000 ^a
	Residual	7003.811	23	304.514		
	Total	42822.857	27			

a. Predictors: (Constant), prov 2, Rainfall (mm)D, prov 1, Max. Temp (°C)D

b. Dependent Variable: Alert thresholdD

Figure 13 ANOVA Matrix

- i. T-Test – is used to determine whether the coefficients of the independent variables and the constant are significant or not. The null hypothesis is $b = 0$ and the alternative hypothesis is $b \neq 0$. If $b = 0$ is true then the independent variable having such coefficient is not significant. Therefore, the independent variable is cancelled out from the model. If $b \neq 0$, then it is significant. Therefore, it should be included in the model. The t-test and significance levels are indicated in the coefficient table shown in Figure 14.

Coefficients^a

Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.
		B	Std. Error	Beta		
1	(Constant)	345.078	102.406		3.370	.003
	Max. Temp (°C)D	-10.213	3.162	-.774	-3.230	.004
	Rainfall (mm)D	.154	.023	.614	6.733	.000
	prov1	-34.851	8.586	-.416	-4.059	.000
	prov2	-48.283	21.028	-.577	-2.296	.031

a. Dependent Variable: Alert thresholdD

Figure 14 Coefficients Matrix

- j. Significance level – The F-value and T-values are accompanied with significance values which determine the level of error of the F-value and T-value. An example is if the significance level is 5%, this means that the chance of getting an error is 1 out of 20 or 5 out of 100. A 1% significance level is 1 out of 100 chance of getting an error. Significance levels from 1 to 5% are highly desirable in regression modeling. The significance level of the F-value is shown in the ANOVA table while that of the coefficients are shown in the coefficient table.
- k. Chi-square test – refers to the statistical test used in the determination of the appropriateness or goodness of fit of actual values to the predicted values of a regression model using actual data. The null hypothesis is $X^2 =, < x^2_{c(k-1)}$ (where: $c(k-1)$ is computed at $k-1$ degrees of freedom. Reject the null hypothesis, otherwise.
- l. Coefficient – refers to the magnitude of growth (coefficient has a positive sign) or decay (coefficient has a negative sign) contributed by an independent variable to the dependent variable. In equation no. 1, the b_1X_1 element means that for every unit of X_1 , the predicted value is either reduced (-) or increased (+) by b_1 . Similarly, in Equation no. 2, the coefficient b_1 of X_1^2 means that for every square of X_1 , the predicted value is decreased (-) or increased (+) by b_1 .
- m. Constant – refers to the initial/lowest point of the impact, if the independent variables are equated to zero.

1. Statistical Modeling Process: Estimating the current distribution and burden of climate-sensitive diseases

Estimating possible future health impacts of climate change must be based on an understanding of the current disease burden and recent trends including the incidence and prevalence of climate-sensitive diseases. In the Philippines, the Department of Health is the major source of the current burden of climate-sensitive diseases at the national and regional levels. At the local level, the provincial, city and municipal health offices maintain their respective health database. These government sources may also provide information on whether current health services are satisfying demand.

The current associations between climate and disease need to be described in ways that can be linked with climate change projections. The associations can be based on routine statistics collected by the Department of Health (e.g., FHSIS, PIDSR) or on published literature. Adverse health outcomes associated with inter-annual climate variability, such as El Niños, also could be considered (as we experienced in 1997 and currently during the summer months of 2010).

a. Disease Impact Modeling and Projected Disease Impacts in 2020 and 2050 and Socioeconomic Impact

Disease impact models for dengue, malaria, cholera were developed out of the available health data from the National Capital Region (NCR) and from Provincial Health Officers (PHOs) of the Provinces of Palawan, Pangasinan and Rizal. Climate change (rainfall, temperature and relative humidity) data used were furnished by PAGASA for the year 1992 to 2009, 2020 and 2050. The disease impact models were used to project disease impacts in 2020 to 2050. The predictive capacity of the models is highly dependent on the accuracy of the health and climate change data. Due to insufficiency of data on leptospirosis and typhoid, no models were developed.

After several runs to screen and select the best models, only 3 models were successfully developed. The diseases where statistically acceptable models were developed are dengue, cholera and malaria. The models are:

$$\text{Dengue Cases} = -1267.347 - 0.615 * \text{Monthly Rainfall} - 21.389 * \text{Maximum Temperature} + 31.442 * \text{Relative Humidity}$$

Cholera Cases = $8.948 + 0.026 * \text{Monthly Rainfall} - 1.681 * \text{Maximum Temperature} + 0.663 * \text{Relative Humidity}$

Malaria Cases = $-218.918 - 0.089 * \text{Monthly Rainfall} + 7.605 * \text{Maximum Temperature}$

Both dengue and cholera impact models were found to be sensitive to monthly rainfall, maximum temperature and relative humidity, whereas malaria is sensitive to monthly rainfall and maximum temperature.

The models can be interpreted in this way: for every unit of the variables, the corresponding responses of disease cases are summarized in the table below:

Table 2 Model specifications of disease cases as responses to climate change variables

Disease Cases	One unit each of the variables will increase or decrease disease per thousand cases					
	Monthly Rainfall (mm/day)		Maximum Temperature (degree centigrade)		Relative Humidity (%)	
	Increase	Decrease	Increase	Decrease	Increase	Decrease
Dengue		615		21,389	31,442	
Cholera	26			1,681	663	
Malaria		89	7,605			

The models in graphical forms together with the observed disease cases and climate change indicators are shown in the following graphs. Figure 15 shows the graphs for dengue. Both observed values and predicted values are close together indicating accuracy.

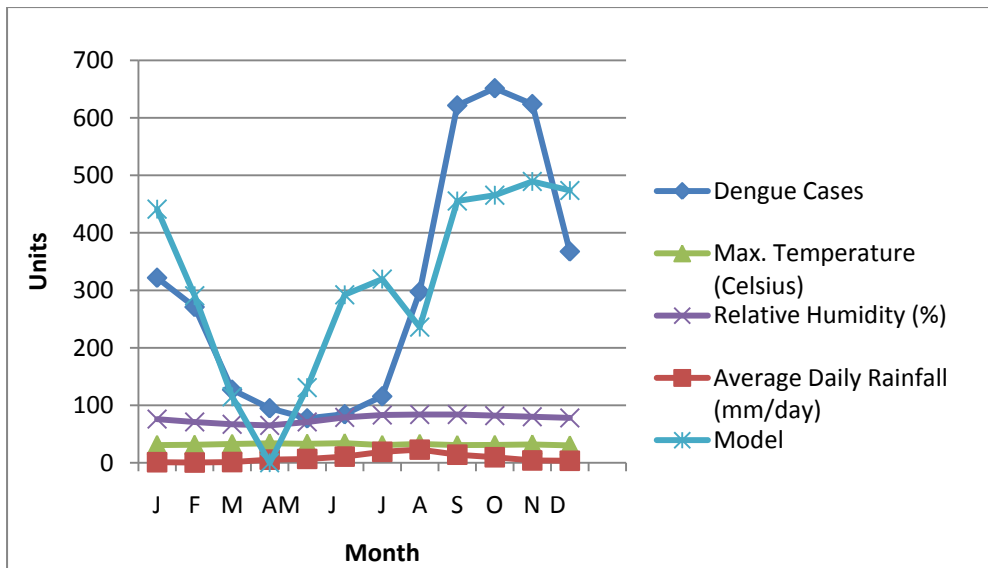


Figure 15 Dengue Cases, Projected Cases and CC Indicators

The graphs for Malaria is shown in Figure 16. The dark blue color represents the graph of malaria cases while the light blue color refers to the projected values. There is also a close coherence between the observed cases and projected values using the model.

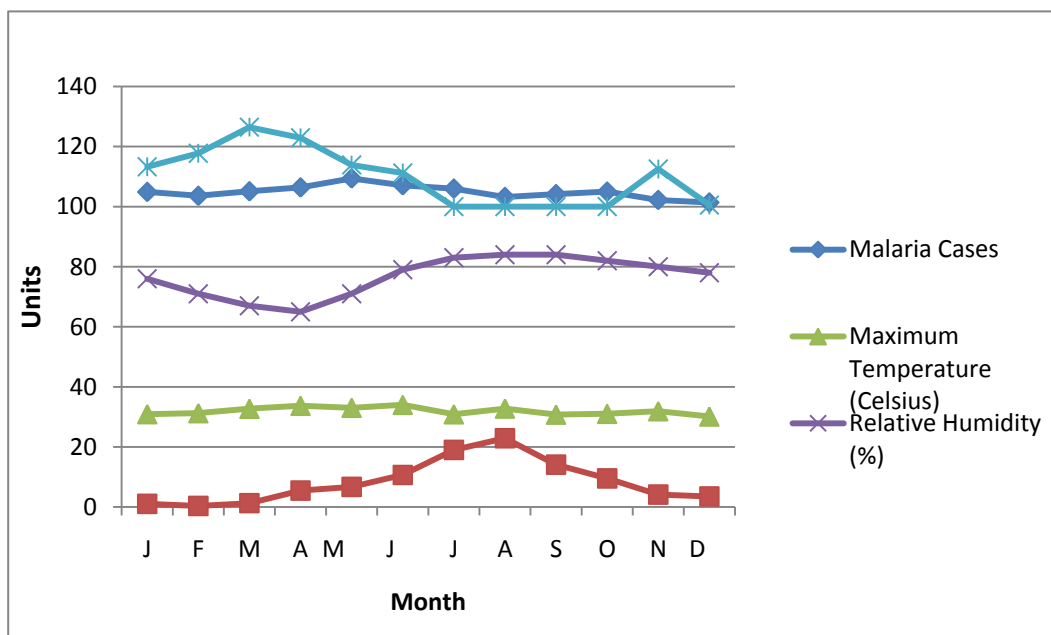


Figure 16 Malaria Cases, Projected Values and CC Indicators

Figure 17 shows that graph of cholera cases vs. projected values. Their fits are almost perfect. This means that the model values are two close to the real observed cases of cholera.

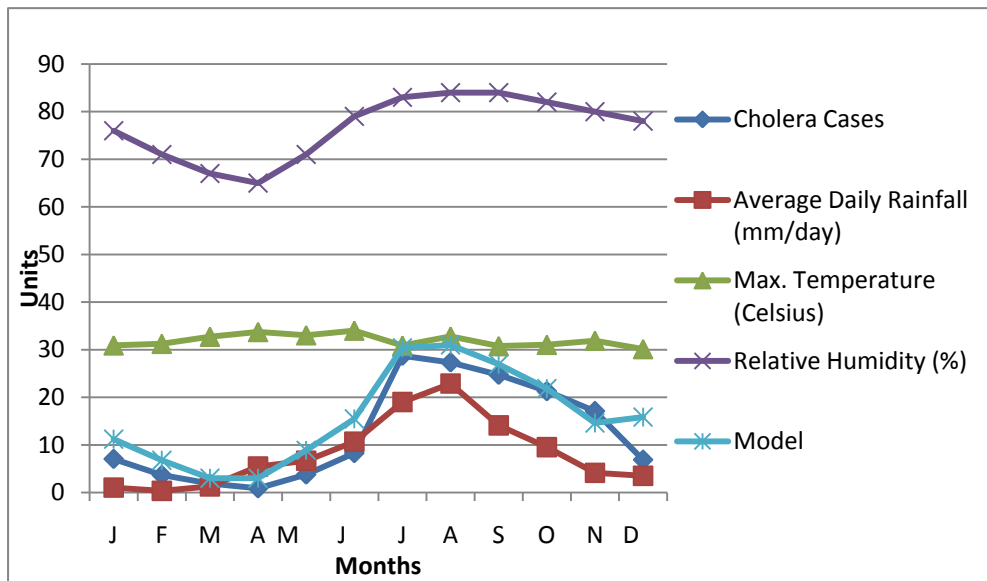


Figure 17 Cholera Cases, Projected Values and CC Indicators

No model was developed for leptospirosis. Instead the observed cases were graphed with the CC indicators. The results are shown in Figure 18. From the curves of leptospirosis observed cases and rainfall, there seems to be a pattern where increase in rainfall indicates an increase in the number of cases. Likewise, a reduction in rainfall means a reduction in leptospirosis cases.

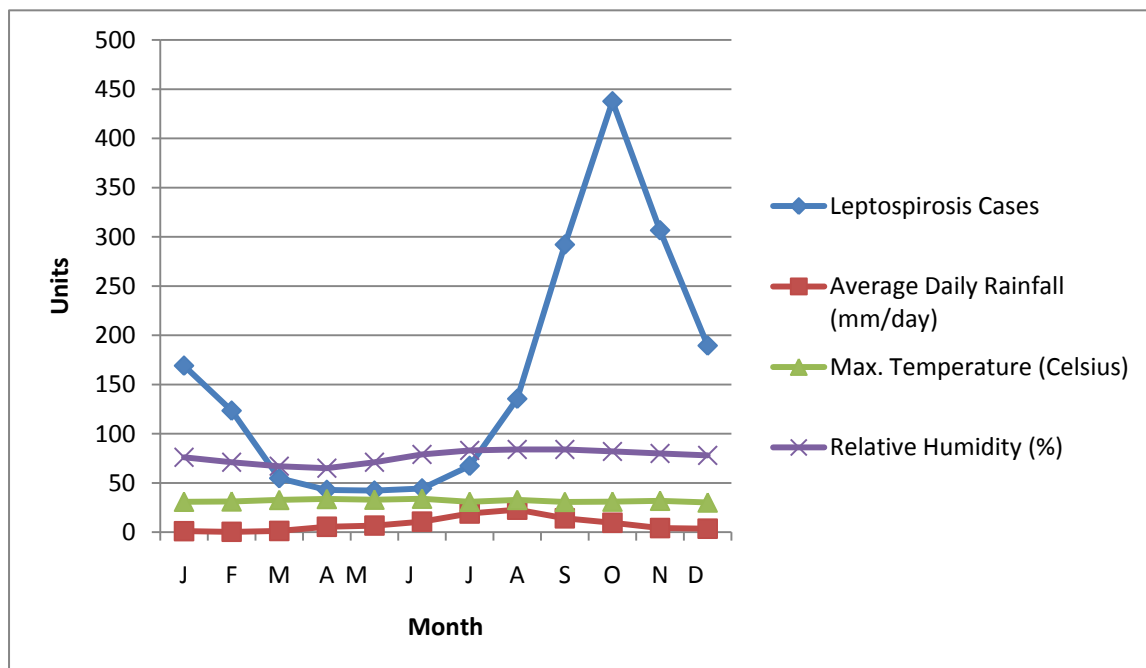


Figure 18 Leptospirosis Cases and CC Indicators

Similarly, in typhoid where no model was developed due to lack of correlations among the independent and dependent variables, apparently has similar pattern with maximum temperature and relative humidity. The relationships, however, are weak (Figure 19).

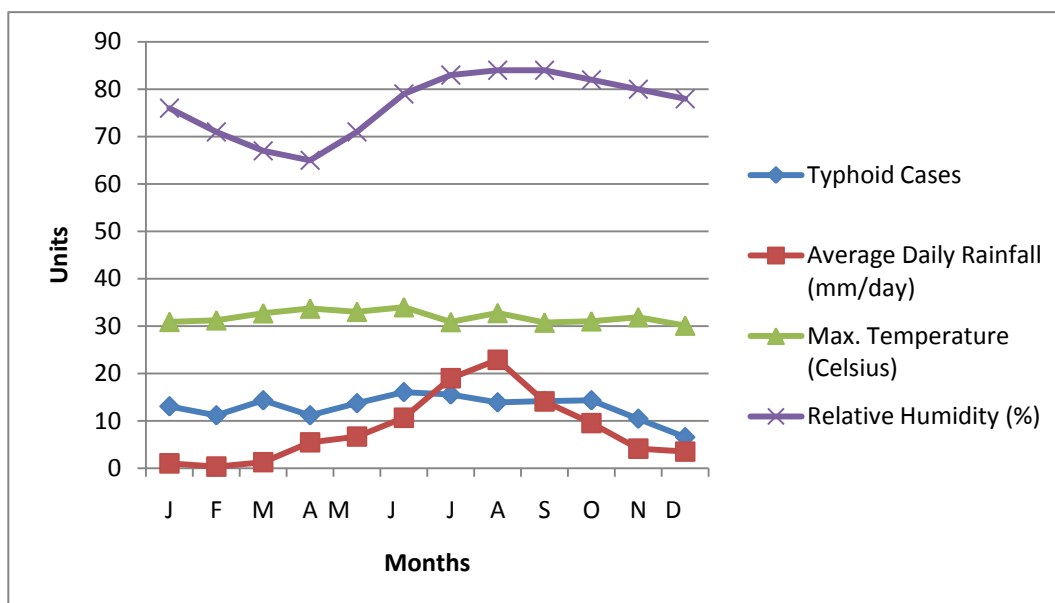


Figure 19 Typhoid Cases and CC Indicators

Assessment and Evaluation of Disease and Climate Change Data

Analysis and evaluation of health and climate change data showed imperfect matching and inadequacies causing major problems in developing the models. A remedial measure adopted was to match projected climate change data from PAGASA in NCR and the three provinces with health data. The health data were also found incomplete in terms of actual cases. This is the reason why the models for leptospirosis and typhoid were not developed.

Monthly averages of disease data from 2002-2007, were provided by the PHO in Palawan, Rizal, and Pangasinan. On the other hand, the weather data were provided by PAGASA. However, the weather data were not actually recorded at the same place and time when the diseases were diagnosed and recorded. The NCR disease data was provided last together with the PAGASA projection of climate change. These were matched with the disease data to push through with the modeling exercises. In general, not all the diseases have complete 12-month average data. The availability of disease and weather data is summarized in Table 3.

Table 3 Availability of Disease and Weather Data, Palawan, Rizal, Pangasinan, and NCR

Disease	Indicators	National Capital Region	Palawan	Rizal	Pangasinan	Rainfall	Maximum Temperature	Minimum Temperature	Mean Temperature	Initial Vector Population
Dengue	Cases	12m	8md	1md	37dd	M	m	m	m	n
	Alert Threshold	n	12md	12md	12md	m	m	m	m	n
	Epidemic Threshold	n	12md	12md	12md	m	m	m	m	n
Malaria	Cases	12m	8md	1md	1md	m	m	m	m	n
	Alert Threshold	n	n	12md	n	m	m	m	m	n
	Epidemic Threshold	n	n	12md	2md	m	m	m	m	n
Cholera	Cases	12m	n	n	1md	m	m	m	M	n
	Alert Threshold	n	n	n	5md	m	m	m	M	n
	Epidemic Threshold	n	n	n	5md	m	m	m	M	n
Leptospirosis	Cases	12m	n	n	1md	m	m	m	M	n
	Alert Threshold	n	n	3md	4md	m	m	m	M	n
	Epidemic Threshold	n	5md	9md	6md	m	m	m	M	n
Typhoid	Cases	12	n	1md	9md	m	m	m	M	n
	Alert Threshold	n	n	5md	n	m	m	m	M	n
	Epidemic Threshold	n	n	9md	3md	m	m	m	M	n

Legend:

8md = 8 months data

n = no data

37dd = 37 days data

m = matched data not sure whether taken at the same time with disease observations.

The provincial data for NCR, Palawan, Pangasinan and Rizal are shown in Book 2, Appendix K Climate Change Impact Modeling Data. It is interesting to note that most disease cases are blank while alert and epidemic thresholds were provided by the PHOs.

The criteria used in evaluating the health and climate change data for use in the disease impact modeling are:

1. Possible pairing or matching of climate change and health data in the absence of health records which already incorporated climate change data.
2. Adequacy of observations. Ideally, the number of data to be used should not be less than 30 observations to show clear trends. Since the data were monthly averages, the maximum number of data is 12 observation points. This study had no other recourse but to use the available data.
3. Existence of health and climate change data relationships. Health data and climate change relationships are distinct in real data so that manufactured data are easily identifiable due to lack of patterns or trends.

The differences in processing health data coming from the 4 selected areas provided by DOH and their PHOs indicate the need to standardize health and climate change data monitoring form required at different levels.

The data that were provided were processed data, i.e., they are monthly averages from 2002 to 2007, without the necessary climate change data. Averaging the monthly disease data limits the number of observations to be used in the modeling exercise resulting in more inferior models. Instead of averaging the disease and climate change data, actual individual observations should be used. In the case of the NCR, the climate change data were projections by the PAGASA in daily averages by month by year from 1992 to 2009.

Assumptions Used in the Impact Modeling

1. The data from the DOH in Manila for disease data for NCR, PHOs in Palawan, Rizal, and Pangasinan are the recognized correct and official data on the following diseases; a) dengue; b) malaria; c) Leptospirosis; d) cholera; and e) typhoid. There are no other official data except these data. Disease diagnosis procedures were properly undertaken by DOH or PHOs, thus establishing the correct types of disease.

2. The observations on the diseases in the locality were due to existing population of disease vectors/carriers that were not recorded. Thus, these variables were not included in the impact models.
3. That the climate change parameters were correct, exact and true conditions at the locations when the diseases were diagnosed. The climate change data came from PAGASA, and these were projections from the nearest weather monitoring stations to or in the province.
4. That the initial diseases' levels were equal to the initial recorded disease levels indicated in the data coming from the PHOs.
5. That the diseases react to changes or variations in the climate change parameters as manifested in the health data.

Results and Testing of the Impact Models

The impact modeling procedure and corresponding results are presented and discussed in the following sections.

How is the disease impact equation formulated?

The equation is formed by referring to the coefficients table (Table 4). The first column shows the list of variables: constant down to prove in this example. The second column indicates the non-standardized coefficients composed of B or b coefficients and their corresponding standard errors. The B or coefficient values are either positive or negative. From these coefficients, the equation is,

$$Y = \text{Constant} + B_1 \text{ Max. Temp} + B_2 \text{ Rainfall} + B_3 \text{ Prov1} + B_4 \text{ Prov2}$$

From the table, Constant = 345.078, $B_1 = -10.214$, $B_2 = +0.154$, $B_3 = -34.851$, $B_4 = -48.283$. Plug in these coefficients in the general equation form above will give the impact disease model. The signs of the B coefficients also should be reflected in the equation.

Table 4 Sample Coefficient Table

Coefficients ^a						
Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.
		B	Std. Error	Beta		
1	(Constant)	345.078	102.406		3.370	.003
	Max. Temp (°C)D	-10.213	3.162	-.774	-3.230	.004
	Rainfall (mm)D	.154	.023	.614	6.733	.000
	prov 1	-34.851	8.586	-.416	-4.059	.000
	prov 2	-48.283	21.028	-.577	-2.296	.031

a. Dependent Variable: Alert thresholdD

Significant Level of the Model

When is the model acceptable? The answer to this question is given by the F-Test. If the F-Test value is highly significant, the model as a whole is acceptable and therefore can be used for predicting values.

Goodness of Fit

The goodness of fit is given by the R-square value of the model. If the r-square value, say is 0.80, this means that the 80% of the predicted values are due to the predictor variables and that 20% are attributed to errors which are not part of the model.

The outputs of the tests of the models are shown in Book 2, Appendix L Testing Climate Change and Health Impact models.

Validating the Impact Models

After developing the impact models, there is a need to test how good they are in predicting values. Observations not used in the model development may be compared to the expected/predicted values using the model. The statistical test to be used is Chi-square test. The formula for this is,

$$X^2 = \text{Sum (observed} - \text{expected)}^2 / \text{Expected}$$

Where: observed data refers to actual data;

Expected data – refers to predicted data using the model

The model has a very good “goodness of fit” if the $X^2 =, < X^2_{c(k-1)}$. Otherwise, the model has a weak goodness of fit or the predicted values are different from the observed values.

How to Use the Models

Since modeling is highly dependent on existing real data which is expensive to generate because of the value and alternative use of money and the cost of monitoring real data, the models developed in this study may be used by DOH, NEDA and LGU in the following alternative uses under the same conditions where the data were collected. Models adjustments for further refinements for better predictive accuracy of the parameters of the selected diseases are necessary.

- a. For outright use in the projection of diseases in any municipality, province or the whole country. For municipal model, plug in the CC indicators from the municipality. For provincial model, plug in the CC indicators from the province. And for national use, sum all the results of the provincial models to make up the projection for the whole country. Averaging the CC indicators at the national level is not advisable because there will be some provinces with projections below or above the average.
- b. For further study to improve models developed. Useful for other provinces not covered in this study by using their actual data on diseases on dengue, malaria, leptospirosis, cholera and typhoid and rainfall, temperature and relative humidity data and test whether the observed and expected values are statistically similar using Chi-square test.
- c. Using the data of the provinces, refine the models by changing the coefficients. The independent variables maybe similar but the coefficients and coefficient of determination are different..
- d. Predicting the impact values serving as early warning to policy makers, planners and community resource leaders and managers.

Projecting Diseases Using the Prediction Models

There are precautionary measures that should be known in using the disease impact models as well as in using the predicted values. There are:

1. Never go beyond the range of the observed independent variables in assuming their values in the prediction of disease impacts unless there are data showing adaptation of the disease vectors in new environmental conditions.
 2. All negative Y values do not exist in the real world and such values can be interpreted as there are levels of the climate change parameters that diseases do not occur.
 3. Models are more accurate if used in areas where the dates were collected all at the same time instead of pairing the health data with the climate change data.
- b. A Time Series Analysis of the Effect of Climate Change on the Incidence of Dengue in the National Capital Region, 1995-2007

As part of the risk estimation step of Activity 1 (Health Risk Assessment (HRA) on Climate Change Vulnerability and Adaptation), an epidemiologic model was proposed to describe the relationship of the different weather elements and the incidence of selected infectious diseases (malaria, dengue, cholera and leptospirosis) based on data from the National Epidemiology Center of the Department of Health and the Philippine Atmospheric, Geophysical and Astronomical Services Administration (PAGASA) of the Department of Science and Technology. A model that could be developed would be helpful in defining any relationship between climate factors and disease that could help prepare communities mitigate the effects of increases in infectious diseases.

Making a predictive model is intended to assess the change in the number of cases of infectious diseases under future climate change conditions. Apart from the results of correlation/regression studies in selected areas in the Philippines, a time series analysis was also conducted for the risk estimation of climate change on health in Metro Manila in order to: 1) to describe the trend of the incidence of selected infectious diseases and outbreaks and correlate these with changes in weather elements indicative of climate change (such as monthly temperature, rainfall and relative humidity) in the National Capital Region during the

period covered; and, 2) to develop an extrapolation of the estimates of computed dengue cases based on climate-related factors using a predictive model.

Methodology

A. Sources of data

The study had been confined to using data from the National Capital Region in order to ensure the completeness and accuracy of data on selected infectious diseases. Regional data might relatively be delayed and inaccurate compared to data obtained from Metro Manila which historically has more cases than other parts of the country.

Data on the number of cases of malaria, dengue, cholera and leptospirosis in the National Capital Region from 1992 to 2007 were obtained from the National Epidemiology Center of the DOH. Population census data and projection data was obtained from the website of the National Statistics Office. Data from the 2007 total Philippine population and total population of the National Capital Region was obtained from the 2007 census of Population. The total Philippine population data obtained for 2000 to 2006 and 2008 to 2009 was obtained from a medium-term assumption from the National Statistics Office¹. Likewise, the 2000 to 2006 and 2008 to 2009 total population for NCR was also obtained from the same website. Population data from 1993 to 1999 were obtained from the Philippine Health Statistics 1960 – 2005 of the DOH. Population data from 1993 to 1996 were obtained by multiplying the Philippine population by 13% which was the average proportion of the size of population of the National Capital Region to the total Philippine population.

Computations for incidence for the infectious diseases listed in Table 5 were obtained from the abovementioned sources of data. Incidence data are reported below per 100,000 population.

Table 5 Incidence of Infectious Diseases, National Capital Region, 1993 to 2007

Infectious Disease	Years Covered	Total number of Cases
Dengue	1993-2007	64,757
Cholera	1992-2009	2,729

¹ http://www.census.gov.ph/data/sectordata/popproj_tab1r.html

Typhoid	1998-2009	4,530
Leptospirosis	1998-2009	879
Malaria	1998-2009*	2,558

*Note: w/o 1995

Due to the large variation of monthly data for rainfall during the 14-year period, these were transformed using the natural logarithm (ln). The transformed data were used in the presentation of the seasonal patterns of rainfall along with the other weather elements. All other data were used in their original raw numeric form.

B. Time Series Analysis

A series of line graphs were constructed to show the trend of the incidence through Excel software (Figure 20 to Figure 23). Based on the relatively higher incidence of dengue, a specific analysis was undertaken to correlate dengue and various weather elements by constructing a line graph to describe a time series analysis of rainfall, temperature and relative humidity with the incidence of dengue.

Further time series analyses were undertaken to develop several models to predict the number of cases of dengue based on climate factors specifically for 1995 to 2007 (that had the most completed data from the available 1993-2007 dataset obtained from the DOH). The Autoregressive Integrated Moving Average (ARIMA) model procedure (SPSS/PASW version 18) was used to determine the contribution of rainfall (transformed to its natural log), maximum and minimum temperature and relative humidity in estimating the number of dengue cases for the whole of the National Capital Region and for each city in NCR. Seasonality (i.e. periodicity of 12 months) and time lags (i.e. climate factors were all subjected to a biologically plausible time lag of one month in estimating the number of dengue cases) were both considered in the development of the models.

Results

Based on the following graphs, the incidence for dengue was far greater than the incidence for malaria, cholera and leptospirosis (which showed a dramatic increase in 2009 due to the leptospirosis epidemic following the September 26 flooding in the aftermath of

Typhoon Ondoy). Data for incidence for malaria, cholera and leptospirosis were adjusted and presented as per 1,000,000 population instead of per 100,000 population, which was used for dengue.

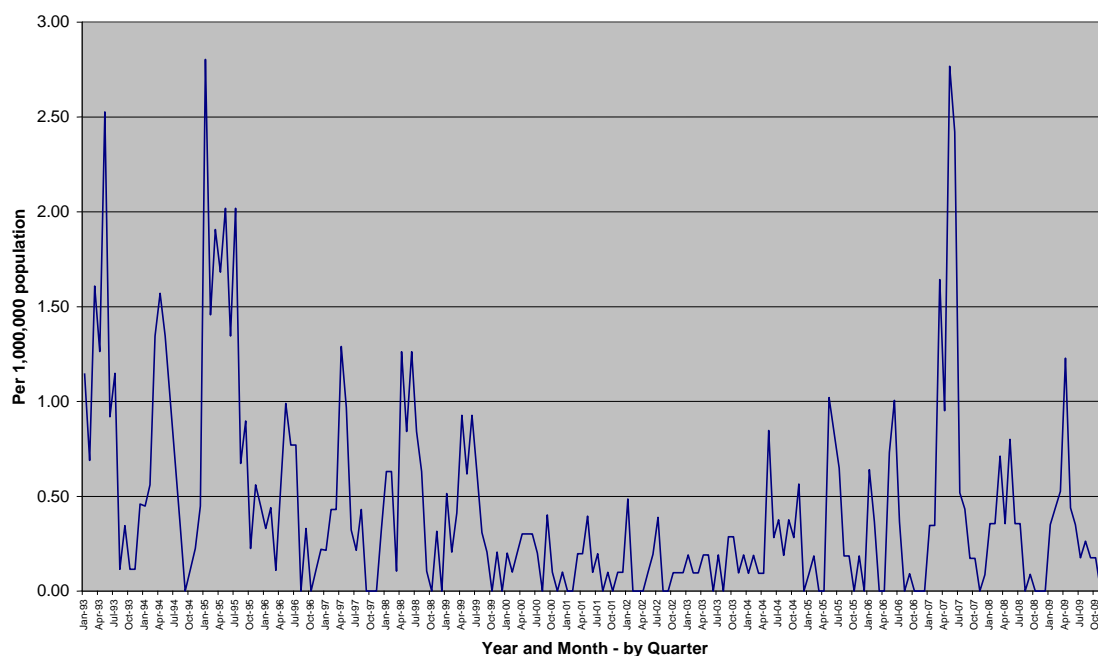


Figure 20 Malaria Incidence: National Capital Region, 1993-2009

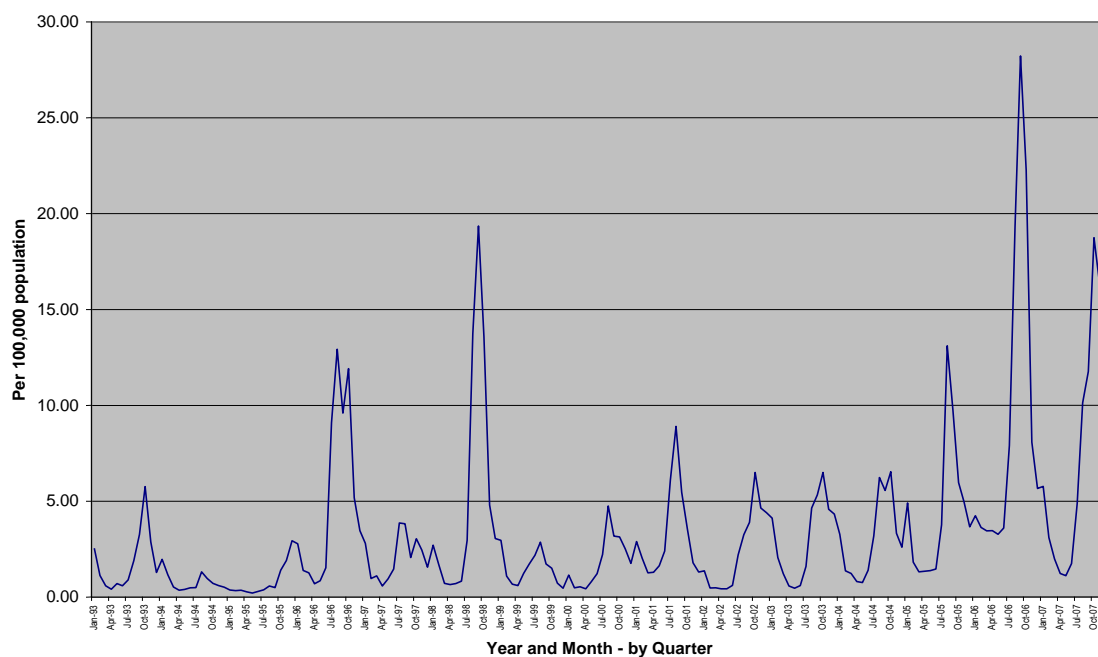


Figure 21 Dengue Incidence: National Capital Region, 1993-2007

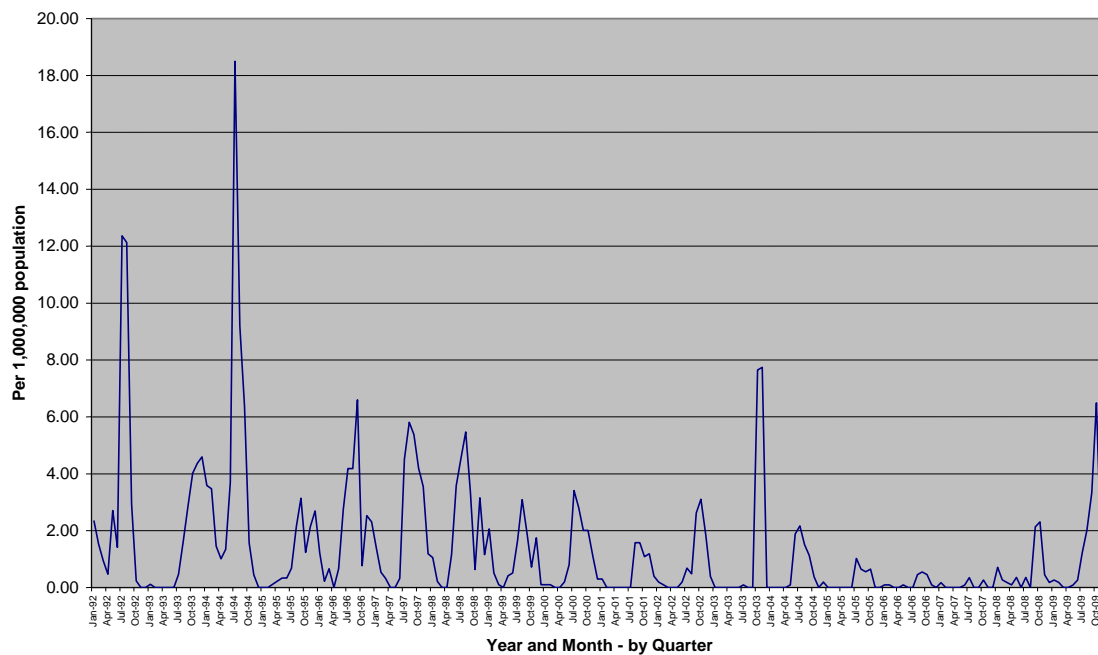


Figure 22 Cholera Incidence: National Capital Region, 1992-2009

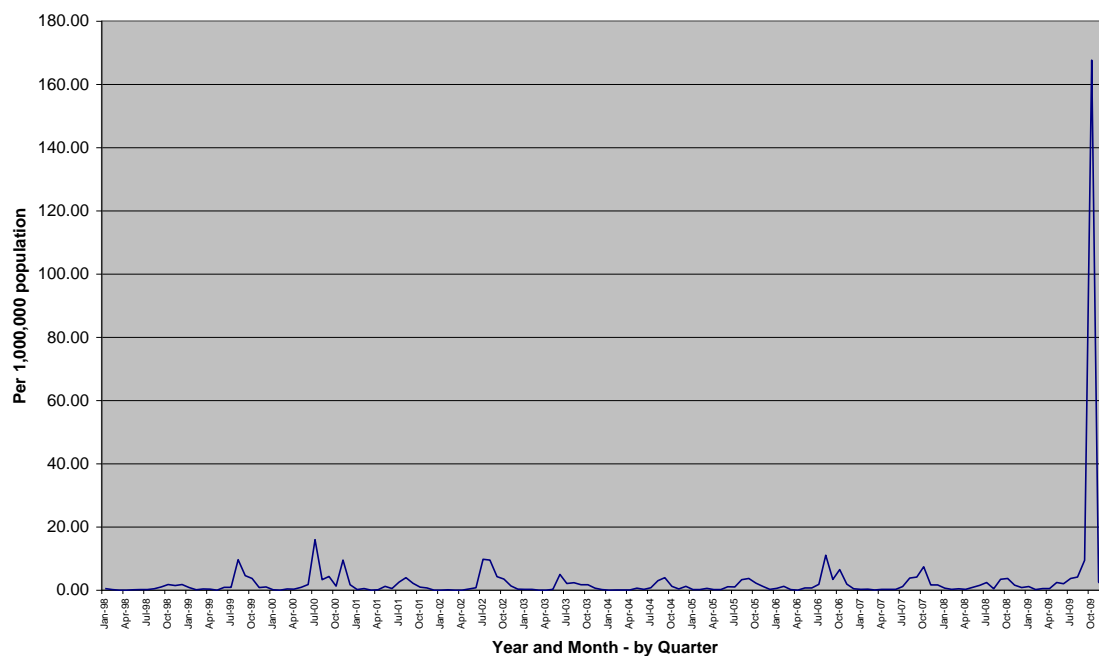


Figure 23 Leptospirosis Incidence: National Capital Region, 1996-2009

Figure 24 is a line graph describing a time series analysis of rainfall, temperature and relative humidity along with the incidence of dengue. Based from the data obtained from the National Epidemiology Center of the DOH, the rise in the incidence of dengue cases is

generally from April to October and this observation apparently coincides with increases in maximum and minimum temperature as well as relative humidity and seasonal increases in rainfall.

There are six observable instances of concordance between the peaks of dengue incidence and the abovementioned climate factors or weather elements in Metro Manila from 1993 to 2007: (refer to Book II, Appendix G)

- i. July 1996 - Feb 1997
- ii. July 1998 - Feb 1999
- iii. July 2001 - Oct 2001
- iv. Aug 2005 - Dec 2005
- v. July 2006 - Feb 2007
- vi. July 2007 - past Dec 2007

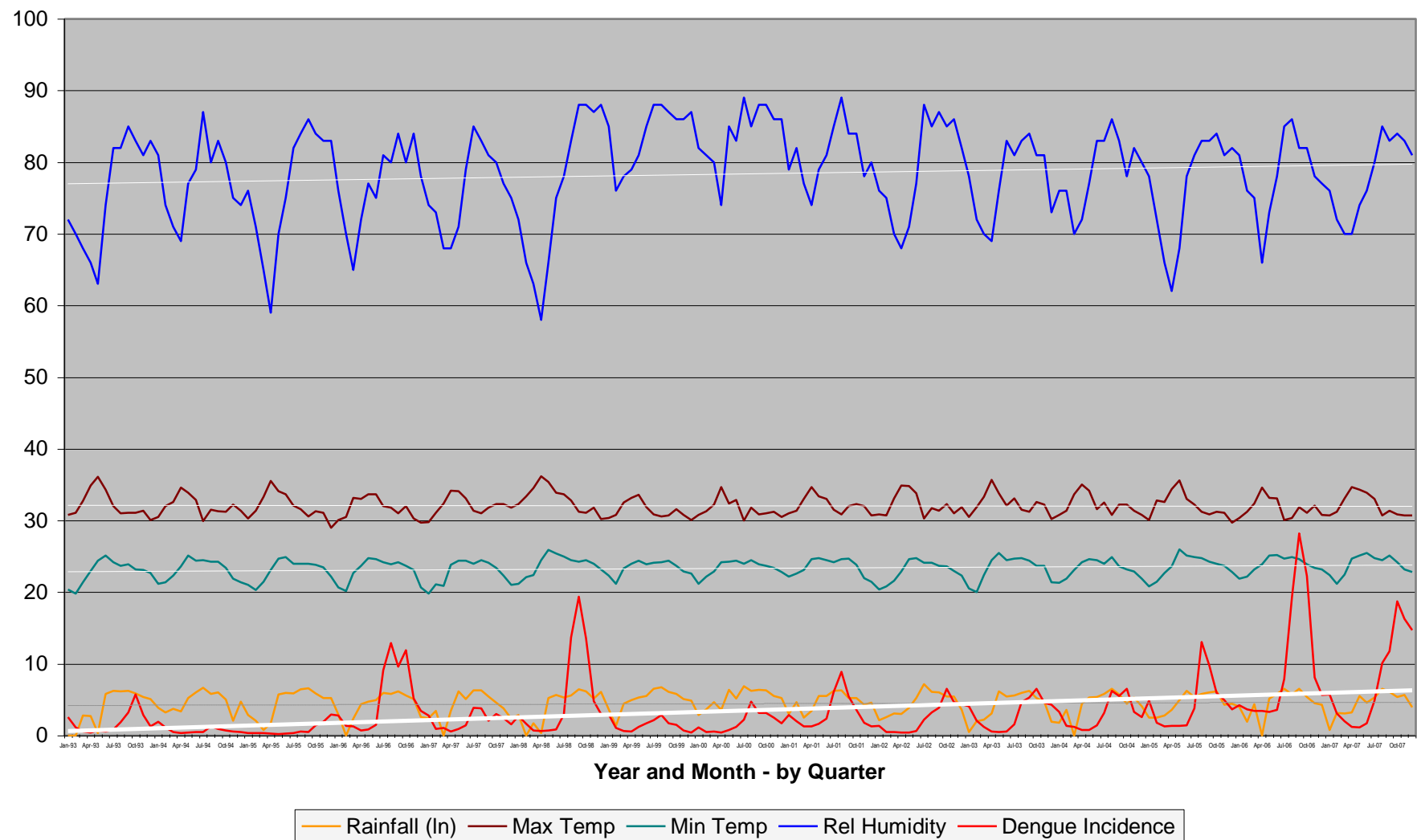


Figure 24 Weather Elements and Dengue Incidence: National Capital Region, 1993-2007

Trend lines (in white) were observed for dengue incidence and for relative humidity. With a documented El Niño phenomenon in 1998 that manifested as an increase in both maximum and minimum temperature (for the months of March to May), a spike in the incidence of dengue was observed a few months later. Similar spikes were observed in 2006 and 2007 in dengue incidence but this may be partially explained by a facilitated degree of reporting with the implementation of the Philippine Integrated Disease Surveillance and Response (PIDSr) system.

Regarding the ARIMA model results, the table below summarizes the data for each model:

Table 6 ARIMA Model Parameters to Predict the Number of Dengue Cases, 1995-2007

				Estimate	SE	t	Sig.
NCR Model	NCR Monthly Cases	Constant		5521.730	2790.687	1.979	.050
		AR, Seasonal	Lag 1	.249	.099	2.526	.013
	Rainfall (Natural Log)	Delay		1			
		Numerator	Lag 0	-41.013	43.665	-.939	.349
		Numerator, Seasonal	Lag 1	-.229	1.085	-.211	.833
	Max Temp	Delay		1			
		Numerator	Lag 0	-114.429	54.775	-2.089	.039
		Numerator, Seasonal	Lag 1	-2.136	1.157	-1.846	.067
	Min Temp	Delay		1			
		Numerator	Lag 0	233.158	58.408	3.992	.000
		Numerator, Seasonal	Lag 1	-.655	.301	-2.178	.031
	Relative Humidity	Delay		1			
		Numerator	Lag 0	2.268	12.732	.178	.859
		Numerator, Seasonal	Lag 1	14.349	80.650	.178	.859
Caloocan Model	Caloocan Monthly Cases	Constant		557.982	319.106	1.749	.083
		AR, Seasonal	Lag 1	.044	.094	.462	.645
	Rainfall (Natural Log)	Delay		1			
		Numerator	Lag 0	-4.918	5.635	-.873	.384
		Numerator, Seasonal	Lag 1	.529	1.369	.386	.700
	Max Temp	Delay		1			
		Numerator	Lag 0	-13.360	6.966	-1.918	.057
		Numerator, Seasonal	Lag 1	-1.762	1.188	-1.483	.140
	Min Temp	Delay		1			
		Numerator	Lag 0	26.563	7.431	3.575	.000
		Numerator, Seasonal	Lag 1	-.543	.356	-1.528	.129
	Relative Humidity	Delay		1			

				Estimate	SE	t	Sig.
		Numerator	Lag 0	.273	1.627	.168	.867
		Numerator, Seasonal	Lag 1	13.597	79.927	.170	.865
Las Pinas Model	Las Pinas Monthly Cases	Constant		97.951	67.585	1.449	.150
		AR, Seasonal	Lag 1	-.018	.091	-.198	.844
	Rainfall (Natural Log)	Delay		1			
		Numerator	Lag 0	.753	1.249	.603	.548
		Numerator, Seasonal	Lag 1	-2.152	3.949	-.545	.587
	Max Temp	Delay		1			
		Numerator	Lag 0	-.768	1.538	-.499	.618
		Numerator, Seasonal	Lag 1	-3.554	8.097	-.439	.661
	Min Temp	Delay		1			
		Numerator	Lag 0	.888	1.651	.538	.591
		Numerator, Seasonal	Lag 1	-.042	1.964	-.021	.983
	Relative Humidity	Delay		1			
		Numerator	Lag 0	.273	.360	.758	.450
		Numerator, Seasonal	Lag 1	1.375	1.915	.718	.474
Makati Model	Makati Monthly Cases	Constant		211.865	102.831	2.060	.041
		AR, Seasonal	Lag 1	.149	.100	1.487	.139
	Rainfall (Natural Log)	Delay		1			
		Numerator	Lag 0	-2.671	1.737	-1.538	.126
		Numerator, Seasonal	Lag 1	-.630	.739	-.852	.396
	Max Temp	Delay		1			
		Numerator	Lag 0	-5.996	2.095	-2.862	.005
		Numerator, Seasonal	Lag 1	-1.432	.673	-2.127	.035
	Min Temp	Delay		1			
		Numerator	Lag 0	9.033	2.276	3.969	.000
		Numerator, Seasonal	Lag 1	-.736	.336	-2.192	.030
	Relative Humidity	Delay		1			
		Numerator	Lag 0	.049	.497	.098	.922
		Numerator, Seasonal	Lag 1	21.804	221.396	.098	.922
Malabon Model	Malabon Monthly Cases	Constant		72.319	115.916	.624	.534
		AR, Seasonal	Lag 1	.348	.096	3.611	.000
	Rainfall (Natural Log)	Delay		1			
		Numerator	Lag 0	-1.093	1.645	-.665	.508
		Numerator, Seasonal	Lag 1	-.520	1.548	-.336	.738
	Max Temp	Delay		1			
		Numerator	Lag 0	.512	2.193	.233	.816
		Numerator, Seasonal	Lag 1	16.597	71.820	.231	.818
	Min Temp	Delay		1			

				Estimate	SE	t	Sig.
		Numerator	Lag 0	5.372	2.294	2.342	.021
		Numerator, Seasonal	Lag 1	-.911	.529	-1.721	.087
	Relative Humidity	Delay		1			
		Numerator	Lag 0	.697	.493	1.413	.160
		Numerator, Seasonal	Lag 1	1.534	1.354	1.133	.259
Mandaluyong Model	Mandaluyong Monthly Cases	Constant		112.230	104.103	1.078	.283
		AR, Seasonal	Lag 1	.766	.089	8.591	.000
	Rainfall (Natural Log)	Delay		1			
		Numerator	Lag 0	.026	1.226	.021	.983
		Numerator, Seasonal	Lag 1	28.961	1376.071	.021	.983
	Max Temp	Delay		1			
		Numerator	Lag 0	-1.595	1.697	-.939	.349
		Numerator, Seasonal	Lag 1	-4.058	3.935	-1.031	.304
	Min Temp	Delay		1			
		Numerator	Lag 0	5.413	1.818	2.977	.003
		Numerator, Seasonal	Lag 1	-.792	.317	-2.498	.014
	Relative Humidity	Delay		1			
		Numerator	Lag 0	-.032	.369	-.086	.932
		Numerator, Seasonal	Lag 1	-24.192	277.134	-.087	.931
Manila Model	Manila Monthly Cases	Constant		57.844	660.301	.088	.930
		AR, Seasonal	Lag 1	.315	.099	3.192	.002
	Rainfall (Natural Log)	Delay		1			
		Numerator	Lag 0	-.012	9.710	-.001	.999
		Numerator, Seasonal	Lag 1	-2.005	1651.096	-.001	.999
	Max Temp	Delay		1			
		Numerator	Lag 0	-7.976	12.568	-.635	.527
		Numerator, Seasonal	Lag 1	-2.671	4.397	-.607	.545
	Min Temp	Delay		1			
		Numerator	Lag 0	27.890	13.337	2.091	.038
		Numerator, Seasonal	Lag 1	-.399	.491	-.813	.418
	Relative Humidity	Delay		1			
		Numerator	Lag 0	2.367	2.865	.826	.410
		Numerator, Seasonal	Lag 1	.630	1.465	.430	.668
Marikina Model	Marikina Monthly Cases	Constant		112.996	78.724	1.435	.154
		AR, Seasonal	Lag 1	.402	.098	4.105	.000
	Rainfall (Natural Log)	Delay		1			
		Numerator	Lag 0	-.975	1.126	-.865	.388
		Numerator, Seasonal	Lag 1	-.364	1.151	-.317	.752
	Max Temp	Delay		1			

				Estimate	SE	t	Sig.
		Numerator	Lag 0	-.575	1.419	-.406	.686
		Numerator, Seasonal	Lag 1	-12.532	30.660	-.409	.683
	Min Temp	Delay		1			
		Numerator	Lag 0	4.004	1.532	2.614	.010
		Numerator, Seasonal	Lag 1	-1.334	.587	-2.272	.025
	Relative Humidity	Delay		1			
		Numerator	Lag 0	.205	.330	.620	.536
		Numerator, Seasonal	Lag 1	5.152	8.665	.595	.553
Muntinlupa Model	Muntinlupa Monthly Cases	Constant		91.160	58.595	1.556	.122
		AR, Seasonal	Lag 1	.481	.100	4.788	.000
	Rainfall (Natural Log)	Delay		1			
		Numerator	Lag 0	.540	.812	.665	.507
		Numerator, Seasonal	Lag 1	-.257	1.487	-.173	.863
	Max Temp	Delay		1			
		Numerator	Lag 0	-1.555	1.035	-1.502	.135
		Numerator, Seasonal	Lag 1	-2.170	1.478	-1.468	.145
	Min Temp	Delay		1			
		Numerator	Lag 0	1.988	1.113	1.787	.076
		Numerator, Seasonal	Lag 1	-1.224	.783	-1.563	.120
	Relative Humidity	Delay		1			
		Numerator	Lag 0	.018	.239	.076	.939
		Numerator, Seasonal	Lag 1	22.732	300.558	.076	.940
Navotas Model	Navotas Monthly Cases	Constant		167.517	84.080	1.992	.048
		AR, Seasonal	Lag 1	.017	.095	.175	.861
	Rainfall (Natural Log)	Delay		1			
		Numerator	Lag 0	-2.533	1.483	-1.708	.090
		Numerator, Seasonal	Lag 1	.033	.609	.055	.956
	Max Temp	Delay		1			
		Numerator	Lag 0	-5.583	1.890	-2.954	.004
		Numerator, Seasonal	Lag 1	-.807	.492	-1.641	.103
	Min Temp	Delay		1			
		Numerator	Lag 0	8.639	1.992	4.337	.000
		Numerator, Seasonal	Lag 1	-.212	.252	-.841	.402
	Relative Humidity	Delay		1			
		Numerator	Lag 0	.039	.437	.089	.929
		Numerator, Seasonal	Lag 1	21.625	240.120	.090	.928
Paranaque Model	Paranaque Monthly Cases	Constant		196.792	160.804	1.224	.223
		AR, Seasonal	Lag 1	.228	.122	1.868	.064
	Rainfall (Natural Log)	Delay		1			

				Estimate	SE	t	Sig.
		Numerator	Lag 0	-.047	2.573	-.018	.986
		Numerator, Seasonal	Lag 1	10.149	575.565	.018	.986
	Max Temp	Delay		1			
		Numerator	Lag 0	-4.479	3.175	-1.411	.161
		Numerator, Seasonal	Lag 1	-1.793	1.525	-1.176	.242
	Min Temp	Delay		1			
		Numerator	Lag 0	8.493	3.403	2.496	.014
		Numerator, Seasonal	Lag 1	-.359	.435	-.825	.411
	Relative Humidity	Delay		1			
		Numerator	Lag 0	.361	.743	.486	.628
		Numerator, Seasonal	Lag 1	2.678	5.794	.462	.645
Pasay Model	Pasay Monthly Cases	Constant		199.333	162.328	1.228	.222
		AR, Seasonal	Lag 1	.466	.145	3.209	.002
	Rainfall (Natural Log)	Delay		1			
		Numerator	Lag 0	-2.152	2.286	-.942	.348
		Numerator, Seasonal	Lag 1	-.284	1.051	-.270	.787
	Max Temp	Delay		1			
		Numerator	Lag 0	-4.974	2.890	-1.721	.088
		Numerator, Seasonal	Lag 1	-1.556	1.004	-1.551	.123
	Min Temp	Delay		1			
		Numerator	Lag 0	8.046	3.125	2.575	.011
		Numerator, Seasonal	Lag 1	-.617	.410	-1.504	.135
	Relative Humidity	Delay		1			
		Numerator	Lag 0	.287	.672	.427	.670
		Numerator, Seasonal	Lag 1	4.053	10.155	.399	.690
Pasig Model	Pasig Monthly Cases	Constant		-58.021	224.831	-.258	.797
		AR, Seasonal	Lag 1	.262	.130	2.009	.047
	Rainfall (Natural Log)	Delay		1			
		Numerator	Lag 0	.000	3.559	.000	1.000
		Numerator, Seasonal	Lag 1	1.860	179421.425	.000	1.000
	Max Temp	Delay		1			
		Numerator	Lag 0	-3.341	4.397	-.760	.449
		Numerator, Seasonal	Lag 1	-.670	1.662	-.403	.687
	Min Temp	Delay		1			
		Numerator	Lag 0	8.657	4.707	1.839	.068
		Numerator, Seasonal	Lag 1	.011	.550	.019	.985
	Relative Humidity	Delay		1			
		Numerator	Lag 0	.531	1.022	.520	.604
		Numerator, Seasonal	Lag 1	-.462	2.133	-.216	.829

				Estimate	SE	t	Sig.
Pateros Model	Pateros Monthly Cases	Constant		27.775	29.120	.954	.342
		AR, Seasonal	Lag 1	-.022	.102	-.214	.831
	Rainfall (Natural Log)	Delay		1			
		Numerator	Lag 0	-.491	.516	-.951	.343
		Numerator, Seasonal	Lag 1	.062	1.123	.055	.956
	Max Temp	Delay		1			
		Numerator	Lag 0	-.497	.632	-.787	.433
		Numerator, Seasonal	Lag 1	-3.033	4.495	-.675	.501
	Min Temp	Delay		1			
		Numerator	Lag 0	1.562	.669	2.334	.021
		Numerator, Seasonal	Lag 1	-.328	.509	-.644	.520
	Relative Humidity	Delay		1			
		Numerator	Lag 0	.118	.148	.796	.427
		Numerator, Seasonal	Lag 1	1.686	2.188	.770	.443
Quezon City Model	Quezon City Monthly Cases	Constant		612.032	689.940	.887	.377
		AR, Seasonal	Lag 1	.515	.084	6.127	.000
	Rainfall (Natural Log)	Delay		1			
		Numerator	Lag 0	-11.154	9.310	-1.198	.233
		Numerator, Seasonal	Lag 1	-.416	.816	-.510	.611
	Max Temp	Delay		1			
		Numerator	Lag 0	-18.568	12.097	-1.535	.127
		Numerator, Seasonal	Lag 1	-2.539	1.622	-1.566	.120
	Min Temp	Delay		1			
		Numerator	Lag 0	48.993	13.095	3.741	.000
		Numerator, Seasonal	Lag 1	-.826	.293	-2.813	.006
	Relative Humidity	Delay		1			
		Numerator	Lag 0	.287	2.769	.104	.918
		Numerator, Seasonal	Lag 1	20.117	196.346	.102	.919
San Juan Model	San Juan Monthly Cases	Constant		-6.380	50.035	-.128	.899
		AR, Seasonal	Lag 1	.618	.088	7.034	.000
	Rainfall (Natural Log)	Delay		1			
		Numerator	Lag 0	.000	.648	-.001	.999
		Numerator, Seasonal	Lag 1	-2.671	3590.017	-.001	.999
	Max Temp	Delay		1			
		Numerator	Lag 0	-.344	.855	-.402	.688
		Numerator, Seasonal	Lag 1	-1.045	3.028	-.345	.731
	Min Temp	Delay		1			
		Numerator	Lag 0	1.328	.921	1.441	.152
		Numerator, Seasonal	Lag 1	-.238	.641	-.372	.711

				Estimate	SE	t	Sig.
	Relative Humidity	Delay		1			
		Numerator	Lag 0	-.032	.193	-.168	.867
		Numerator, Seasonal	Lag 1	-.450	5.827	-.077	.939
Taguig Model	Taguig Monthly Cases	Constant		291.684	158.119	1.845	.067
		AR, Seasonal	Lag 1	.133	.113	1.174	.242
		Delay		1			
	Rainfall (Natural Log)	Numerator	Lag 0	-1.252	2.683	-.467	.642
		Numerator, Seasonal	Lag 1	-1.315	3.355	-.392	.696
		Delay		1			
	Max Temp	Numerator	Lag 0	-4.157	3.321	-1.252	.213
		Numerator, Seasonal	Lag 1	-3.487	3.075	-1.134	.259
		Delay		1			
	Min Temp	Numerator	Lag 0	10.481	3.526	2.972	.004
		Numerator, Seasonal	Lag 1	-.778	.461	-1.685	.094
		Delay		1			
	Relative Humidity	Numerator	Lag 0	.491	.771	.637	.525
		Numerator, Seasonal	Lag 1	3.469	5.451	.636	.526
		Delay		1			
Valenzuela Model	Valenzuela Monthly Cases	Constant		270.178	179.792	1.503	.135
		AR, Seasonal	Lag 1	-.034	.091	-.371	.711
		Delay		1			
	Rainfall (Natural Log)	Numerator	Lag 0	-3.536	3.342	-1.058	.292
		Numerator, Seasonal	Lag 1	.018	.981	.018	.986
		Delay		1			
	Max Temp	Numerator	Lag 0	-9.664	4.116	-2.348	.020
		Numerator, Seasonal	Lag 1	-1.176	.778	-1.511	.133
		Delay		1			
	Min Temp	Numerator	Lag 0	18.508	4.411	4.195	.000
		Numerator, Seasonal	Lag 1	-.312	.281	-1.112	.268
		Delay		1			
	Relative Humidity	Numerator	Lag 0	-.560	.966	-.580	.563
		Numerator, Seasonal	Lag 1	-1.715	3.810	-.450	.653
		Delay		1			

Table 7 Summary of p-values for Predicting the Number of Dengue Cases using Climate Factors

Model	Autoregression (One Month Lag)	Rainfall (Natural Log)		Maximum Temperature		Minimum Temperature		Relative Humidity	
		Current Month	One Month Lag	Current Month	One Month Lag	Current Month	One Month Lag	Current Month	One Month Lag
NCR Model	0.013	0.349	0.833	0.039	0.067	0.000	0.031	0.859	0.859
Caloocan	0.645	0.384	0.700	0.057	0.140	0.000	0.129	0.867	0.865
Las Pinas	0.844	0.548	0.587	0.618	0.661	0.591	0.983	0.450	0.474
Makati	0.139	0.126	0.396	0.005	0.035	0.000	0.030	0.922	0.922
Malabon	0.000	0.508	0.738	0.816	0.818	0.021	0.087	0.160	0.259
Mandaluyong	0.000	0.983	0.983	0.349	0.304	0.003	0.014	0.932	0.931
Manila	0.002	0.999	0.999	0.527	0.545	0.038	0.418	0.410	0.668
Marikina	0.000	0.388	0.752	0.686	0.683	0.010	0.025	0.536	0.553
Muntinlupa	0.000	0.507	0.863	0.135	0.145	0.076	0.120	0.939	0.940
Navotas	0.861	0.090	0.956	0.004	0.103	0.000	0.402	0.929	0.928
Paranaque	0.064	0.986	0.986	0.161	0.242	0.014	0.411	0.628	0.645
Pasay	0.002	0.348	0.484	0.088	0.123	0.011	0.135	0.670	0.690
Pasig	0.047	1.000	1.000	0.449	0.687	0.068	0.985	0.604	0.829
Pateros	0.831	0.343	0.956	0.433	0.501	0.021	0.520	0.427	0.443
Quezon City	0.000	0.233	0.611	0.127	0.120	0.000	0.006	0.918	0.919
San Juan	0.000	0.999	0.999	0.688	0.731	0.152	0.711	0.867	0.939
Taguig	0.242	0.642	0.696	0.213	0.259	0.004	0.094	0.525	0.526
Valenzuela	0.711	0.292	0.986	0.020	0.133	0.000	0.268	0.563	0.653

The above results in Table 7 provide consistent results that the observed minimum temperatures for the current month provide the most significant positive contributions to the model to predict the number of dengue cases for any month of observation. The significant contribution of observed minimum temperature is seen in most of the cities in NCR and is summarized in the following table:

Table 8 Number of cases predicted by minimum temperature

Model	Predicted Number of Dengue Cases per each 1°C increase in recorded minimum temperature
NCR	233
Caloocan	27
Makati	9
Malabon	5
Mandaluyong	5
Manila	28
Marikina	4
Navotas	9
Paranaque	9
Pasay	8
Pateros	2
Quezon City	49
Taguig	10
Valenzuela	19

In Book 2, Appendix G is a series of line graphs that present the actual and model-fitted data for NCR and each of the cities in NCR.

Discussion

Outbreaks of dengue are apparently cyclical in nature and are known to depend on epidemiological as well as immunological factors that influence the dynamics of disease. However, although both herd immunity and the predominance of specific dengue virus serotypes in the areas are ideal data to be used for analysis in forecasting, the lack of local seroprevalence surveys undermine attempts to assess the effects of these determinants on dengue incidence. Based on monthly data of the number of dengue cases that was provided by the Department of Health – National Epidemiology Center, the ARIMA analyses was nonetheless limited to the years 1995-2007 after reviewing the datasets for completeness. Moreover, data for weather elements obtained from PAGASA was assumed to fairly apply to all cities in NCR.

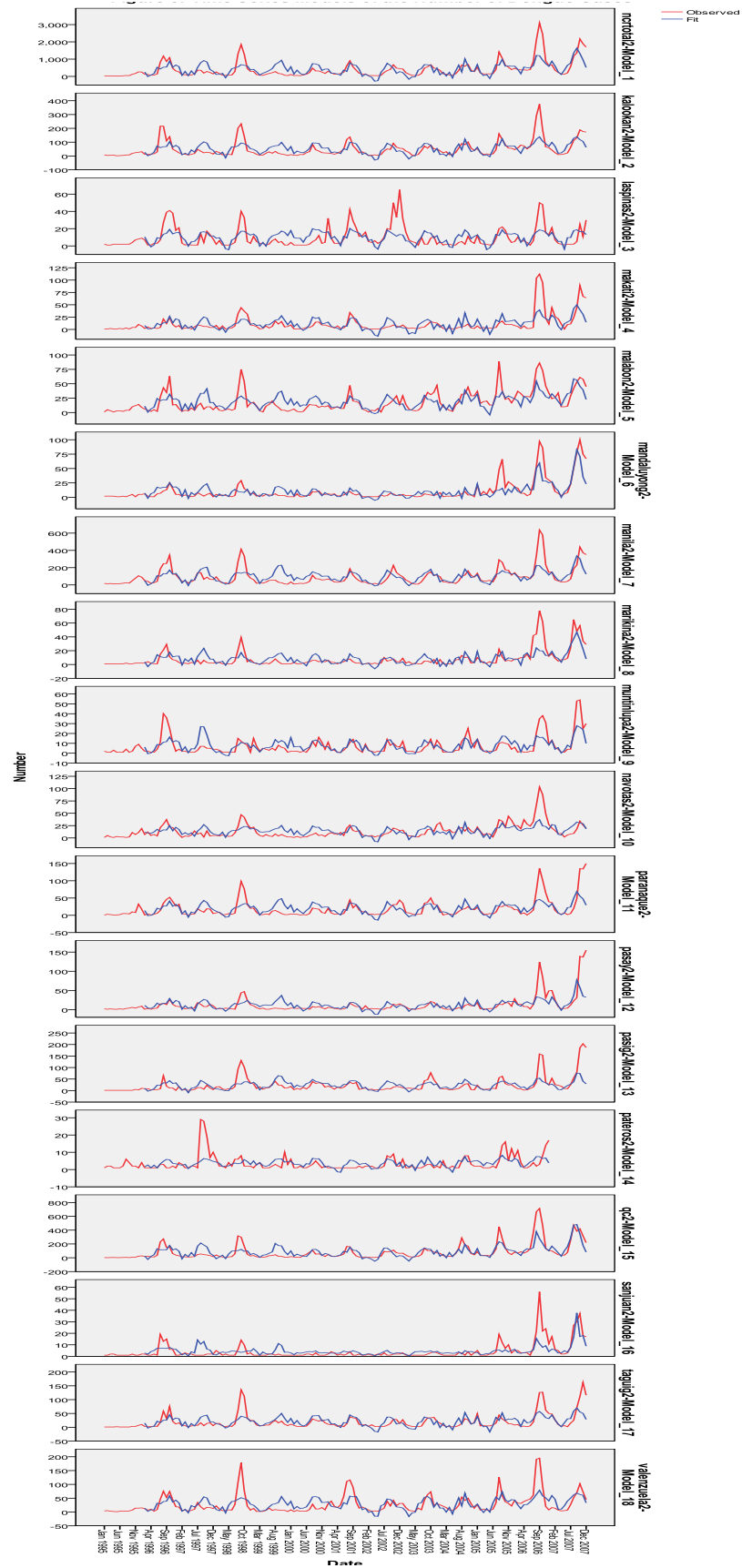


Figure 25 Time Series Models of the Numbers of Dengue Cases

Based on the results of the predictive models for the number of dengue cases, it is apparent that recorded minimum temperature from PAGASA can be used to estimate the number of dengue cases for NCR and for selected cities. However, **it should be mentioned that these models depended heavily on assumptions of the adequacy of the level of reporting of cases as well as the actual intensity of dengue virus transmission in these areas.** Thus, the robustness of the models could relatively be more appreciated in areas where intense dengue virus transmission was documented through reliable reporting each month during the time period covered in the study. This would be helpful in interpreting the results of Figure 25 (Time Series Models of the Number of Dengue Cases) in determining which Local Government Unit would have a relatively better fit of the model based on the adequate disease reporting in areas known to often experience dengue outbreaks.

Nevertheless, comparing the autoregression (i.e. ARIMA) analysis results with the patterns of dengue incidence and climate factors in Figure 24 (Weather Elements and Dengue Incidence: National Capital Region, 1993-2007), it is important to note that peaks of minimum temperature, observed usually from April to June, seem to be followed by a dramatic increase in dengue incidence within a month's time. **A peak of dengue incidence occurs thereafter in about a month after the start of the increase of cases. This coincides with the years when a surge of cases was experienced in NCR (as was mentioned previously: 1996, 1998, 2001, 2005 and 2006). (This is evident as crests of maximum temperature seem to frequently transpire a little earlier compared to the peaks of minimum temperature. This would be consistent with the lack of significance in estimates for dengue cases based on maximum temperature.)**

Regarding the generalizability of the results of the models developed, though the data analysis had solely used data from cities of NCR, it would be **potentially useful to also apply the results to other LGUs elsewhere (i.e. other urban areas) where communities have experienced outbreaks of dengue in the past.** It is therefore critical that local health officials should work closely with national health authorities to coordinate efforts in mitigating the effects of a rise in temperature (i.e. recorded minimum temperature) on a possible increase in dengue cases and/or the occurrence of dengue outbreaks particularly during periods when an occurrence of an El Niño/La Niña –Southern Oscillation (ENSO) condition in the Pacific Ocean is announced and experienced.

2. Estimating the future potential health impacts attributable to climate change

Once the current burden of disease is described, models of climate change or qualitative expert judgments on plausible changes in temperature and precipitation over a particular time period can be used to estimate future impacts. Health models can be complex spatial models or can be based on a simple relationship between exposure and response. Models of climate change should include projections of how other relevant factors could change in the future, such as population growth, income, water and sanitation coverage, and other relevant factors. Projections from models developed for other sectors can be incorporated, such as projections for flood risk, changes in food supply and land use changes.

The exercise of attributing a portion of a disease burden to climate change is in its early infancy. Analysis should consider both the limits of epidemiologic evidence and the ability of the model to incorporate the non-climatic factors that also determine a health outcome. For example, the portion of deaths due to natural climatic disasters that can be attributed to climate change will reflect the degree to which the events can be related to climate change. For vector-borne diseases, other factors, such as population growth and land use, may be more important drivers of disease incidence than climate change.

There are three possible approaches such as: (1) comparative risk assessment; (2) disease-specific models; and (3) qualitative assessment.

a. Comparative risk assessment

Comparative risk assessment was used as part of the WHO Global Burden of Disease project to estimate how much disease climate change could cause globally. The project used standardized methods to quantify disease burdens attributable to 26 environmental, occupational, behavioral, and lifestyle risk factors in 2000 and at selected future times up to 2030. The disease burden is the total amount of disease or premature death within the population. Comparing fractions of the disease burden attributable to several different risk factors requires (1) knowledge of the severity/disability and duration of the health deficit and (2) the use of standard units of health deficit. For this purpose, the project used the disability-adjusted life year (DALY), which is the sum of Years of life lost due to premature death (YLL), and Years of life lived with disability (YLD). YLL takes into account the age at death; YLD

takes into account disease duration, age at onset, and a disability weight reflecting the severity of disease.

Comparing the *attributable* burdens for specific risk factors required knowledge of (1) the baseline burden of disease, absent the particular risk factor; (2) the estimated increase in risk of disease/death per unit increase in risk factor exposure (the “relative risk”); and (3) the current or estimated future population distribution of exposure. The *avoidable* burden was estimated by comparing projected burdens under alternative exposure scenarios.

The global assessment used WHO estimates of the baseline burden of climate-sensitive diseases (diseases included were cardiovascular deaths associated with thermal extremes, diarrhea episodes, cases of malaria, malnutrition and deaths in natural disasters). Existing and new models were used to quantify the effect of climate variations on each of these outcomes (the relative risk), taking into account adaptation to changing conditions and potentially protective effects of socio-economic development. The HADCM2 climate model produced by the Hadley Centre (United Kingdom) gave the population distribution of exposure; this model describes future climate under various scenarios of greenhouse gas emissions. Climate change was expressed as the change in climatic conditions relative to those observed in the reference period 1961–1990.

Disease burdens were estimated for five geographical regions and for developed countries. The attributable disease burden was estimated for 2000. The climate-related relative risks of each health outcome under each climate change scenario, relative to the situation if climate change does not occur, were estimated for 2010, 2020 and 2030. The results give a first indication of the potential magnitude and distribution of some of the health effects of climate change.

Taking a comparative risk assessment approach requires data on the burden of climate-sensitive diseases, exposure–response relationships for these diseases across a range of ambient temperatures (and other weather variables) and the ability to link these with population, climate and socio-economic scenarios. Therefore, this approach may be difficult to apply where data or expertise in these methods are limited.

b. Disease-specific models

Predictive models of the health impacts of climate change use different approaches to classify the risk of climate-sensitive diseases. For malaria, results from predictive models are commonly presented as maps of potential shifts in distribution attributed to climate change. The models are typically based on climatic constraints on the development of the vector and parasite; maps generated identify potential geographic areas of risk, but do not provide information on the number of people who may be at risk within these areas. Few predictive models incorporate adequate assumptions about other determinants of the range and incidence of disease, such as land-use change or prevalence of drug resistance for malaria, or about adaptive capacity.

i. MARA/ARMA

Malaria is a disease caused by four different strains of *Plasmodium* carried by a variety of *Anopheles* mosquitoes. The most serious form of malaria is caused by *Plasmodium falciparum*. Approximately 48% of the world population remains exposed to the risk of malaria.

A country-level model was developed to show how the range of stable falciparum malaria in Zimbabwe could change under different climate change scenarios. Zimbabwe was chosen because it has areas where the climate is suitable for endemic malaria transmission, areas where transmission is absent and areas where the climate is occasionally suitable, resulting in epidemics. The model was based on MARA/ARMA (Mapping Malaria Risk in Africa/Atlas du Risque de la Malaria en Afrique), which mapped and modeled the current distribution of malaria in sub-Saharan Africa.

MARA/ARMA uses three variables to determine climatic suitability for a particular geographic location: mean monthly temperature, winter minimum temperature and total cumulative monthly precipitation. The MARA/ARMA decision rules were developed using fuzzy logic to resolve the uncertainty in defining distinct boundaries to divide malarious from non-malarious regions. Temperature is a major factor determining the distribution and incidence of malaria. Temperature affects both the *Plasmodium* parasite and the *Anopheles* mosquito, with thresholds at both temperature extremes limiting the survival or development of the two organisms. *Anopheles* must live long enough to bite an infected person, allow the parasite to develop and then bite

a susceptible human. The lower temperature threshold of 18° C is based on the time required for parasite development and length of mosquito survivorship at that temperature; below 18°C few parasites can complete development within the lifetime of the mosquito. The mosquito survivorship rate peaks at 31°C. At this point, less than 40% of the mosquitoes survive long enough for the parasite to complete its development cycle. As temperatures rise above 32°C, the mosquito's probability of survival decreases. **Higher temperatures, however, enable the mosquitoes to digest blood meals more rapidly, which in turn increases the rate at which they bite. This increased biting rate coupled with faster development of the parasite leads to increased infective bites for those mosquitoes that do survive.** The upper temperature threshold for both mosquitoes and larvae to survive is 40°C.

The COSMIC programme was used to generate Zimbabwe-specific scenarios of climate change that were then used as inputs to MARA/ARMA to generate maps of future transmission potential. The same approach can be applied in other countries covered by MARA/ARMA as long as a geographic information system is available. Data from MARA/ARMA are readily available and the COSMIC program is free. A major limitation of the model is that it includes only climate and not other drivers of malaria transmission, including land-use change and drug resistant parasites. The output is maps of future transmission potential, not projected numbers of cases.

ii. MIASMA

MIASMA (Modeling Framework for the Health Impact Assessment of Man-Induced Atmospheric Changes) includes modules for (1) vector-borne diseases, including malaria, dengue fever and schistosomiasis; (2) thermal heat mortality; and (3) ultraviolet (UV)-related skin cancer due to stratospheric ozone depletion. The models are driven by population and climate/atmospheric scenarios, applied across baseline data on disease incidence and prevalence, climate conditions and the state of the stratospheric ozone layer. Outputs are:

(1) For vector-borne disease modules, cases and fatalities from malaria, and incident cases for dengue fever and schistosomiasis;

(2) for the thermal stress module, cardiovascular, respiratory and total mortality; and (3) for skin cancer module, malignant melanoma and non-melanoma skin cancer.

Climate input is module or disease specific. For the vector-borne diseases, maximum and minimum temperature and rainfall are required, as well as other baseline data determined by local experts. For example, for malaria it would help to know the level of partial immunity in the human population and the extent of drug resistant malaria in the region. For thermal stress, maximum and minimum temperatures are required. For skin cancer, the column entitled loss of the stratospheric ozone over the site is required to determine the level of UV-B radiation potentially reaching the ground.

iii. CIMSIM and DENSiM

These models are designed to determine the risk of dengue fever. CIMSIM is a dynamic life-table simulation entomological model that produces mean-value estimates of various parameters for all cohorts of a single species of *Aedes* mosquito within a representative area. Because microclimate is a key determinant of vector survival and development for all stages, CIMSIM contains an extensive database of daily weather information. DENSiM is focused on current control measures and requires field surveys to validate some of the data. DENSiM (Focks et al., 1995) is essentially the corresponding account of the dynamics of a human population driven by country- and age-specific birth and death rates. The entomological factors passed from CIMSIM are used to create the biting mosquito population. An infection model accounts for the development of the virus within individuals and its passage between the vector and human populations.

Inputs into DENSiM are a pupal/demographic survey to estimate the productivities of the various local water-holding containers, and daily weather values for maximum/minimum temperature, rainfall and saturation deficit. The parameters estimated by DENSiM include demographic, entomologic, serologic and infection information on a human age-class and/or time basis.

c. Qualitative assessment

Potential future health risks of climate change can be estimated from knowledge of the current burden of climate-sensitive diseases, the extent of control of those diseases and how temperature and precipitation can affect the range and intensity of disease. For example, is highland malaria a current problem? What is the extent of that problem? How well is the disease controlled during epidemics? How could the burden of disease be affected if temperature increased so that the vector moved up the highlands? Similarly, future risks can be estimated from relationships used in the WHO Global Burden of Disease project.

C. Outputs of the V&A Tools

1. Projected 2020 and 2050 Cases of Selected Diseases

In projecting the 2020 and 2050 cases of the climate change-related diseases, the PAGASA projection data for rainfall, maximum temperature and relative humidity were used in the models (Table 9).

Table 9 Projected Climate Change Data in 2020 and 2050

Month	Daily Rainfall		Monthly Rainfall		Daily Max. Temperature		Daily Relative Humidity	
	2020	2050	2020	2050	2020	2050	2020	2050
Jan	0.00	0.00	0.00	0.00	31.30	32.60	72.95	72.33
Feb	0.40	0.10	12.40	3.10	32.30	33.70	72.94	72.11
Mar	0.50	0.20	15.50	6.20	34.20	36.30	64.13	63.27
Apr	0.70	0.40	21.00	12.00	36.60	38.00	61.25	60.84
May	2.10	1.70	65.10	52.70	37.60	38.70	66.47	64.79
Jun	15.90	9.20	477.00	276.00	33.10	36.30	72.95	72.58
Jul	25.40	16.90	787.40	523.90	32.00	34.20	80.08	79.82
Aug	38.20	21.90	1146.00	657.00	30.30	32.80	73.05	72.77
Sept	27.60	13.60	855.60	421.60	31.50	33.10	72.73	72.39
Oct	2.30	18.80	69.00	564.00	33.10	32.60	79.64	78.81
Nov	0.70	6.90	21.70	213.90	32.70	32.90	66.13	65.56
Dec	6.30	7.00	195.30	217.00	30.40	31.40	88.44	87.64
Total	120.10	96.70	3666.00	2947.40	395.10	412.60	870.76	862.92

Average	10.00833	8.05833	305.5	245.617	32.925	34.38333	72.56308	71.9097
Data Source: PAGASA, 2010								

How many disease cases would there be in 2020 without any adaptation measures or interventions? The impact models for dengue and cholera in NCR could be used to predict the number of cases of these diseases. The predicted values or number of cases of dengue and cholera are presented in the following sections.

Dengue Cases Projection

Using the projected climate change data in 2020 by the PAGASA, plug into the impact model for dengue cases, the projected dengue cases in NCR by 2020 will have a total of 2,128 cases (Table 10).

Table 10 Dengue Cases Projection, 2020

Month	Cases	Rainfall (mm/mo)	Max. Temp (°C)	Relative Humidity %
JAN	357	0	31.3	72.9
FEB	327	12.4	32.3	72.9
MAR	8	15.5	34.2	64.1
APR	negative	21	36.6	61.2
MAY	negative	65.1	37.6	66.5
JUN	25	477	33.1	73.0
JUL	82	787.4	32	80.1
AUG	negative	1146	30.3	73.1
SEP	negative	855.6	31.5	72.7
OCT	486	69	33.1	79.6
NOV	99	21.7	32.7	66.1
DEC	743	195.3	30.4	88.4
Total	2128	3666		

In 2050, there will be 1,735 cases of dengue (Table 11). This is 18.4% lower than the 2020 projection. This difference is explained by the reduction in average monthly rainfall and increase in the average monthly maximum temperature as well as reduction in the average monthly relative humidity.

Table 11 Dengue Cases Projection, 2050

Month	Cases	Rainfall (mm)	Max. Temp (°C)	Relative Humidity
JAN	310	0	32.6	72.3
FEB	277	3.1	33.7	72.1
MAR	negative	6.2	36.3	63.3
APR	negative	12	38	60.8
MAY	negative	52.7	38.7	64.8
JUN	69	276	36.3	72.6
JUL	189	523.9	34.2	79.8
AUG	negative	657	32.8	72.8
SEP	41	421.6	33.1	72.4
OCT	166	564	32.6	78.8
NOV	negative	213.9	32.9	65.6
DEC	683	217	31.4	87.6
Total	1735	2947.4		

Cholera Cases Projection

It is projected that there will be 143 cases of cholera in 2020 (Table 12) using the impact model parameters.

Table 12 Cholera Cases Projection, 2020

Month	Cases	Rainfall (mm)	Max. Temp (°C)	Relative Humidity
JAN	5	0.00	31.30	72.95
FEB	3	12.40	32.30	72.94
MAR	negative	15.50	34.20	64.13
APR	negative	21.00	36.60	61.25
MAY	negative	65.10	37.60	66.47
JUN	14	477.00	33.10	72.95
JUL	29	787.40	32.00	80.08
AUG	36	1146.00	30.30	73.05
SEP	26	855.60	31.50	72.73
OCT	8	69.00	33.10	79.64
NOV	negative	21.70	32.70	66.13
DEC	22	195.30	30.40	88.44
Total	143	3666.00		

In 2050, there will be 99 cases of cholera (Table 13). This is a 31.06% reduction in number of cases from 2020 due to a 19.6% reduction in total rainfall, increase in maximum temperature and reduction in average relative humidity.

Table 13 Cholera Cases Projection, 2050

Month	Cases	Rainfall (mm)	Max. Temp (°C)	Relative Humidity
JAN	2	0.00	32.60	72.33
FEB	0	3.10	33.70	72.11
MAR	negative	6.20	36.30	63.27
APR	negative	12.00	38.00	60.84
MAY	negative	52.70	38.70	64.79
JUN	3	276.00	36.30	72.58
JUL	18	523.90	34.20	79.82
AUG	19	657.00	32.80	72.77
SEP	12	421.60	33.10	72.39
OCT	21	564.00	32.60	78.81
NOV	3	213.90	32.90	65.56
DEC	20	217.00	31.40	87.64
Total	99	2947.40		

Malaria Cases

Malaria is projected to have 258 cases in 2020 (Table 14). Its predictors are monthly rainfall and maximum temperature.

Table 14 Malaria Cases Projection, 2020

Month	Cases	Rainfall (mm)	Max. Temp (°C)
JAN	19	0	31.30
FEB	26	12.4	32.30
MAR	40	15.5	34.20
APR	58	21	36.60
MAY	61	65.1	37.60
JUN	negative	477	33.10
JUL	negative	787.4	32.00
AUG	negative	1146	30.30
SEP	negative	855.6	31.50
OCT	27	69	33.10
NOV	28	21.7	32.70
DEC	negative	195.3	30.40

Month	Cases	Rainfall (mm)	Max. Temp (°C)
Total	258	3666	395.10

In 2050, malaria is projected to increase to 308 cases (Table 15). This is due to the reduction in rainfall and increase in temperature.

Table 15 Malaria Cases Projection, 2050

Month	Cases	2020 Rainfall (mm)	Max. Temp (°C)
JAN	29	0	32.60
FEB	37	3.1	33.70
MAR	57	6.2	36.30
APR	69	12	38.00
MAY	71	52.7	38.70
JUN	33	276	36.30
JUL	negative	523.9	34.20
AUG	negative	657	32.80
SEP	negative	421.6	33.10
OCT	negative	564	32.60
NOV	12	213.9	32.90
DEC	1	217	31.40
Total	308	2947.4	

The methodology of impact modeling was presented and discussed sequentially in the paper so that planners may be guided in case they would like to use the same procedure. Likewise, the process used in screening the models follows the most stringent scientific statistical tools used in testing the validity of the models as well as their specific elements. All models that did not pass the tests were discarded. The accepted models that passed through the screening process were the ones presented in this study.

The models may be used under the following conditions:

1. The models can be used nationwide provided that the climate change conditions are similar to those areas where the models were developed. While the models for predictive purposes may still be used for instance in 2020 and 2050 projections caution should be exercised when the predictors are beyond the most probable values.

2. For other provinces, they may want to test the models with their health data for the last five years, and feed these data to the models to test their goodness of fit using Chi-Square Test. If there is no difference between the health data and the predicted values, use the model in that province. Otherwise, the province should opt to develop its own disease impact models using its provincial data.

General vs Specific Model Applications²

As a background, the models were based on data from the NCR, Palawan, Pangasinan and Rizal. The health data from Pangasinan and Rizal were not useful because of insufficiency and therefore not suitable for modeling purposes. Most of the data were on alert thresholds and epidemic thresholds³, which according to DOH experts were not useful because such data were projected on actual cases. Data on actual cases for most of the diseases were not readily available.

Due to the definition of alert and epidemic thresholds, the study searched for alternative data where disease cases are available. These data were found available from the NCR. With the exception of malaria cases in Palawan, the models on alert and epidemic thresholds were totally abandoned. Instead new models were developed based only on dengue and cholera cases from NCR because these were the diseases that showed positive correlations to CC indicators. Because the data used came from NCR, Palawan, Pangasinan and Rizal, the models developed appeared as site specific models. Let us look deeper into this.

Disease vectors are certain species of mosquitoes for malaria and dengue, animals mostly rats for leptospirosis, and bacteria/virus as pathogens for cholera and typhoid. All these vector species and pathogens have their own biological and environmental limits of habitat where they grow well and thrive. The limiting factors are generally environmental factors such as temperature, rainfall and relative humidity and the conditions on the ground where they live. Beyond the environmental limits of disease vectors and pathogens, they will die until the vectors and pathogens mutate and adapt to a new threshold level of environmental conditions where they could still survive. This means therefore that the

² A question during the peer review was raised that the equation/s used in the model projections are too site specific and may prove to be difficult to use by national government agencies. Also, it would be more pragmatic if the model to be chosen would yield the highest projection or worst case scenario as this would prove to be more useful in local CC planning and programming.

³ Alert threshold and epidemic threshold according to DOH experts are based on certain units of standard deviations from the mean of actual diseases cases. So that if there are no actual cases, there should be no estimates of alert threshold and epidemic threshold.

mosquitoes carrying malaria in Cagayan valley has similar environmental threshold level in Cagayan De Oro and in other places in the country. If such environmental thresholds are not present in an area, then malaria-carrying mosquitoes will not thrive and therefore no malaria cases. The same is true with dengue, leptospirosis, typhoid and cholera. In the case of leptospirosis where rats are the major vector, they live in moist areas close to garbage sites and sewerage system. If their habitats are changed, meaning cleaned and the temperature is increased, they will look for an area where the condition is still moist and dirty environment. In the case of typhoid and cholera, if water and food sources are contaminated within a certain environmental threshold level, the cholera will survive and will continue to infect vulnerable people.

If the environmental conditions conducive for vector growth are present anywhere in any barangay, municipality and province in the country, the diseases have the potential to occur in such areas.

Thus, since the models were based on environmental conditions defined by temperature, rainfall and relative humidity for each of the studied diseases, the models therefore can be used in either specific sites or in any municipality, province or nationwide as long as the climate change indicators are given in each of these areas or in general the whole country. The limiting assumption is that the vectors and pathogens will not mutate to adapt to the changing environment as there is no data available to forecast mutation impact.

2. Cost Implications of Disease Impacts in 2020 and 2050

Background

Climate change is expected to cause the emergence of various diseases and a rise in disease prevalence and intensity. As guide for effective local governance, particularly in decision making in terms of resource allocation for the reduction of risks and future threats associated with diseases arising from climate change, it is important to come up with estimates of the costs associated with these diseases.

This study component aimed to determine the following:

- a) Cost implications of the diseases: dengue, malaria, leptospirosis, cholera, and typhoid in NCR, Palawan, Pangasinan, and Rizal in terms of diagnosis,

treatments, income loss of affected individuals, and prevention measures based on results of previous studies; and

- b) Percentages of costs over the provincial incomes of the three provinces.

Methodology

The study used the benefit transfer approach, wherein secondary economic data from similar studies were adopted and used in the calculations of the cost impacts of the diseases. The economic data used for dengue were derived from the study by Borja M, Lorenzo FM et al. in 2007, titled “Burden of Disease and Economic Evaluation of Dengue” (unpublished). On the other hand, the economic data for malaria were lifted from the study of Lorenzo FM, Rivera P, et al. in 2004, titled, “Burden of Disease and Economic Evaluation of Malaria” (unpublished). The previous studies utilized cost-effectiveness analysis.

Since these studies were conducted in 2007 and 2004, the future costs data for dengue and malaria were projected to 2020 and 2050 by applying an average interest rate of 4.3% per annum (NSO, 2010).

Using the disease impact models, the projected costs were applied to the projected “cases”, “alert thresholds”, and “epidemic thresholds” of dengue and malaria in 2020 and 2050 for Palawan and Pangasinan. There were no economic data and projected cases, alert thresholds and epidemic thresholds for Rizal province. Thus, no economic analysis was done.

The cost parameters considered for dengue were costs of diagnoses and treatments, income losses, and cost of preventive measures. Generally, the costs of diagnoses and treatments of dengue are charged to the budget of the provincial government while income losses are shouldered by the infected persons. Income taxes, however, that accrue to the government are not accounted for in this study but it can be determined by applying 10% income tax rate to the income losses.

For malaria, the costs of diagnoses and treatments of hospitalized cases due to individual vectors and preventive measures were computed using the same annual growth increment of 4.3% up to years 2020 and 2050.

To estimate how much net savings the provincial governments of Palawan and Pangasinan would have in 2020 and 2050, the costs of preventive measures computed for 2020 and 2050 were applied and deducted from the costs of diagnoses and treatments for the same periods.

NATIONAL CAPITAL REGION

Costs of Dengue

Dengue cases, 2020. Table 16 presents the monthly and total cases and monthly and annual costs for dengue diagnoses, treatments and income losses. The funds required for diagnoses and treatments are expected to come from the provincial government, while income loss is an estimate of benefit foregone from those affected by the disease and as well as taxes that would accrue to the government. There will be projected 1,735 cases of dengue in NCR in 2020. This will require a total cost of PhP 9.3 M for diagnosis and treatment cost of PhP 4.5 M and a total income loss of PhP 1.3 M from families that will be affected. The total cost of dengue will be PhP15.1 Mil. The percentages of monthly cost for diagnosis, treatment and income loss over total are given in the table. The total cost of diagnosis is 54% of the total cost of dengue, treatment cost is 31% and income loss is 15%.

Table 16 Projected Dengue Costs (PhP), NCR, 2020

Month	Dengue Cases	Cost of Dengue Cases in 2020						
		Monthly Cost of Diagnosis	% Over Grand Total	Monthly Treatment Cost	% Over Grand Total	Monthly Income Loss	% Over Grand Total	Grand Total
Cost in 2007		2531		1223		357		4111
Cost in 2020		4375.1		2114.09		617.11		7106.3
JAN	357	1,560,681.57		754,136		220,135		2,534,953
FEB	327	1,432,438.49		692,168		202,046		2,326,653
MAR	8	34,833.37		16831.8185		4913.2646		56,578
APR	negative							
MAY	negative							
JUN	25	109,906.04		53,108		15,502		178,516
JUL	82	358,100.38		173,038		50,510		581,648
Aug	negative							
SEP	negative	-						
OCT	486	2,127,359.17		1,027,960		300,065		3,455,384
NOV	99	433,776.55		209,604.96		61,184.40		704,566
DEC	743	3,251,177.22		1,571,000		458,580		5,280,757

Month	Dengue Cases	Cost of Dengue Cases in 2020						
		Monthly Cost of Diagnosis	% Over Grand Total	Monthly Treatment Cost	% Over Grand Total	Monthly Income Loss	% Over Grand Total	Grand Total
Total	2128	9,308,273	61.57	4,497,846	29.75	1,312,936	8.68	15,119,055
Basic data source: Borja M, Lorenzo FM et al. (2007) in their study entitled “ Burden of Disease and Economic Evaluation of Dengue” (unpublished)								
Note: Dengue cases, alert thresholds and epidemic thresholds were projected using the impact models.								
Costs were projected using a 4.3% annual growth rate (NSO, 2010)								
Blank cells indicate negative figures.								

Dengue Cases, 2050. Table 17 presents the dengue cases and the corresponding costs of diagnoses, treatments and income loss in 2050. Comparison between the 2020 and the 2050 cost figures shows that there would be a substantial increase in the cost of dengue from PhP 15.11 M to PhP 43.6 M. This increase is not due to increase in dengue cases but to the cost of money.

Table 17 Projected Dengue Costs (PhP), NCR, 2050

Month	Dengue Cases	Cost of Dengue Cases in 2050						
		Monthly Cost of Diagnosis	% Over Grand Total	Monthly Treatment Cost	% Over Grand Total	Monthly Income Loss	% Over Grand Total	Grand Total
Cost in 2007		2531		1223		357		4111
Cost in 2050		15470.97		7475.7		2182.19		25128.86
JAN	310	4,796,001		2,317,467	17.86744	676,479		7,789,947
FEB	277	4,285,459		2,070,769	15.96542	604,467		6,960,694
MAR	negative							
APR	negative							
MAY	negative							
JUN	69	1,067,497		515,823	3.976945	150,571		1,733,891
JUL	189	2,924,013		1,412,907		412,434		4,749,355
AUG	negative							
SEP	41	634,310		306,504		89,470		1,030,283
OCT	166	2,568,181		1,240,966		362,244		4,171,391
NOV	negative							
DEC	683	10,566,673		5,105,903		1,490,436		17,163,011
Total	1735	26,842,133	61.57	12,970,340	29.75	3,786,100	8.68	43,598,572
Basic data source: Borja M, Lorenzo FM et al. (2007) in their study entitled “ Burden of Disease and Economic Evaluation of Dengue” (unpublished)								
Note: Dengue cases, alert thresholds and epidemic thresholds were projected using the impact models.								
Costs were projected using a 4.3% annual growth rate (NSO, 2010)								
Blank cells indicate negative figures.								

Cost of Preventing Dengue

NCR, 2020. What if the government of NCR would want to save the funds intended for the diagnosis and treatment of dengue in 2020? What would be its courses of action and how much should it invest by that period? Answers to these questions are shown in Table 18. There are three important actions that should be done. These are fogging, larval survey, and ovitrap. The corresponding costs for these preventive measures are presented in the table.

Table 18 Cost of Preventive Measures of Dengue, NCR, 2020.

Preventive Measure	Cost/HH (2007)	Cost/HH (2020)	Frequency of Application (times/year)	Total
Fogging	330	570.44	4	1,055,562.02
Larval Survey	224	387.21	4	716,502.60
Ovitrap	326	563.53	4	1,042,767.19
Total	880	1,521		2,814,831.80
Note:				
Total population (2000)		9,932,560		
Total population (2020)		12,038,263		
Household size	4.6			
Annual growth rate	1.06			
Number of Persons affected in 2020		2128		
Equivalent number of households		463		
Basic data source: Borja M, Lorenzo FM et al (2007) in their study entitled “ Burden of Disease and Economic Evaluation of Dengue” (unpublished).				
Costs were projected with a 4.3% annual cost increase (NSO, 2010). http://www.census.gov.ph/ncr/ncrweb/NCR%20quickstat/manila_summary.html				

NCR, 2050. Preventing dengue in 2050 using the same preventive measures would need a total of PhP 1.9 million for alert threshold and PhP 3.7 million for epidemic threshold (Table 19).

Table 19 Cost of Preventive Measures of Dengue, NCR, 2050.

Preventive Measure	Cost/HH (2007)	Cost/HH (2050)	Frequency of Application (times/year)	Total
Fogging	330	2017	4	3,043,039.13

Larval Survey	224	1369	4	2,065,404.35
Ovitrap	326	1993	4	3,006,830.43
Total	880	5379		8,115,273.91
Note:				
Population (2000)		9,932,560		
Population (2050)		15,196,817		
Household size		4.6		
Annual growth rate		1.06		
Number of Persons affected in 2050		1,735.00		
Equivalent number of households		377.173913		
Number of households that would be affected in 2050 epidemic threshold		173		
Basic data source: Borja M, Lorenzo FM et al (2007) in their study entitled “ Burden of Disease and Economic Evaluation of Dengue (unpublished)”				
Note: Population in 2050 was projected based on the 2000 population data with 3.6% growth rate and 4.98 household size (NSO,2010).				
Costs were projected with a 4.3% annual cost increase (NSO, 2010).				

Net Savings from Preventing Dengue

Applying effective preventive measures against dengue would result in significant savings on the part of the provincial government in the amounts of PhP 10.9 M in 2020 and PhP 31.69 M in 2050. (Table 20)

Table 20 Net savings from preventing Dengue

Cost Item	2020	2050
	PhP	PhP
Diagnosis	9,308,272.79	26,842,132.95
Treatment	4,497,846.09	12,970,339.50
Cost of Preventive Measures	2,814,831.80	8,115,273.91
Net Savings	10,991,287.08	31,697,198.54

PALAWAN

Costs of Malaria

Malaria Cases, Palawan, 2020. Table 21 shows the projected monthly cases of malaria in Palawan, cost of diagnosing malaria in hospital, total cost of treatment, cost of falciparum treatment, cost of vivax, cost of treatment for additional drugs in hospitalized cases, and treatment cost of sequelae. For a total of 187 projected cases of malaria in Year 2020, the total fund requirement (total cost for diagnosis plus the total cost of treatment) would be PhP 0.68 M.

Table 21 Projected Cost (PhP) of Malaria Cases, Palawan, 2020

Month	Cases	Costs of diagnosis (hospital) per case	Total costs of treatment	Cost of treatment P. falciparum	Cost of treatment P. vivax	Total cost of treatment for Additional Drugs (hospitalized cases)	Total cost of treatment for sequelae
Cost in 2004		1224.9	627.6	62.6	12.7	327.3	224.9
Cost of 2020		2402.4	1230.9	122.9	25	641.9	441.10
JAN	17	40,841.58	20,925.31	2088.89	425.11	10911.83	7,498.72
FEB	20	48,048.92	24,618.01	2457.52	500.13	12837.45	8,822.03
MAR	24	57,658.70	29,541.61	2949.02	600.16	15404.94	10,586.43
APR	29	69,670.93	35,696.11	3563.4	725.19	18614.3	12,791.94
MAY	22	52,853.81	27,079.81	2703.27	550.15	14121.19	9,704.23
JUN	15	36,036.69	18,463.51	1843.14	375.1	9628.09	6,616.52
JUL	16	38,439.13	19,694.41	1966.02	400.11	10269.96	7,057.62
AUG	8	19,219.57	9,847.20	983.01	200.05	5134.98	3,528.81
SEP	14	33,634.24	17,232.61	1720.26	350.09	8986.21	6,175.42
OCT	6	14,414.68	7,385.40	737.26	150.04	3851.23	2,646.61
NOV	10	24,024.46	12,309.00	1228.76	250.07	6418.72	4,411.01
DEC	6	14,414.68	7,385.40	737.26	36.65	3851.23	2,646.61
Total	187	449,257.38	230,056.74	22,977.81	4,562.85	120,030.16	83,151.95
Data source: Lorenzo FM, Rivera P, et al (2004). Burden of Disease and Economic Evaluation of Malaria. Costs were projected with a 4.3% annual cost increase (NSO, 2010).							

Cost of Preventing Malaria

Malaria Cases, Palawan, 2020. The projected amount required to prevent malaria diseases in Palawan is PhP 0.29 M in Year 2020 (Table 22)

Table 22 Projected Cost (PhP) of Malaria Prevention, 2020, Palawan

Month	2020 Cases	Cost of using insecticide treated bed nets (ITN)	Cost of focal spraying	Costs of early diagnosis	Costs of early treatment	Total
Cost in 2004 per case		50.1	716.2	6.7	3.1	776.1
Cost in 2020 per case		98.3	1404.6	13.2	6.1	1522.2
JAN	17	1,670.46	23,878.55	224.5	103.84	25,877.35
FEB	20	1,965.24	28,092.41	264.11	122.17	30,443.93
MAR	24	2,358.29	33,710.89	316.94	146.6	36,532.72
APR	29	2,849.60	40,733.99	382.97	177.14	44,143.70
MAY	22	2,161.77	30,901.65	290.53	134.38	33,488.33
JUN	15	1,473.93	21,069.31	198.09	91.63	22,832.96
JUL	16	1,572.20	22,473.93	211.29	97.73	24,355.15
AUG	8	786.1	11,236.96	105.65	48.87	12,177.58
SEP	14	1,375.67	19,664.69	184.88	85.52	21,310.76
OCT	6	589.57	8,427.72	79.23	36.65	9,133.17
NOV	10	982.62	14,046.20	132.06	61.08	15,221.96
DEC	6	589.57	8,427.72	79.23	36.65	9,133.17
Total	187	18,375.04	262,664.03	2,469.47	1,142.27	285,978.00
Data source: Lorenzo FM, Rivera P, et al (2004). Burden of Disease and Economic Evaluation of Malaria (Unpublished) Costs were projected with a 4.3% annual cost increase (NSO, 2010).						

Malaria Cases, Palawan, 2050. Table 23 presents the projected monthly malaria cases and the costs of diagnosis and treatments. The projected 185 malaria cases in 2050 are a bit less compared to the 2020 figures (187) but the required costs are significantly higher. This is due to the cost of money which increased the funding requirement in 2050. The provincial government would require a total budget of PhP2.38 M for the diagnoses and treatment of malaria in 2050, compared to PhP 0.68 M in 2020.

Table 23 Projected Costs of Malaria, Palawan, 2050

Month	Cases	Costs of diagnosis (hospital)	Total costs of treatment	Cost of treatment P. falciparum	Cost of treatment P. vivax	Total cost of treatment for Additional Drugs (hospitalized cases)	Total cost of treatment for sequelae
Cost in 2004		1224.9	627.6	62.6	12.7	327.3	224.9
Cost in 2050		8495.4	4352.6	434.5	88.4	2269.7	1,559.80
JAN	22	186,898.38	95,757.96	9559.14	1945.39	49934.5	34,315.50
FEB	25	212,384.53	108,815.86	10862.66	2210.67	56743.75	38,994.89

Month	Cases	Costs of diagnosis (hospital)	Total costs of treatment	Cost of treatment P. falciparum	Cost of treatment P. vivax	Total cost of treatment for Additional Drugs (hospitalized cases)	Total cost of treatment for sequelae
MAR	28	237,870.67	121,873.76	12166.18	2475.96	63553	43,674.27
APR	33	280,347.58	143,636.93	14338.71	2918.09	74901.75	51,473.25
MAY	22	186,898.38	95,757.96	9559.14	1945.39	49934.5	34,315.50
JUN	13	110,439.95	56,584.25	5648.58	1149.55	29506.75	20,277.34
JUL	15	127,430.72	65,289.52	6517.6	1326.4	34046.25	23,396.93
AUG	4	33,981.52	17,410.54	1738.03	353.71	9079	6,239.18
SEP	12	101,944.57	52,231.61	5214.08	1061.12	27237	18,717.55
OCT	1	8,495.38	4,352.63	434.51	88.43	2269.75	1,559.80
NOV	7	59,467.67	30,468.44	3041.55	618.99	15888.25	10,918.57
DEC	3	25,486.14	13,057.90	1303.52	265.28	6809.25	4,679.39
Total	185	1,571,645.50	805,237.36	80,383.70	16,358.99	419,903.74	288,562.15
Data source: Lorenzo FM, Rivera P, et al (2004). Burden of Disease and Economic Evaluation of Malaria Costs were projected with a 4.3% annual cost increase (NSO, 2010).							

Cost of Malaria Prevention

Malaria Cases, Palawan, 2050. The preventive measures against malaria are: a) use of treated bed nets; b) focal spraying; c) early diagnosis; and d) early treatment. These measures, properly undertaken in 2050 with the right timing, would cost the provincial government of Palawan a total of PhP 0.99 M only (Table 24).

Table 24 Cost Analysis Projections of Malaria Control Strategies, Palawan, 2050

Month	2020 Cases	Cost of using insecticide treated bed nets (ITN)	Cost of focal spraying	Costs of early diagnosis	Costs of early treatment	Total
Cost in 2004		50.1	716.2	6.7	3.1	776.1
Cost in 2050		347.5	4966.9	46.7	21.6	5382.7
JAN	22	7,644.32	109,272.51	1027.34	475.2	118419.37
FEB	25	8,686.72	124,173.31	1167.43	540	134567.46
MAR	28	9,729.13	139,074.11	1307.52	604.8	150715.56
APR	33	11,466.47	163,908.77	1541.01	712.8	177629.05
MAY	22	7,644.32	109,272.51	1027.34	475.2	118419.37
JUN	13	4,517.10	64,570.12	607.06	280.8	69975.08
JUL	15	5,212.03	74,503.99	700.46	324	80740.48
AUG	4	1,389.88	19,867.73	186.79	86.4	21530.8
SEP	12	4,169.63	59,603.19	560.37	259.2	64592.39

OCT	1	347.47	4,966.93	46.7	21.6	5382.7
NOV	7	2,432.28	34,768.53	326.88	151.2	37678.89
DEC	3	1,042.41	14,900.80	140.09	64.8	16148.1
Total	187	64,281.74	918,882.49	8,638.98	3,996.01	995,799.25
Data source: Lorenzo FM, Rivera P, et al (2004). Burden of Disease and Economic Evaluation of Malaria Costs were projected with a 4.3% annual cost increase (NSO, 2010).						

Net Savings from the Implementation of Preventive Measures for Malaria

The expected savings of the provincial government of Palawan in preventing malaria are PhP 0.39 M and PhP 1.38 M in 2050 (Table 25).

Table 25 Net savings from preventive measures for malaria.

Cost Item	2020	2050
	PhP	PhP
Diagnosis + Treatment	679,435.77	2,376,882.86
Cost of Preventive Measures	285,978.00	995,799.25
Net Savings	393,457.77	1,381,083.61

Costs of Leptospirosis, Cholera, and Typhoid

There were no cost data on the diagnoses, treatments, income losses and costs of prevention for leptospirosis, cholera, and typhoid in NCR, Palawan, Pangasinan, and Rizal. Thus, no economic analyses were done.

Cost Impact of Diseases to Provincial Income

The study used the income classification of provinces set by the Department of Finance through Department Order No.23-08 Effective July 29, 2008 (Table 26).

Table 26 Income Classification of Provinces

Class	Average Annual Income
First	P 450 M or more
Second	P 360 M or more but less than P 450 M
Third	P 270 M or more but less than P 360 M

Class	Average Annual Income
Fourth	P 180 M or more but less than P 270 M
Fifth	P 90 M or more but less than P 180 M
Sixth	Below P 90 M
Data source: NSCB (2010) website.	

NCR, Palawan, Rizal and Pangasinan fall within First Class Provinces each with an income of more than PhP450 M. The funds and the percentages of costs over the annual provincial income of PhP450 M are shown in Table 27. Dengue will have 3-7% cost of diagnosis and treatment over NCR annual income from 2020 to 2050. The % cost of preventing dengue is from 0.63% (2020) to 1.8% (2050). The % saving will be 2.73% in 2020 and 7.89% in 2050 if the preventive measures will be implemented.

Table 27 Percentages of Disease Costs Over Provincial Annual Income.

Disease	Annual Income	2020	%Over Income	2050	%Over Income
NCR, Palawan, Pangasinan, Rizal	450 Mil				
Dengue					
a. Diagnosis and treatment		15,119,055.00	3.36	43,598,572.00	9.69
b. Preventive		2,814,831.30	0.63	8,115,273.91	1.80
c. Savings		12,304,223.70	2.73	35,483,298.09	7.89
Malaria					
a. Diagnosis and treatment		679,435.77	0.15	2,376,882.86	0.53
b. Preventive		285,978.00	0.06	995,799.25	0.22
c. Savings		393,457.77	0.09	1,381,083.61	0.31
Cholera					
a. Diagnosis and treatment		no data		no data	
b. Preventive		no data		no data	
c. Savings					

Conclusions

Economic impact analyses were accomplished only for dengue and malaria. Other diseases such as leptospirosis, cholera, and typhoid were not covered in the economic

analysis due to lack of data. Rizal was not also covered because of lack of both climate change and economic data on the selected diseases.

The results in NCR and Palawan indicate that malaria and dengue in 2020 would require about 1% of its annual income for the diagnoses and treatments of malaria and dengue. In 2050, the allocation for funding for the same diseases would reach no less than 2% of the provincial income.

However, Pangasinan in 2020 would need about 18% of its income only for diagnoses and treatments of malaria and dengue. In 2050, the budget requirement for both diseases would be reduced to 4% owing to the reduced number of malaria and dengue cases, which is not attributed to preventive measures that would be implemented, but to the changes in the climate indicators. Such climate change nonetheless, may be good from the point of view of reducing disease occurrence.

Considering the five diseases for budgeting purposes, the provincial government may allocate in the future roughly a total of 2.5% of the income of Palawan in 2020 and 5% in 2050 assuming that the average cost requirement of each disease would more or less be the same with malaria and or dengue. On the other hand, Pangasinan would allocate roughly 45% of its income in 2020 to address the five diseases and 20% in 2050.

Considering the substantial savings that could be generated from applying preventive measures, the two provincial governments may consider investing on financing preventive measures to lessen the cost impacts of the diseases, thus lessen the burden of the provincial governments in addressing these diseases.

Both governments should not wait for the diseases to reach epidemic levels before they address the malaria and dengue outbreaks as well as other diseases that would emerge and be aggravated by climate change conditions. It is most certainly beneficial to prevent disease outbreaks before they even emerge.

D. Compendium of Good and Innovative Climate Change Adaptation Practices

The main objectives of this activity were to identify policy options and measures on climate change adaptation measures on health that suit Philippine setting and the integration of these measures for national and local development planning processes. These outputs were obtained through an intensive literature review, as well as consultation with experts on

the various diseases and meetings with representatives of health agencies. Validation was undertaken through the visits in 3 selected provinces namely Palawan, Rizal and Pangasinan.

Experiences with the different adaptation practices where they have been implemented were gathered through an extensive search of related literature from the internet and through presentations of experts on the various diseases. These practices are being assessed and attempts are also being made to explain successes and failures, especially the factors that contributed to them. The adaptation strategy were categorized to address the vulnerabilities identified in the V&A framework, comprising of the following: (a) individual/family/community; (b) health system and infrastructure; (c) pathogen and vector factors; (d) socio-economic factors; (e) environmental factors; and (f) health and environmental policy. The adaptation measures must incorporate capacitating the individual, family, and/or community to analyze and adequately respond to future climate risks.

1. Adaptation Options Derived from Literature Review

Adaptation is a key response strategy to minimize potential impacts of climate change. A primary objective of adaptation is the reduction, with the least cost, of death, disease, disability and human suffering. The ability to adapt to climate change, and specifically the impacts on health, will depend on many factors including existing infrastructure, resources, technology, information and the level of equity in different countries and regions. Cross-sectoral policies that promote ecologically sustainable development and address the underlying driving forces will be essential in managing health impacts and adaptation measures. Strategies to deal with the impacts of climate change on health need intersectoral, and cross-sectoral adaptation measures and collaboration. The health sector alone, or in limited collaboration with a few sectors, cannot deal with the necessary "primary" adaptation. Sensitive indicators of "climate-environmental" health impacts are needed to monitor possible changes at regional and national levels. Capacity building is an essential step for adaptation and mitigation strategies. This should include education, training and awareness raising, as well as the creation of legal frameworks, institutions and an environment that enables people to take well-informed decisions for the long term benefit of society (IDS, 2006).

Climate change will affect human health and well-being through a variety of mechanisms: availability of fresh water supplies, efficiency of local sewerage systems, food

security, changes in food production, security of human dwellings, distribution and seasonal transmission of vector-borne diseases, and increased frequency and severity of extreme weather events. Adaptation is a key response strategy to minimize potential impacts of CC. In health, the primary objective of adaptation is reduction, with the least cost, of death, disease, disability and human suffering (IDS, 2006).

Vulnerability (of an individual or a country) is a function both of the exposure to changes in climate and on the ability to adapt to the impacts associated with that exposure. Causes of population vulnerability to ill-health in the face of environmental stress also include the level of dependency (such as reliance on others for information, resources, and expertise) and geographical isolation (as in small island countries)

The primary objective of adaptation is to reduce disease burdens, injuries, disabilities, suffering and deaths. Many impacts of climate change - including health impacts - can be reduced or avoided by various adaptations (Smit, 1993; MacIver and Klein, 1999).

The key determinants of health – as well as the solutions – lie primarily outside the direct control of the health sector. They are rooted in areas such as sanitation and water supply, education, agriculture, trade, tourism, transport, development and housing.

ADAPTATION TO CLIMATE CHANGE AND ADAPTABILITY:

Types of Adaptation

- Adaptation can be either reactive or anticipatory. *Reactive* adaptation occurs after the initial impacts of climate change have appeared, while *anticipatory* (or proactive) adaptation takes place before impacts are apparent.
- Adaptation can also be classified based on whether the adaptation is motivated by private or public interests. Private decision-makers include both individual households and commercial companies, while public interests are served by governments at all levels (Klein, 2000, Table 28).
- A distinction is often made between *planned* and *autonomous* adaptation (Carter et al., 1994). *Planned* adaptation is the result of a deliberate policy decision, based on an awareness that conditions have changed or are about to change and that action is required to return to or maintain a desired state. *Autonomous* adaptation involves the changes human systems will undergo in response to changing conditions, irrespective of any policy, plan or decision.

Table 28 Types of Adaptation to Climate Change

	Anticipatory / Proactive	Reactive
Private	<ol style="list-style-type: none"> 1. Purchase of insurance 2. Construction of "disaster" resistant houses 	<ol style="list-style-type: none"> 1. Changes in insurance premiums
Public	<ol style="list-style-type: none"> 1. National disaster insurance fund 2. Urban planning 3. New building codes, design standards 4. Incentives for relocation 5. Immunization campaigns 	<ol style="list-style-type: none"> 1. Monitoring and surveillance 2. Compensatory payments and subsidies 3. Enforcement of building codes, design standards

Note: Adapted from Klein, 2000

The United Nations Framework Convention on Climate Change suggests that anticipatory adaptation deserves particular attention from the international climate-change community.

Five generic objectives of anticipatory adaptation:

1. *Increasing the robustness of infrastructural designs and long-term investments*—for example, by **extending the range of temperature or precipitation, which a system can withstand without failure, and changing the tolerance of loss or failure (e.g. by increasing economic reserves or by insurance)**;
2. *Increasing the flexibility of vulnerable managed systems*—for example, by **allowing mid-term adjustments** (including change of activities or location) and **reducing economic lifetimes (including increasing depreciation)**;
3. *Enhancing the adaptability of vulnerable natural systems*—for example, by **reducing other (non-climatic) stresses and removing barriers to migration** (animal or human) (including establishing eco-corridors);
4. *Reversing the trends that increase vulnerability ("maladaptation")*—for example, by **introducing setbacks for development in vulnerable areas** such as floodplains and coastal zones; and
5. *Improving societal awareness and preparedness*—for example, by **informing the public of the risks and possible consequences of climate change and setting up early-warning systems**.

Table 29 Examples of Primary and Secondary Adaptation Measures to Reduce Health Impacts

Impact	Primary adaptive measures	Secondary adaptive measures
Heat stress	<ol style="list-style-type: none"> 1. Heatwave warning systems 2. Urban planning 	<ol style="list-style-type: none"> 1. Health personnel educated to detect and treat heat stress
Extreme weather events	<ol style="list-style-type: none"> 1. Disaster preparedness and mitigation 2. Early warning systems 3. Disaster protection measures, such as "room for the river" 	<ol style="list-style-type: none"> 1. Disaster response
Infectious diseases	<ol style="list-style-type: none"> 1. Integrated environmental management 	<ol style="list-style-type: none"> 1. Disease surveillance and monitoring 2. Control of vector-, food- and water- borne diseases
Food security	<ol style="list-style-type: none"> 1. International mechanisms of agriculture, trade and finance 2. Seasonal climate forecasting 3. Famine early warning systems 4. National and local agriculture measures, such as tailored land use planning, avoidance of monocultures, upgraded food storage and distribution systems, conservation of soil moisture and nutrients 	<ol style="list-style-type: none"> 1. Monitoring and surveillance 2. Implementation of nutrition action plans
Water	<ol style="list-style-type: none"> 1. Pollution reduction and pollution control policies 2. Demand management and water allocation policies 3. Waste water treatment 4. Economic and regulatory measures to increase irrigation efficiency 5. Capacity building 	<ol style="list-style-type: none"> 1. Monitoring and surveillance 2. Capacity building

Note: Adapted from Menne, 2000a

Table 30 Adaptation Options to Reduce the Potential Health Impacts of Climate Change

Adaptation Option	Level	No of People that will Benefit	Feasibility	Barriers	Cost
1. Interagency co-operation	G, R, N	+++	++	++	+
2. Improvements to public health infrastructure	N,L	+++	+	+	++
3. Early warning and epidemic forecasting	L	++	++	+	+
4. Support for infectious disease control	N,L	++	+++	+	+

5. Monitoring and surveillance	N,L	++	+++	+	+
6. Integrated environmental management	L	+	++	+	++
7. Urban design (including transport systems)	L	+	+	++	++
8. Housing, sanitation, water quality	L	+	+	+	+
9. technologies (e.g. air conditioning)	L	+	+++	+	+
10. Public Education	L	+++	+++	+	+
G = Global, R= Regional, N = National, L = Local, +++ = large effect, ++ = medium effect, + = small effect.					

Note: Adapted from McMichael et al., forthcoming in IPCC Special Report on Technology Transfer.

Weather forecastesating, seasonal forecasting and early warning systems

- Through modern meteorological and hydrological advances such as satellites, radar, and weather prediction models, it is now possible to provide communities threatened by potential major disasters with information to allow them to take preventive action in time.
- The **use of climate forecasts for epidemic prediction** needs to be linked with early warning systems of known epidemic risk factors.
- **Hot weather watch / warning system** has been used in the United States to predict specific air masses up to 2 days in advance. One an air
- mass is classified as oppressive with the likelihood of high mortality, a “health warning” is issued to the public health authorities, which prepare a public health response.
- The most elementary form of adaptation is to **launch or improve monitoring and surveillance systems**.

Control of vector-borne and water-borne diseases (WHO, 2000)

Malaria

- Early diagnosis and prompt treatment

- Selective and sustainable adaptation measures including vector control, early detection and containment or prevention of epidemics
- Local capacity building for basic and applied research
- Advances in the mapping of malaria using satellite data, validated with surveillance information, will help target control efforts
- Access to anti-malaria drugs
- Preventive measures such as bed nets and housing design
- Epidemic forecasting
- Environmental management

Dengue

- Surveillance of vector densities and disease transmission
- Developing selective and sustainable vector control, including preparedness for emergency control
- Strengthening local capacity for assessment of the social, cultural, economic and environmental factors that lead to increased vector densities and increased transmission of disease
 - Early diagnosis and prompt treatment of DHF
 - Research in vector control
 - Mobilization of other sectors to incorporate dengue control into their goals and activities

Diseases contracted through public water supplies

1. Access to safe drinking water
2. Boiling
3. Use of submicrometre point-of-use filters may reduce the risk of waterborne cryptosporidiosis
4. Simple filtration procedure involving the use of domestic material can reduce the number of vibrios attached to plankton in raw water
5. Use of 5% calcium hypochlorite solution to disinfect water and subsequent use of the treated water in a narrow-mouthed jar produced drinking water from non-potable sources that met WHO standards for microbiological quality

Enhancing Adaptive Capacity

- **Intersectoral collaboration**

1. Integrated water management
 2. Integrated environmental management
 3. Urban planning
- **Partnerships with the private sector**
 - **Technological development and capacity**
 - **Adequate expenditure on health care and prevention** (On average, health expenditures in low income countries in 1994 were \$16 per capita. In contrast, average health expenditures in high-income countries were more than \$1800 per capita.)
 - In Vietnam, Health workers have succeeded (in the battle against malaria) through government commitment, **increased funding**, and the widespread use of locally-produced low-cost tools. About 12 million Vietnamese are protected by **house spraying and insecticide-impregnated bed nets**. In areas where malaria is endemic, **insecticide impregnation is provided as a public service, free of charge**.

Adaptation includes the strategies, policies and measures undertaken now and in the future to reduce potential adverse health effects. Individuals, communities and regional and national agencies and organizations will need to adapt to health impacts relating to climate change. At each level, options range from incremental changes in current activities and interventions, to translation of interventions from other countries/regions to address changes in the geographic range of diseases, to development of new interventions to address new disease threats. The degree of response will depend on factors such as who is expected to take action; the current burden of climate-sensitive diseases; the effectiveness of current interventions to protect the population from weather- and climate-related hazards; projections of where, when and how the burden of disease could change as the climate changes (including changes in climate variability); the feasibility of implementing additional cost-effective interventions; other stressors that could increase or decrease resilience to impacts; and the social, economic and political context within which interventions are implemented.

Because climate will continue to change for the foreseeable future and because adaptation to these changes will be an ongoing process, active management of the risks and benefits of climate change needs to be incorporated into the design, implementation and evaluation of disease control strategies and policies across the institutions and agencies

responsible for maintaining and improving population health. In addition, understanding the possible impacts of climate change in other sectors could help decision makers identify situations where impacts in another sector, such as water or agriculture, could adversely affect population health.

In reality, many of the possible measures for adapting to climate change lie primarily outside the direct control of the health sector. They are rooted in areas such as sanitation and water supply, education, agriculture, trade, tourism, transport, development and housing. Inter-sectoral and cross-sectoral adaptation strategies are needed to reduce the potential health impacts of climate change.

A policy analysis can determine the feasibility of, and priorities among, these options. When identifying specific measures to implement, it is often informative to list all potential measures, without regard to technical feasibility, cost or other limiting criteria; this is the theoretical range of choice (White, 1961). It is a comprehensive listing of all the measures that have been used anywhere, new or untried measures, plus other measures that can only be imagined. The list can be compiled from inventory of current practice and experience, from a search for measures used in other jurisdictions and in other societies, and from a brainstorming session with scientists, practitioners and affected stakeholders on measures that might be options in the future. Listing the full range of potential measures provides policy makers with a picture of measures that could be implemented to reduce a climate-related risk, and which choices are constrained because of a lack of information or research, as a consequence of other policy choices, among others.

The general vulnerabilities of the human sector to climate change-related diseases according to the Vulnerability and Adaptation Framework are shown below:

Table 31 Health Sector Vulnerabilities to Climate Change-related diseases, 2011

Vulnerability Indicator	Dengue	Malaria	Leptospirosis	Cholera	Typhoid
Individual, family, community	All ages with poor sanitary practices and facilities, low immune system, poor hygienic practices, low access to sanitary water, lack of health facilities, do not live in climate resistant houses, and are	All ages with poor sanitary practices and facilities, low immune system, poor hygienic practices, do not live in climate-resistant houses and lack health facilities are highly vulnerable.	All ages, families, communities exposed in flood-prone areas where population of rats and other animals who can be disease vectors are high are highly vulnerable.	All ages with water systems and food sources are easily contaminated with septic waste leakages during floods are highly vulnerable.	All ages with ingestion of contaminated food and water that spoiled are highly vulnerable.

Vulnerability Indicator	Dengue	Malaria	Leptospirosis	Cholera	Typhoid
	active outdoors especially at dawn and dusk are highly vulnerable				
health systems and infrastructure	Highly vulnerable are those that have no or low access to health practitioners, and health facilities such as clinics and hospitals and drug stores including other important medical facilities.				
pathogen/vector factors	Communities and households environment that have no proper sanitation, no proper control of animals living near humans, no waste management system, presence of canals and water bodies that are habitat of pathogens and vectors are highly vulnerable				
socio-economic factors	Highly vulnerable are the poor sector of the population. Those that are below poverty income threshold level and have difficult access to health services i.e. cannot afford doctor's treatment as well as medicines.				
environmental factors	Highly vulnerable are communities close to bodies of stagnant water, unsanitary environment, lack of waste management system, temperature, rainfall and relative humidity favoring the growth of pathogens and vectors.				
health/environmental policy	Highly vulnerable are communities and families not covered by policies on the regular monitoring and treatment of diseases and maintenance of a sanitary environment.				

The adaptation measures reported by the PHOs and stakeholders in Palawan, Pangasinan and Rizal are shown in Table 32.

Table 32 Adaptations to Climate Change-related Diseases in Palawan, Pangasinan and Rizal, 2011

Adaptation Practices	Dengue	Malaria	Leptospirosis	Cholera	Typhoid
Individuals and Family					
Use of treated or untreated mosquito nets.	Proper use of nets at the right time and right place	Proper use of nets at the right time and right place			
Provision of screens and sealing of holes in houses	Prevent entries of mosquitoes	Prevent entries of mosquitoes			
Cleanliness of immediate household's surroundings	Removal of waters in containers inside and outside the house	Removal of breeding grounds of mosquitoes inside and outside the house by practicing proper waste disposal	Elimination of damp areas conducive for rat's habitat. Clean drainage system most often to prevent breeding grounds of rats		

Adaptation Practices	Dengue	Malaria	Leptospirosis	Cholera	Typhoid
Water, sanitation and good hygienic practices				Source out water for drinking that are safe or free from contamination. Sterilize water before drinking. Store foods properly avoiding contacts with probable carriers of cholera. Practice sanitation and good hygiene in the family.	Same as cholera
Consciousness on good health maintenance	Early diagnosis and treatment of climate change-related diseases.				
Maintenance of pets at home that can reduce growth of vectors and pathogens	Breeding of larvivorous species of fish		Maintenance of cats that feed on rats		
Barangay or Community					
Presence of active barangay health workers.	Report suspected cases to hospitals for immediate diagnosis and treatment	Microscopists for malaria only for immediate diagnosis and treatment of climate change-health related diseases	Report cases of suspected infected persons for treatment	Refer cases to hospitals for diagnosis and treatment	Refer cases to hospitals for immediate diagnosis and treatment
Decanting	Spraying pesticides that are not toxic to human being		Destroy rats and breeding grounds and habitat		
Provision of a centralized clean water sources that are well protected and maintained whole year round				Spring development; Prevention of water source contamination by sealing potential entry of pathogens/vectors.	
Community ordinances: zoning and resettlement of high risk groups	Resettlement in dengue-free zones.	Resettlement in malaria free zone.	Resettlement in elevated and non-flood prone	Remove sources of water contamination or resettlement contaminated groups.	

Adaptation Practices	Dengue	Malaria	Leptospirosis	Cholera	Typhoid
or informal settlers.			areas.		
Proper waste management system at community level	Removal of wastes that promote growth of pathogens/vectors; cleaning of water ways		Eliminate breeding grounds of rats	Removal of sources of contamination; location of water sources away from sewage/waste dumping areas. dengue	Prevent sources of pathogens/ vectors coming from waste/sewa ge areas.
Presence of manned and active health workers in BHCs.	Regular diagnosis, treatment and referrals/endorsement to hospitals that can treat diseases.				
Information and Education Campaign at the Community Level	Barangay Health Centers with regular information campaign activities for the barangay population regarding prevention adaptation measures of all diseases				
Health systems and infrastructure					
Presence of a network of complimentary hospitals complete with laboratory, medicines, and medical facilities within the province where costs of diagnosis and treatments are affordable.	Conduct thorough diagnoses and treatments of infected persons.				
Health care system	PhilHealth card necessary for each family				
Holistic health maintenance projects	Fourmula-1, Vaccination, PIDSR, etc.	Fourmula-1, PIDSR, malaria treatment medicines, etc.	Fourmula 1, PIDSR, leptospirosis treatment medicines	Fourmula 1, PIDSR, cholera treatment medicines	Fourmula 1, PIDSR, typhoid treatment medicines
Pathogen/vector factors					
Innovative practices to eliminate vectors and pathogens.	Solar insecticide capture and destroy		Rats trapping	Floating Toilet Device	Floating Toilet Device

Adaptation Practices	Dengue	Malaria	Leptospirosis	Cholera	Typhoid
Regular spraying of chemicals that are non- toxic to human beings to eliminate pathogens and vectors inside and outside the house.	Regular and simultaneous spraying that kills mosquitoes and other insects, fungi and other pathogens in all houses and breeding grounds in a barangay.		Regular and simultaneous decanting by barangay level.		
Elimination of growth factors and habitat.	Cleaning of water ways, streams and other water bodies, and proper sanitary practices at the household level.		Cleaning of canals; removal of rat habitat and wastes.	Avoid food spoilage by refrigeration and maintenance of clean and safe water sources.	
Socio-economic Factors					
Health subsidies in vulnerable communities or barangays.	Subsidies to all vulnerable families in the form of free or affordable health card.				
Provision of livelihood and income generating projects to increase income of vulnerable communities.	Planting, processing and marketing of medicinal plants proven to strengthen immune system; manufacture and marketing of decanting and trap gadgets; production and marketing of insect repellants; production, breeding and marketing of pets that feed on insects and rats.				
PPP for clean and safe water system				Replace old water system vulnerable to contamination	Replace old water system vulnerable to contamination.
Environmental factors					
Forestation	Planting and management of integrated forest plantations that drive away mosquitoes	Planting and management of integrated forest plantations that drive away mosquitoes	Planting of forest species that attract rats from residential areas.		
Establishment, maintenance and management of sanitary landfills.	Eliminates breeding grounds of insects, pathogens and vectors.		Eliminates breeding grounds of rats.	Eliminates breeding grounds of insects, pathogens and vectors.	
Periodic cleaning and declogging of waterways,	Breeding grounds of mosquitoes in stagnant water are destroyed.		Flowing streamflow prevent s	Clean and declogged waterways also washout pathogens and vectors that live	

Adaptation Practices	Dengue	Malaria	Leptospirosis	Cholera	Typhoid
streams and rivers to allow waterflow continuously.			deposition of wastes for rat foods .	on stagnant water.	
Health/ environmental policy					
Policy on the integration of health and climate change education in primary and secondary education	Education on the prevention of dengue at home and in school .	Education on the prevention of malaria at home and in school.	Education on the prevention of leptospirosis	Education on the prevention of cholera	Education on the prevention of typhoid
Climate risk proofing policies	Adoption and implementation of adaptation measures for climate change-related health problems in all DOH projects				
Policy on mandatory coverage of population for health care system	Full coverage in highly vulnerable areas.				
Policy on Strengthened Provincial Disaster Coordinating Council	Creation of a sub-council on disease-related disaster prevention and management				
Disaster preparedness policy.	Nationwide capacity building of people on disaster preparedness brought about by climate change-related diseases.				

International, regional, national and local literature on climate change adaptation in relation to health were gathered as well as reports on combating the four priority diseases namely malaria, dengue, leptospirosis, and cholera/typhoid. An annotated bibliography formatted by using endnotes in Microsoft Word which documented all relevant reference materials on climate change adaptation is in the process of preparation. See book 3 annex B. Among the collected adaptation measures and disease combating strategies, the team has identified good and innovative practices that are relevant to national and sub-national development processes in the health sector.

A short-listing of these adaptation measures was undertaken, guided by a set of prioritization criteria formulated by the project team. In addition, climate change adaptation practices that are based on local indigenous knowledge and cultural practices, if there are any, will likewise were documented.

2. Field documented Innovative Climate Change Adaptation Options for the Health Sector

The following section describes three innovative climate change adaptation options currently deemed effective and implemented in the field validation sites. They are mostly concerned with water and waste management.

Solar Water Disinfection (SODIS)

Solar Water Disinfection (SODIS) is a simple, environmentally sustainable, low-cost solution for drinking water treatment at household level for people consuming microbiologically contaminated raw water. Through the use of solar energy, it improves the quality of drinking water by destroying microorganisms that cause water-borne diseases. These pathogenic microorganisms are susceptible to two effects of sunlight: 1) radiation in the spectrum of UV-A light (wavelength 320-400nm) and 2) heat (increased water temperature). SODIS takes advantage of the synergy of these two effects, as their combined effect is much greater than the sum of the single effects. Thus, the mortality of the microorganisms increases with more simultaneous exposure to temperature and UV-A light.

SODIS is ideal for disinfection of small quantities of water with low turbidity. Placed in transparent plastic bottles, contaminated water is exposed to full sunlight for 6 hours to destroy the pathogens. Water with more than 50% cloudiness must be exposed for 2 consecutive days in order to be safe for consumption. Treatment time can be reduced to one hour if water temperatures exceed 50°C, and treatment efficiency can be improved if the plastic bottles are exposed on sunlight-reflecting surfaces such as aluminum or corrugated iron sheets.

By destroying pathogens present in drinking water, SODIS reduces the occurrence of enteric diseases such as **infectious diarrhea** (from bacterial infections with enteropathogenic *Escherichia coli*), **dysentery** (watery diarrhoea from bacterial infections with *Salmonella* or *Shigella*), **dysentery** (from parasitic infection with *Giardia lamblia* ("Giardiasis") or *Entamoeba histolytica* ("Amoebiasis")), and **cholera** (from bacterial infection with *Vibrio cholera*).

Floating Toilet Device

The Floating Toilet Device is a project of the Center for Health Development of Ilocos, in collaboration with hon. Mayor Alfonso Celeste, officials, and the fish pen owners association of the municipality of Bolinao. Drinking water contaminated with fecal matter and vibrio cholera has been strongly associated with numerous cases of cholera in the 2004 outbreak in Pangasinan. The lack of LGU programs and projects related to water supply and sanitation led to the re-emergence of the cholera outbreak in 2008. The lack of investment in such programs and projects has been identified by the DOH as one of the major environmental factors that contributed to the persistence of cholera in the province of Pangasinan.

As a long term solution to end the cholera epidemic cycle, the Cholera Containment Strategy and the environmental sustainability projects under it were employed. Households living near bodies of water were considered as a major drawback in the containment strategy. For the purpose of preventing the contamination of water sources, the technology of floating sanitary toilets was developed and piloted in the municipality of Bolinao, Pangasinan.

Solar-powered Clean Water System (SCW System)

Water disinfection through the Solar-powered Clean Water (SCW) System, developed by the Ateneo Innovation Center, involves the use of ultraviolet irradiation to destroy microorganisms in collected rainwater. The UV lamps are powered by solar energy, which is collected by solar panels and stored in batteries.

The SCW System is being applied as a method of domestic wastewater treatment in Calaca, Batangas. For this community with a population of 700, the initial recommendation is to build 2 sets of 6 water cleaning stations. The following parameters serve as a basis for this design:

- Houses are still being constructed.
- The rate of effective UV (ultraviolet) irradiation and ceramic filter is at most 2 liters per minute (120 liters in a day).
- The duration of UV operation is 4 hours a day.

Labor and part devices of an SCW System are estimated at Php 50,000. The Ateneo Innovation Center can provide training for maintenance of the system. On the other hand, design and construction of the rainwater tank and collection system will be done separately by an independent contractor.

3. Prioritized Adaptation Options

Adaptation includes the strategies, policies and measures undertaken now and in the future to reduce potential adverse health effects. Individuals, communities and regional and national agencies and organizations will need to adapt to health impacts relating to climate change. At each level, options range from incremental changes in current activities and interventions, to translation of interventions from other countries/regions to address changes in the geographic range of diseases, to development of new interventions to address new disease threats. The degree of response will depend on factors such as who is expected to take action; the current burden of climate-sensitive diseases; the effectiveness of current interventions to protect the population from weather- and climate-related hazards; projections of where, when and how the burden of disease could change as the climate changes (including changes in climate variability); the feasibility of implementing additional cost-effective interventions; other stressors that could increase or decrease resilience to impacts; and the social, economic and political context within which interventions are implemented.

Because climate will continue to change for the foreseeable future and because adaptation to these changes will be an ongoing process, active management of the risks and benefits of climate change needs to be incorporated into the design, implementation and evaluation of disease control strategies and policies across the institutions and agencies responsible for maintaining and improving population health. In addition, understanding the possible impacts of climate change in other sectors could help decision makers identify situations where impacts in another sector, such as water or agriculture, could adversely affect population health.

In reality, many of the possible measures for adapting to climate change lie primarily outside the direct control of the health sector. They are rooted in areas such as sanitation and water supply, education, agriculture, trade, tourism, transport, development and housing. Intersectoral and cross-sectoral adaptation strategies are needed to reduce the potential health impacts of climate change.

A policy analysis can determine the feasibility of, and priorities among, these options. When identifying specific measures to implement, it is often informative to list all potential measures, without regard to technical feasibility, cost or other limiting criteria; this is the theoretical range of choice (White, 1961). It is a comprehensive listing of all the measures that have been used anywhere, new or untried measures, plus other measures that can only be imagined. The list can be compiled from inventory of current practice and experience, from a search for measures used in other jurisdictions and in other societies, and from a brainstorming session with scientists, practitioners and affected stakeholders on measures that might be options in the future. Listing the full range of potential measures provides policy makers with a picture of measures that could be implemented to reduce a climate-related risk, and which choices are constrained because of a lack of information or research, as a consequence of other policy choices, among others.

Adaptation Evaluation Decision Matrix (AEDM)

AEDM is a decision making tool designed to assist policy makers on what climate change adaptation measures need to be prioritized and adopted based on a set of criteria. It answers which of the adaptation measures are worth implementing due their effectiveness in addressing the disease/ health problems at the soonest possible time at least cost, within policy mandates and programs, and practicable and implementable at the family level. In utilizing this tool it shall be assumed that all climate change adaptations that will be included are cost- effective based on a literature review or country best practices.

The criteria recommended in the AEDM for evaluating adaptation measures are shown in Table 32. Information required maybe qualitative or quantitative depending on the availability and type of the information. Qualitative rating can be variations of (+) or (-). Quantitatively, rates or scores or actual quantitative data such as costs can be used. The criteria are described as follows:

- Practicability of implementation - pertains to feasibility of implementation given the *policies, resources* (financial, human resources, equipment/ materials), *systems* (financing, monitoring, evaluation, operations and information), *guidelines and organizational structure*. The scores or rates or degrees of (+) or (-) will depend on the presence or absence of these inputs.
- Cost- effectiveness – achieving desired health outcomes at least cost. If cost effectiveness ratios for the adaptation measures are available, these can be used basis to score or rate low to high cost effectiveness ratios. If no ratios can be

obtained from information available to the policy maker, then variations of (+) mark can be used to show degrees of cost- effectiveness (low → high). If no data is available on cost effectiveness, effectiveness measures such as health outcomes need to be identified first. Examples of health outcomes can be low incidence, prevalence, or mortality rates related to malaria, dengue, leptospirosis, cholera and typhoid. Health records in health centers can be used to quantify effectiveness. Quantitatively, incidence, prevalence or mortality rates can be used. Qualitatively, variations of (+) and (-) to depict highs and lows can be employed. Costs, on the other hand, are more straightforward. These are actual total costs incurred by the health center to prevent diseases such as malaria, dengue, leptospirosis, cholera and typhoid. If no costs are available, perception of the cost incurred can be described using degrees of (+) or (-) marks.

- Within the policy/ program – this section assumes that there is a policy and/ or program already in place. The criterion then pertains to the scope of the policy or program. The extent of coverage or inclusion of an adaptation measure to a current policy or program will merit variations of (+) mark or a score. Absence of the adaptation measure in the current policy or program will mean a (-) mark or a score.
- Safe to family members – the criterion ensures that the utilization of adaptation measure will not be hazardous to members of the family or community.
- Impact to the environment – pertains to the overall effect to the general environment of the community.

After the scores or rates have been decided on, totals need to be computed based on (+) and (-) if done qualitatively or the scores/ rates if done quantitatively.

Table 33 Adaptation Evaluation Decision Matrix

Disease/Adaptation Measure	Practicability of implementation		Cost-effectiveness		Within policy/program		Safe to family members		Impact to the environment		Total
	+	-	+	-	+	-	+	-	+	-	
Impact Rating	+	-	+	-	+	-	+	-	+	-	
Dengue											
<i>a.Adaptation 1</i>											
<i>b.Adaptation 2</i>											
Malaria											
<i>a.Adaptation 1</i>											
<i>b.Adaptation 2</i>											

The adaptation measures in Table 34 were obtained from the review of literature (compendium of good and innovative climate change adaptation practices). The matrix was completed to demonstrate the way policymakers and implementers can accomplish it. Adaptation measures are varied and need to be identified given the context or setting of the community where the measures will be implemented.

As in the earlier discussion on Adaptation Evaluation Decision Matrix, a set of criteria were used to help policymakers identify cost effective adaptation measures that are applicable to their local context or setting. Adaptation measures under the General Adaptation category are cross-cutting interventions and are not solely to address health issues caused by climate change. Such include harmonization of policies, health surveillance and early warning, health service delivery and programs, capacity building, social health insurance coverage, stakeholder partnerships and capacity building, public awareness on disease prevention and environmental health. Disease-specific adaptation measures are grouped according to vector-borne diseases and water/food-borne diseases. For Malaria, Dengue and Leptospirosis, presence of an integrated vector management program is considered to be a cost effective measure since it aims to address the management of different types of vectors found in a particular community. Interventions in the integrated program may involve decanting and management of wetland breeding sites for mosquitoes and provision of proper footwear and safe drinking water. For the water/ food-borne diseases like cholera and typhoid, the best adaptation measures are focused on proper sanitation, proper human waste disposal and provision of safe drinking water.

The assessment of each of the criterion is discussed on page 124. Based on the assessment and scoring done, items with 11-15 points are comprised of regular and existing programs that need to be reinforced by local government units to help address effects of climate change on health. Items with 7-10 points are measures that are quite new and are not yet widely implemented, lack current local policy support, lack implementation mechanisms and/or strong political will to effectively address health issues. Based on best practices, it is advised that a mix of general and disease specific adaptation measures be prioritized and pursued. Adaptation measures can likewise be prioritized and implemented according to a timeframe set by policymakers and implementers: short-term, medium-term and long-term.

Table 34 Adaptation Evaluation Decision Matrix based on Literature

Disease/Adaptation Measure	Practicability of implementation		Cost-effectiveness		Within policy/program		Safe to family members		Impact to the environment		Total
Impact Rating	+	-	+	-	+	-	+	-	+	-	
General Adaptation											
Mainstreaming CC in government policies	+		++		+		+		++		7
CC Capacity building of policy makers and implementers	++		+++		+			-	++		7
Increased stakeholder partnership and collaboration for CC and disease prevention	++		+++		+		+++		+		9
Intensifying public health surveillance and early warning system especially in vulnerable areas	+++		+++		+++		+++		+++		15
Improvement of health service delivery and clinical and public health programs	+++		+++		+++		+++		++		14
Increased social health insurance coverage (safety net)	+++		+++		+++		+++			--	10
Environmental cleanliness	+++		+++		+		+++		+++		13
Reforestation	++		++		+		+		+++		9
Land zoning restrictions and resettlement programs	+		++		++		++		+		8
Reinforcement of public awareness on disease prevention	+++		++		+++		+++		+++		14
Dengue, Malaria, Leptospirosis											
Integrated vector management program– to include regular decanting; management of wetland breeding sites; proper footwear and provision of safe drinking water	+++		+++			---	+++		+++		9
Cholera, and Typhoid											
Promotion of basic hygiene and sanitation	+++		+++		+++		+++		+++		15
Safe drinking water (SODIS)	+++		+++			-	+++		+		9
Solar Powered Clean Water system(SCW system)	+++		+++			-	+++		+		9
Floating Toilet Device	+++		+++			--	+++		+++		10

+ /- least, ++/--mid, +++/---most

E. Integrated Monitoring and Evaluation Framework (IM&EF)

The framework in schematic form is shown in Figure 26 (also see Book 2, Appendix E). The main objective of the IM&EF is to enable periodic M&E of climate change trends and impacts on the effectiveness of policies and measures for reducing vulnerability and increasing adaptive capacity in the Health sector. The M&E framework/strategy is based on existing M&E system in the health sector as well as from M&E systems of NGAs and international organizations. Consequently, the activities undertaken include the review of relevant on-going M&E frameworks and analysis of how climate change parameters could be incorporated in the existing M&E system, as well as the formulation of a strategy on how to build capacity for implementing the system.

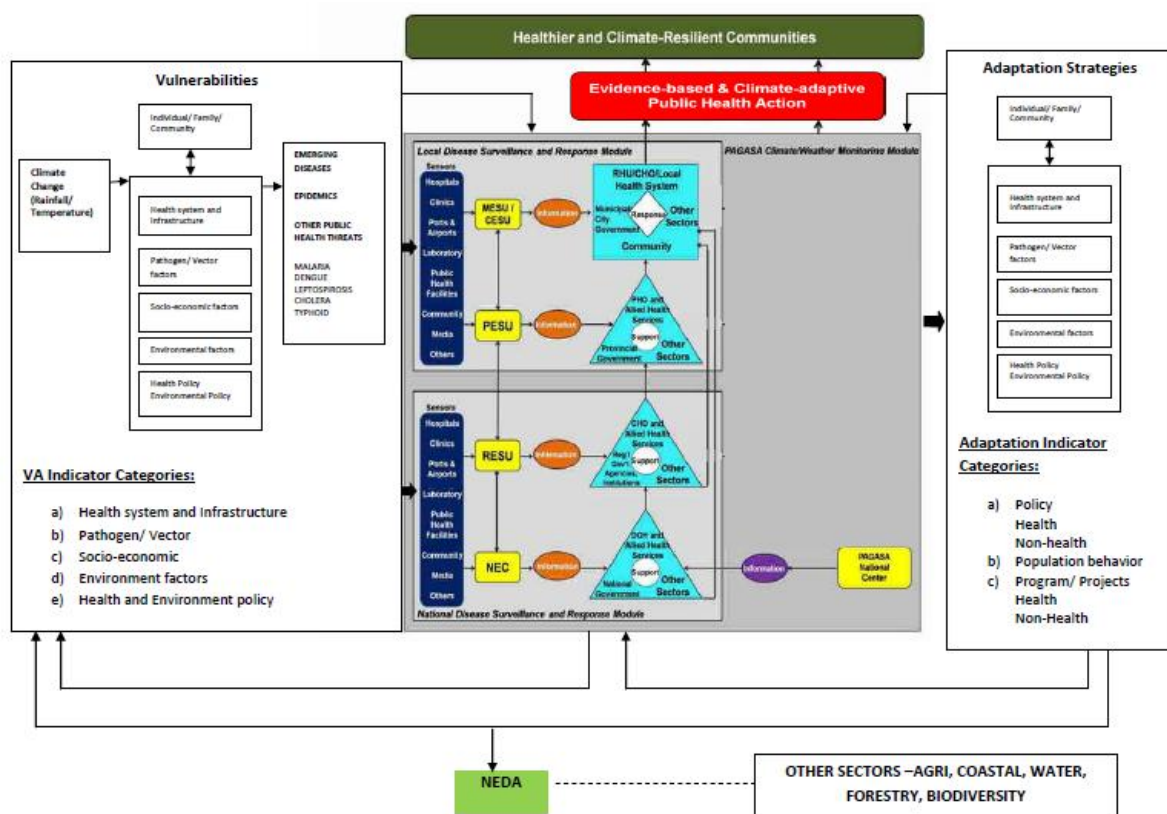


Figure 26 Integrated M&E Framework

How the framework was formed

The inventory and assessment of relevant on-going M&E frameworks and systems in the international, national and local levels involved the search for M&E systems related to climate change from internet sources and from consultation meetings with DOH officials.

At the international level, M&E frameworks were sourced from the United Nations Development Program's (UNDP) Global Environment Facility. These frameworks generally monitor climate change adaptation and climate change programs. Relative to health, the International Federation of Red Cross and Red Crescent Societies' M&E Sourcebook has provided information that are useful for the development of climate change adaptation M&E in the health sector.

At the national level, monitoring and evaluation systems of different government agencies were examined. These agencies include the Department of Agriculture (DA), Department of Agrarian Reform (DAR), Department of Environment and Natural Resources (DENR), Department of Health (DOH), Department of Science and Technology (DOST), Department of Trade and Industry (DTI), National Economic Development Authority (NEDA), and the National Statistics Office (NSO).

Relative to health, the National Framework Strategy on Climate Change (NFSCC) under the Climate Change Act has prioritized the following strategies for the sector:

- a. Assessment of the vulnerability of the health sector to climate change.
- b. Improvement of climate-sensitivity and increase in responsiveness of public health systems and service delivery mechanisms to climate change.
- c. Establishment of mechanisms to identify, monitor and control diseases brought about by climate change; and improved surveillance and emergency response to communicable diseases, especially climate-sensitive water-borne and vector diseases.

It should be noted that **all of the above strategies require the strengthening of the M&E system, especially on surveillance and emergency response, which should take into account climate parameters that greatly impact on disease prevalence and control.**

The Philippine National AIDS Council's has developed an M&E system for AIDS, but the 4th AIDS Medium Term Plan Report has noted difficulty in the system's operationalization due to substantial resource requirements. At the provincial level, a non-health M&E system was developed for a coastal resource management project in the island province of Camiguin. The project's methodology for fish catch and water quality monitoring and results analysis provide a useful model for implementing M&E systems at the local level. However, substantial resource support was noted that could account for the relative success of the system.

This activity also looked into the determination of the capacity of relevant government entities at the national and provincial levels including the Department of Health and PAG-ASA. The different surveillance and monitoring systems of the Department of Health, past and present, were considered in determining the entry point for the M&E system to be proposed.

These systems include the following: (1) Philippine Integrated Disease Surveillance and Response (PIDSR); (2) Monitoring and Evaluation for Equity and Effectiveness (ME3) through FOURmula One (F1); (3) National Epidemic Sentinel Surveillance System (NESSS); (4) Field Health Service Information System (FHSIS); and (5) Health Emergency Management Staff (HEMS). In addition, there is a Notifiable Disease Reporting System (NDRS) that generates information on 17 diseases and 7 syndromes, the data from which is used to generate morbidity rates; the Expanded Program on Immunization Surveillance System (EPI Surveillance) that focuses on the monitoring of priority vaccine-preventable diseases targeted for eradication and elimination namely: poliomyelitis, measles and neonatal tetanus; and the HIV AIDS Registry program that keeps track of the number of AIDS-HIV cases through a voluntary testing program.

With the incorporation of most of the above surveillance systems into PIDSR (as per DOH Administrative Order 2007-0036 dated October 2007), the latter appears to be the most appropriate for enhancement through the integration of climate change. PIDSR aims to address the inefficiencies, redundancies, and duplication of efforts resulting from multiple surveillance systems, which had resulted in extra costs and training requirements that had kept some personnel unmotivated and overloaded.

The proposed M&E requires direct coordination with PAGASA and other forecasting systems, for a more efficient decision-making process. The flow of information to the government agencies and LGUs would then be supplemented with close coordination with the DOH Central Office, the provincial offices, its hospitals, down to the rural health units and

barangay health centers. Adaptation strategies on health that are suited and applicable to the respective terrain and topography will be left for LGUs to decide upon, after being given the list of appropriate and validated strategies from Activity 3 of this project.

Validation of the proposed CCA M&E framework and system for the health sector

A framework for the strategy to develop the climate change adaptation M&E system for the health sector was initially developed. Following the round table discussion with various stakeholders on April 15, 2010, the project team was advised by NEDA to limit the M&E system to a form that will enhance existing M&E systems of the national and provincial development planning processes for the health sector. Efforts to identify entry points to integrate climate change into the M&E system in the health sector and in the national and provincial development planning process has zeroed in on PIDSR.

The team has also identified the different principles that will underpin the development of the M&E Strategy as follows:

- It shall verify the effectiveness of the implementation of policies, programs, and projects in terms of changes and/or improvements in the situation of target groups, their behavior, application and utilization of skills, and how these changes can be attributed to interventions such as technical assistance and management services delivered by implementers.
- The M&E system shall build on existing disease surveillance systems to collect data for the selected diseases and for tracking temperature and rainfall (precipitation) and should provide a mechanism for integrating, analyzing and decision-making involving the two data sets.
- The M&E system must be simple, provide quick results, be cost-effective and operated in a manner that is both transparent and with clearly-defined accountabilities and responsibilities.
- The M&E system must be able to provide a mechanism to facilitate the systematic communication and/or sharing of results across different levels, to include decision-makers, implementers, and the general public, especially at the level of the household, as well as for a feedback mechanism.

- The M&E system shall involve a minimum amount of relevant and practical indicators.
- The M&E system shall be subject to review every three years, and may be modified subject to the lessons learned and to suit the needs of stakeholders.
- The detailed implementation of the M&E strategy shall be described under M&E operations plan, to be formulated and implemented on an annual basis by the Department of Health.

The team has identified indicators for the M&E system that are relevant for national, regional and provincial development planning processes in the health sector in relation to Climate Change. It includes sensitive indicators categorized under several “dashboard” indicators. The matrix is shown as Table 35.

Table 35 Climate Change M&E Dashboard Indicators

AREAS	DASHBOARD INDICATORS	FIRST LEVEL INDICATORS	SECOND LEVEL INDICATORS	THIRD LEVEL INDICATORS	MONITORING LEVEL (Barangay, Municipal, Provincial, National)	MONITORING FREQUENCY (Daily, Weekly, Monthly, Quarterly, Annually)	POSITION / AGENCY
I. Climate & Env'l Parameters	CLIMATE CHANGE EARLY WARNING	1 % increase beyond rainfall threshold			P	D	NDCC with PHO
		1 degree increase above temperature threshold			P	D	NDCC with PHO
II. Public Health and Health Service Interventions	EARLY DISASTER RESPONSE	increase in public awareness (say additional 10% of population)	Community participation in disaster preparedness projects & activities	Implementation of adaptation strategies	M	M	RHU/ BHS
		Functional disease surveillance system	Prevalence of diarrhea	Proper waste disposal: ---% of HH with sanitary toilets ---% of HH with clean source of water ---% of HH with proper garbage disposal	M,P	W, M	SI-RHU PHO

AREAS	DASHBOARD INDICATORS	FIRST LEVEL INDICATORS	SECOND LEVEL INDICATORS	THIRD LEVEL INDICATORS	MONITORING LEVEL (Barangay, Municipal, Provincial, National)	MONITORING FREQUENCY (Daily, Weekly, Monthly, Quarterly, Annually)	POSITION / AGENCY
				---% of establishments with sanitary permits			
			Number/% of (+) malarial smears	Active case finding: no. of probable cases	M,P	W	MHO-RHU PHO
			Number/% of validated dengue cases	Active case finding: no. of probable cases	M,P	W	MHO-RHU PHO
		Increased control of infectious disease	Incidence of diarrhea	Proper waste disposal: % of HH with sanitary toilets % of HH with clean source of water % of HH with proper garbage disposal % of Establishments with sanitary permits			
			Implementation of programs on integrated vector management	Implementation of decanting activities	M	W	SI-RHU
	ACCESS TO PRIMARY HEALTH CARE	Increased diagnosis of malaria thru microscopy & rapid diagnostic test	Number/% of (+) malarial smears	Active case finding: No. of probable cases	M,P	W,M	MHO-RHU PHO
		Increased treatment of malaria	% of malaria cases treated	Availability of 1st-line and 2nd-line drugs	M,P,N	W,M	MHO-RHU PHO DOH
		Increased diagnosis of dengue cases	% of validated dengue cases	Active case finding: No. of probable cases	M,P	W,M	MHO-RHU PHO
		Increased access to treatment of diarrhea	% of diarrheal cases treated	% of HH with sanitary toilets % of HH with clean source of water % of HH with proper garbage disposal % of Establishments	M,P	W,M	MHO-RHU PHO

AREAS	DASHBOARD INDICATORS	FIRST LEVEL INDICATORS	SECOND LEVEL INDICATORS	THIRD LEVEL INDICATORS	MONITORING LEVEL (Barangay, Municipal, Provincial, National)	MONITORING FREQUENCY (Daily, Weekly, Monthly, Quarterly, Annually)	POSITION / AGENCY
				with sanitary permits Nutritional status of under 5 children			
III. Environmental and social determinants of health	ENVIRONMENTAL HEALTH AND SAFETY	Integrated vector management	% of Provincial, city and municipal governments engaged in vector management	Existing and functional programs found in LGUs on integrated vector management	B,M,P	Q	CHO, PHO
		Effective Sanitary Programs	% Increase in awareness on sanitary programs	% of HH with sanitary toilets % of HH with clean source of water % of HH with proper garbage disposal % of Establishments with sanitary permits % decrease in food and water borne diseases	B, M, P	Q	SI- RHU PHO
IV. Health System and Infrastructure	INTEGRATED NATIONAL PROGRAM ON CLIMATE CHANGE	Stakeholder engagement: Existing partnerships of DOH with other CC-related institutions (government and private) Presence of funding for the CC program at the national level % of health facilities (hospitals, health centers, Barangay stations, clinics) with adaptation	Existing framework and plan Existing working groups on CC	Outputs to collaborative work and projects brought about by existing partnerships	N N N	Q A A	USEC-DOH DOH NEDA DOH LGUs

AREAS	DASHBOARD INDICATORS	FIRST LEVEL INDICATORS	SECOND LEVEL INDICATORS	THIRD LEVEL INDICATORS	MONITORING LEVEL (Barangay, Municipal, Provincial, National)	MONITORING FREQUENCY (Daily, Weekly, Monthly, Quarterly, Annually)	POSITION / AGENCY
		programs and are emergency and disaster preparedness					
	CC RESEARCH AND DEVELOPMENT	Research and development agenda % of funds/ grants in R&D for CC Funds raised and utilized for collaborative projects on CC at national and provincial levels	% of research proposals funded	Outputs/ Completion of researches funded	N	A	DOH CC related agencies NEDA

Legend: B – Barangay; M – Municipal; P – Provincial; N – National; D – Daily; W – Weekly; M – Monthly; Q – Quarterly; A - Annually

Organized into a matrix, the climate change M&E system/s being developed will include a strategic action plan for mainstreaming the CC M&E into the national and provincial development planning processes, which will entail the crafting of relevant updated policies and regulations that take cognizance of the climate change impacts on health.

Previous to the RTD, it was deemed that the M&E framework/system for the health sector to be workable, must have the following characteristics:

- a. It should be user friendly;
- b. It should allow participation of multi-agencies working in the health sector including NGOs;
- c. It should allow workability in any levels of governance in the health sector from the field level to the central office; and
- d. It should be cost effective.

The DOH Central office, with its primary functions for policy and program development, technical assistance, and training, is expected to lead in mandating the inclusion of climate change M&E systems into its regional and local offices. This is critical for mainstreaming the developed M&E framework which will be included in the mandates of the LGUs and DOH. The system will be included into the policies, programs, and projects of each locality. As such, financing will also come from the Local Government Units.

PIDSR as the Centerpiece of the Integrated M&E Framework

The framework of the proposed Health Sector Climate Change Monitoring and Evaluation System is shown in Figure 26. The centerpiece is the conceptual framework for the Philippine Integrated Disease Surveillance and Response System (PIDSR). PIDSR was adopted by the Department of Health in 2007 through Department Administrative Order 2007-0036 that was signed on October 1, 2007 by then Health Secretary Francisco T. Duque III.

The original PIDSR framework was formulated following assessments done in 2006 that showed the inadequacy of having several existing surveillance systems. Prior to the implementation of PIDSR, there existed four major disease surveillance systems in the Philippines. These were the following: (a) **NDRS, FHSIS or Notifiable Disease Reporting System of the Field Health Service Information System**; (b) **NESSS or National Epidemic Sentinel Surveillance System**; (c) **EPISurv or Expanded Programme on Immunization diseases targeted for eradication or, elimination Surveillance System**; and (d) **IHBSS or Integrated HIV/AIDS Behavioural and Serologic Surveillance System**. Having multiple systems was found by the 2006 assessment as having contributed to inefficient surveillance, “characterized by redundancy and duplication of efforts, extra and sometimes prohibitive costs, a demoralized health workforce, inaccurate and delayed reporting, and ultimately unrealized health outcomes” (NEC-DOH, 2008).

The other driving force for the integration of disease surveillance systems in the Philippines was the need for the country to meet its commitment as a member of the international community, following the adoption on 23 May 2005 of the International Health Regulations (2005) during the World Health Assembly, where the Philippines is a state party. IHR 2005 required all state parties “to carry out an assessment of public health events arising in their territories” and “then to notify WHO of all qualifying events within 24 hours of such an assessment” (WHO, 2008). Aligning the country’s disease surveillance and response system with the requirements of IHR 2005 was needed in order for the Philippines

to be consistent in its application of the assessment and notification requirements under IHR 2005. Consistency with IHR 2005 was deemed as “crucial to ensure prompt communication to WHO of those events which may need coordinated international public health assessment and response” (WHO, 2008). In the light of global threats to public health such as SARS and avian flu, and given the poor public health infrastructure in the Philippines, the country could ill afford a disease surveillance and response system that was out of sync with the rest of the world.

According to the PIDSR Manual of Operations (NEC-WHO, 2008), the PIDSR framework is one that

“... embodies an integrated functional disease surveillance and response system institutionalized from the national level down to the community level. Each level of the health care delivery system interacts with each other while performing their basic roles and responsibilities. Standard case definitions to detect priority diseases are to be used in all disease reporting units and a comprehensive flow of reporting is adopted.”

With PIDSR, the health sector has a surveillance system in place that enables early detection, reporting, investigation, assessment, and prompt response to emerging diseases, epidemics and other public health threats. By being integrated, PIDSR

“... emphasizes standardized nationwide preparation rather than ad hoc reactions to outbreaks; it secures human and financial resources needed to operate an on-going, effective system; monitors disease outbreaks particularly at the local level; confirms diagnoses if necessary through laboratory tests; reports outbreaks in a timely manner; responds with the most effective public health intervention based on hard evidence; takes action to prevent future outbreaks; and evaluates the performance of both the intervention and the surveillance system itself.”

Health and relevant institutions that are responsible for taking appropriate action in response to public health threats have been grouped into two: (a) local and (b) national disease surveillance and response modules. The local module includes provincial, municipal and city governments, health offices, hospitals, laboratories, surveillance units, ports and airports, media, and the community itself. This module is tasked with providing immediate response in the event of public health threats. The national disease surveillance and response module consists of corresponding agencies/communities at the regional and

national levels, with the Department of Health exercising overall leadership and providing technical support at the national level.

The Epidemiology and Surveillance Units (ESUs) at the municipality, city, and provincial levels were strengthened and when not yet existing, established to provide public health surveillance and epidemiology services. Staffing of the local health offices was also prescribed to ensure the presence of personnel responsible for surveillance. PIDSR-trained disease surveillance coordinators were also designated by hospitals to be at the frontline of disease notification, investigation and reporting. At the regional level, RESUs were responsible for consolidating data from the provinces as well as to provide technical support.

Vital to PIDSR's effective functioning is the quality, accuracy and timeliness of information as well as the existence of clearly-defined reporting and feedback systems for communicating information. PIDSR has capacitated ESUs at the primary level to transform data into useful information for front-line management, monitoring and measurement of progress on local targets. Through PIDSR, information is transformed into evidence, which when packaged, communicated and disseminated to decision-makers make them "change their understanding of the issues and needs" (NEC-DOH, 2008). Only when hard evidence is available would public health action be taken, which insures that interventions made are the appropriate responses to the threats to public health.

On top of PIDSR's framework is its goal of "Healthier Communities," which is achieved through the reduction of mortality and morbidity by an institutionalized, functional, integrated disease surveillance and response system nationwide. The objectives of PIDSR, as enumerated in the Manual of Procedures (2008), are as follows:

1. To increase the number of LGUs able to perform disease surveillance and response.
2. To enhance capacities at the national and regional levels to efficiently and effectively manage and support local capacity development for disease surveillance and response.
3. To increase utilization of disease surveillance data for decision making, policy making, program management, planning and evaluation at all levels.

Features of PIDSR in Relation to Climate Change

In formulating the M&E strategy for the health sector, the scope of work as prescribed by the National Economic and Development Authority (NEDA) envisioned the development of a new system and/or the enhancement of existing M&E system for national

and provincial development planning processes. The team opted for the latter, and selected to anchor the M&E system for climate change in the health sector on PIDSR.

PIDSR – its advantages for climate change M&E

The team took notice of the following advantages of PIDSR which firmed up the decision to anchor the M&E for climate change in the health sector on this existing system:

- 1) Inclusion of the five notifiable diseases, namely malaria, dengue, cholera, typhoid and leptospirosis, as targets for surveillance, under the category “epidemic prone diseases.” With the project team’s decision to focus on the five notifiable diseases, it was deemed important to use an M&E system that keeps track of these highly infectious, climate-sensitive diseases. Providentially, PIDSR has included them as targets for surveillance; thus, PIDSR affords an avenue in which the proposed monitoring system on the impacts of climate change on the five selected diseases can easily be configured.
- 2) PIDSR lends itself to early detection and response to epidemics. In view of the anticipated climate change impacts on health, which would assume epidemic proportions under business-as-usual scenarios, the capacity of PIDSR for early detection and response would be harnessed to address abnormally frequent disease occurrences and other emergency health situations borne by climate change.
- 3) PIDSR strengthened local capacity for surveillance and response. Vulnerabilities to climate change encompass the entire spectrum of society, but the degree varies depending on a number of factors. Vulnerabilities at the local levels, especially in resource-poor communities, are most likely to be high. This necessitates the ability to make localized decisions based on relevant and timely information and to intervene when necessary to avert projected disaster situations. With increasing human health risks attributable to climate change, the importance of having a local-level M&E system that is linked to the national level system for immediate support, cannot be over-emphasized.
- 4) Integrated response to epidemics and other public health threats. The impacts of climate change on health will most likely be brought about by the interplay of factors that will influence the severity and scope of disease occurrences and the lingering effects of disasters. Under such conditions, piecemeal approaches to respond to public health threats would produce

negligible and short-lived results. Having an integrated system may afford holistic solutions that will be more effective in the long term.

- 5) Open lines of communication are established at all levels. Actions at all levels, from the disease reporting units up to the national planners and decision-makers, that are designed to respond to climate change, will invariably require timely and reliable information from many sources. An institutionalized communication system that allows free exchange of information is critical to the success of interventions designed to reduce vulnerabilities to climate change, particularly during extreme weather events and occurrences of climate-related disasters.
- 6) PIDSR uses the latest in information technology for the reporting and dissemination of information. This augurs well for quick data consolidation, analysis and interpretation which are necessary inputs for prompt disaster response and real-time decision-making. Correlation with climatic data is also made a lot easier.

Limitations of PIDSR in relation to climate change

Despite its advantages, PIDSR in its present form cannot yet be fully adopted without modification due to some inherent limitations. The following are some of the features which are specific to the diseases that may limit PIDSR's usefulness as an M&E system on climate change in relation to health:

1. Dengue and malaria:

All indicators used to monitor dengue and malaria are medical signs and symptoms. No environmental data are collected to predict and confirm dengue and malaria cases.

2. Leptospirosis:

The indicators used to monitor leptospirosis cases include medical signs and symptoms as well as exposure to infected animals or an environment contaminated with animal urine (e.g., wading in flood waters, rice fields, and drainage). The climate change-related indicator used is only precipitation. Temperature and relative humidity are not considered.

3. Cholera:

The indicators used to monitor cholera are cases of dehydration and acute watery diarrhea to track the history of cholera epidemicity in an area. No environment or climate

change-related indicators are being monitored to be used as tool in predicting and/or anticipating suspected cholera cases.

Proposed Modifications to PIDSR to make it Climate Change Compliant

As mentioned in the foregoing discussions, the proposed M&E framework is anchored on an existing M&E framework in the Health sector which is PIDSR. However, as can be seen in **Error! Reference source not found.**, the project team is proposing that PIDSR be modified to reflect the importance of periodic assessments of vulnerabilities and the monitoring of adaptation systems in the light of climate change. It is strategic for the proposed M&E framework to be linked to the frameworks for these activities as well.

A common understanding of the meaning of vulnerability and adaptation is important. Hence, the following definitions of these and other related terms have been adopted, both from the IPCC report and the Climate Change Act of 2009 (GEF, 2008; Climate Change Act of 2009):

Vulnerability is the degree to which a system is susceptible to, or unable to cope with, adverse effects of climate change, including variability and extremes. It is a function of the **character**, **magnitude**, and **rate of climate change** and **variation to which a system is exposed**, its **sensitivity**, and its **adaptive capacity**.

Adaptive capacity is the ability of a system to adjust to climate change (including climate variability and extremes) to moderate potential damages, to take advantage of opportunities, or to cope with the consequences.

Adaptation refers to adjustments in natural or human systems in response to actual or expected climatic stimuli or their effects that moderates harm or exploits beneficial opportunities.

As per IPCC, various kinds of adaptation can be distinguished as follows:

Anticipatory adaptation – Adaptation that takes place before impacts of climate change are observed. This is also referred to as proactive adaptation.

Autonomous adaptation – Adaptation that does not constitute a conscious response to climatic stimuli but is triggered by ecological changes in natural systems and by market or welfare changes in human systems. This is also referred to as spontaneous adaptation.

Planned adaptation – Adaptation that is the result of a deliberate policy decision, based on awareness that conditions have changed or are about to change and that action is required to return to, maintain, or achieve a desired state.

GEF (2008) further qualified that climate change impact or vulnerability assessment is **ex-ante** evaluation which should be distinguished from monitoring and evaluation of adaptation interventions which is **ex-post** evaluation in nature.

Vulnerability assessment and its link to the M&E framework

On the left hand panel of the proposed M&E framework is the abridged vulnerability framework (described in great detail in other parts of the report). It is sufficient to mention the following main points on the methodology used and the significance of the framework *vis a vis* the overall M&E for climate change. As mentioned in the foregoing section, assessing vulnerabilities is an **ex ante** analysis, which for the health sector means being able to measure susceptibility to diseases, determining potential causes that contribute to more prevalent disease spread, and identifying weaknesses in the health system that can further deteriorate due to climate change.

The starting point for defining vulnerability relative to the five climate-sensitive diseases was the epidemiological triad which consists of host, pathogen and environment, and what contributes to these factors.

Relative to host as a factor, the contributors to this component of the triad have been broken down to individual and family and/or community related factors. Individual vulnerabilities can be determined from the following: (a) standard of living, (b) disease reservoir or the current level of infection, (c) genetic make-up, and (c) personal habits. Determinants of family community vulnerability include: (a) population density and growth, (b) unemployment and poverty levels, as well as (c) migration patterns and degree of urbanization.

On the aspect of pathogen as a factor, the following are deemed as contributory causes: (a) microbe replication and movement, (b) vector reproduction and movement, (c) microbe and vector evolution, (d) feeding frequency and longevity, and (e) habitat formation.

Vulnerabilities arising from the environment may be derived from contributions from the following: (a) the state of watersheds and forest cover, (b) loss of biodiversity, (c) access to safe water, (d) occurrence of flash floods, and (e) other factors such as sanitation, solid waste management, agricultural production and government policies and regulations that impact on human settlements, land use and zoning.

Finally, it is also important to know how the health system (including health infrastructure, quality, and access to health care) and health policy and regulations are making an impact on the vulnerabilities of individuals and communities relative to the five diseases.

Apart from the disease-related vulnerabilities that emanate from the epidemiological triad associated with each of the five (5) climate-sensitive diseases, the country's vulnerability associated with the occurrence of tropical cyclone is ranked highest in the world, and third in terms of people exposed to such seasonal event (CCC, 2010). On average, twenty (20) typhoons hit the country each year. El Niño droughts and La Niña flooding have been triggered by extreme climate variability. Erosible soils along steep/unstable mountain slopes, degraded forests and watersheds, unplanned settlements, combine with geologic/seismic dangers to put communities and individuals more prone to climate-related disaster risks.

It will be instructive to mention that the Vulnerability and Adaptation (V&A) Assessment Toolkit published by the Philippine Rural Reconstruction Movement under the Second National Communication on Climate Change (2009), identified the following communities as vulnerable to the effects of climate change on health: (a) far-flung barangays (mountainous or coastal); (b) populations that have least access to health services and are in congested/dense urban slum areas; (c) those in areas that are endemic to climate-sensitive diseases, e.g., malaria, coupled with "bad" health system; and (d) those that are culturally challenging, i.e., resistant to health education or change in their behavior towards health, brought about by culture or beliefs.

Adaptation strategies and relationship with the M&E framework

On the right hand panel of the M&E framework can be seen the abridged framework for the proposed adaptation strategies for the health sector. It should be readily apparent that the different categories of proposed adaptation strategies correspond with the identified vulnerabilities in the health sector relative to climate change. The evaluation of adaptation interventions takes the form of an **ex post** analysis, which means that what is going to be measured is the effectiveness of the proposed strategies in bringing about an improved capacity of individual and communities to weather the effects of climate change. It should be evident that strategies that result in improved adaptive capacity actually reduce vulnerabilities in the long term.

Although presented in separate boxes in the framework, the assessment of vulnerability and the formulation of adaptation strategies are best undertaken following a

continuum that enables the use of the results of vulnerability assessments as inputs for decisions *vis a vis* adaptation practices. This relationship is shown in the following matrix table which outlines the steps in V&A assessment in the health sector using climate sensitive diseases as the identified vulnerability (PRRM, 2009):

Table 36 Matrix showing the Climate Change and Health V&A Assessment Flowchart

Climate Change and Health V&A Assessment Flowchart			
Step 1 Identify/Screen health vulnerability in area/community	Step 2 Conduct analysis (Quantitative/Qualitative)	Step 3 Identify action to be taken	Step 4 Evaluate and feedback
<ul style="list-style-type: none"> ■ Presence of diseases (determine climate sensitivity/consider epidemic potential) ▶ Consider number of cases, occurrence of disease 	<ul style="list-style-type: none"> ■ Utilize sentinel sites NESSS/MET for weather parameters ■ Focused group discussions/KII 	<ul style="list-style-type: none"> ■ Preventive (adaptation) over curative (mitigation) parameters ■ Prioritize measures <ul style="list-style-type: none"> ○ Efficiency vs. Effectiveness ○ Cost/timeframe <ul style="list-style-type: none"> ▶ i.e., information drives/mass screening, smearing for febrile people, fast lane for Dengue ■ Policy formulation for health impacts – climate change compliance/resilience 	<ul style="list-style-type: none"> ■ Utilize statistical analysis and correlate adaptation measure ■ Identify indicators of success (intermediate and long-term) ■ Refine flowchart to incorporate other factors (i.e., socio-economic)
<ul style="list-style-type: none"> ■ Availability of response mechanisms ▶ Health infrastructure (human and financial/infra – health centers/hospitals) 			
<ul style="list-style-type: none"> ■ Occurrence of extreme weather events (quantity and quality) 			

Note: adapted from: Philippine Rural Reconstruction Movement (PRRM). 2009. *Vulnerability and Adaptation Assessment Toolkit. Philippines Second National Communication on Climate Change*

Principles of climate change M&E for the health sector

The team has identified the different principles that underpin the development of the M&E Strategy as follows:

- It shall verify the effectiveness of the implementation of policies, programs, and projects in terms of changes and/or improvements in the situation of target groups, their behavior, application and utilization of skills, and how these changes can be attributed to interventions such as technical assistance and management services delivered by implementers.

- The M&E system shall build on existing disease surveillance systems to collect data for the selected diseases and for tracking temperature and rainfall (precipitation) and should provide a mechanism for integrating, analyzing and decision-making involving the two data sets.
- The M&E system must be simple, provide quick results, be cost-effective and operated in a manner that is both transparent and with clearly-defined accountabilities and responsibilities.
- The M&E system must be able to provide a mechanism to facilitate the systematic communication and/or sharing of results across different levels, to include decision-makers, implementers, and the general public, especially at the level of the household, as well as for a feedback mechanism.
- The M&E system shall involve a minimum amount of relevant and practical indicators.
- The M&E system shall be subject to review every three years, and may be modified to take into account the lessons learned and to make it more attuned to the needs of stakeholders.
- The detailed implementation of the M&E strategy shall be described under M&E operations plan, to be formulated and implemented on an annual basis by the Department of Health.

This proposed set of principles is summarized in matrix format, as shown in Table 37, for the purpose of assigning responsibility centers, identifying appropriate tools, and listing of relevant indicators that will insure that each of these principles are observed/met in the implementation of the M&E framework.

Table 37 Matrix table showing the monitoring and evaluation principles, responsible actors and levels, relevant tools and indicators to be collected

Monitoring and Evaluation Principles	Actors / Levels	Tools	Indicators Collected	Indicators to be added
A. Tracking of Implementation of Policy, Programs and Projects	Policy: DOH Field level effectiveness: RHUs, local governments	PIDSR aggregate report incorporated into the Field Health Service Information System (FHSIS) annual morbidity report	Health status statistics, health services coverage, notifiable diseases	Environment / climate indicators
B. Build on Existing Surveillance System by Integrating Environmental Data Collection	Enabling policy: DOH & DOST Data analysis: National, regional and provincial Health Offices	Yearly report showing correlations between notifiable diseases and environmental factors	Same as above	Correlation statistics Capacity building needs on data analysis at different levels
C. Promote transparency and demonstrate clearly-defined accountabilities and responsibilities.	Enabling policy: DOH Field level application: Regional, Provincial, City and Municipal levels	Yearly summaries that can be readily attributed to weekly, monthly, and quarterly reports	Health systems statistics	PAGASA providing data services on climate parameters to health system operators
D. Systematic communication and/or sharing of results across different levels.	ALL levels	Reports, bulletins, press releases, radio broadcasts	Capacity building strategies for personnel of DRUs/ESUs; Availability of communication systems	Contact details of relevant media outlets and of health offices in various levels
E. Prudent selection of relevant and practical indicators	DOH, NDCC and Related Agencies	DAOs and other related policy issuances	Measures of usefulness of indicators	
F. Systematic review and development of the M&E system every 3 years	Enabling policy: DOH Inputs for system modification: All levels	M&E framework for the health sector	Results of periodic assessments	
G. M&E operations plan formulation and implementation	DOH: for integration into overall DOH annual operations plan	DOH annual operations plan	Budget for M&E	

The above principles complement the guiding principles of PIDSR as contained in DAO 2007-0036. The M&E framework on climate change for the health sector upholds the leadership of the DOH and is supportive of the agency's goal of attaining a more responsive health system for the country. The proposed M&E principles are also in agreement with the

spirit of decentralization with the strengthened recognition of the roles of local governments on matters pertaining to health. It also aims to be compatible with the 2005 IHR surveillance and response standards. It is designed to be useful and flexible, adopts the principle of partnership and shared responsibility, maintains privacy and confidentiality of patients' information, and will continue to demand professionalism and high ethical standards among public health workers.

Information needs and M&E strategy at different levels

National level

Information needs and uses

- The Department of Health will benefit from information on how the impact of climate change on the five (5) climate-sensitive diseases is influenced by policies and programs that are planned, designed and coordinated at the national level. In turn, the information will serve as inputs to modify, adjust or enhance government policies and programs, as well as those of partner institutions. Likewise, information from M&E will be useful in allocating DOH's resources and in directing potential partners to areas where support and assistance are needed. M&E information will also result in a better understanding of the factors that contribute to success or failure of interventions, and in ensuring the sustainability of achieving desired results for an extended time period. Finally, M&E will provide information on capacity strengthening requirements at all levels of implementation, which the national level agency (DOH) can use in negotiating with global donors.

M&E strategy

- The Department of Health (DOH) shall perform leadership and coordination roles in the implementation of the M&E strategy. It shall establish and maintain its linkage with the Department of Science and Technology (DOST), through the Philippine Atmospheric, Geophysical and Astronomical Services Administration (PAGASA), which "provides flood and typhoon warnings, public weather forecasts and advisories, and other specialized information and services primarily for the protection of life and property and in support of economic, productivity and sustainable development." DOH shall also coordinate with the National Disaster Coordinating Council (NDCC), being the President's adviser on disaster preparedness programs, disaster operations and rehabilitation efforts undertaken by the government and the private sector. NDCC acts

as the top coordinator of all disaster management efforts in the country. It also serves as the highest allocator of resources to support local Disaster Coordinating Council (DCC) efforts.

Local levels

Information Needs and Uses

Local government units (LGUs) and district/provincial hospitals will benefit from information that will enable them to assess impact of climate on disease occurrence at the local level, and to measure effectiveness of adaptation measures as well as to make decisions which to employ given local situations. In the case of impending climate extremes such as flooding, LGUs should be able to immediately provide localized responses and harness local partners to undertake the issuance of early warning systems, direct rescue operations, mobilize resources for containment of vectors, and to track movement of people affected by diseases so as to limit their spread and reach. M&E information shall enable LGUs to identify the weaknesses of data gathering systems, data quality and reliability that will be used as the basis for M&E system improvement, and of human resources (individual households, community members and health service providers) and institutional capacity building needs.

M&E strategy

M&E should build on existing systems, and should be based on available local resources and capacity, but enhanced through the setting up of coordination mechanisms with local weather stations, local radio stations and other mass media communication systems, and with clearly defined roles and timeframes in terms of data analysis, decision-making, and reporting mechanisms. The M&E system shall empower households and communities to implement measures for disease prevention and control and/or to minimize effects of extreme climate conditions when given clear and timely warning signals from LGUs. It should be linked with local disaster coordinating councils (at the level of the provinces, cities and municipalities, and barangays) on disaster preparedness and mitigation efforts.

Indicators for the proposed M&E framework

Indicators are vital in measuring the effectiveness of climate change adaptation interventions. Dashboard indicators are the ultimate measures of four domains in the Monitoring and Evaluation matrix (Climate and Environmental Parameters, Public Health and

Health Service Interventions, Environmental and Social Determinants of Health, and Health System and Infrastructure). Contributing to the attainment of dashboard indicators are the 1st, 2nd and 3rd level indicators. Based on the matrix, most of the indicators measured at the level of the community are 1st level indicators. The matrix is composed of eight sections and these include:

- Domains
- Dashboard indicators
- 3rd level indicators or outcome indicators
- 2nd level indicators or output indicators
- 1st level indicators or objective indicators
- Level and frequency of monitoring
- Position or agency responsible
- Source of information

The M&E matrix/ table contains different indicators for various stakeholders such as PAGASA, DOH and provincial and municipal LGUs as indicated in the “position or agency responsible” part of the matrix. **First level indicators** are the most basic of the 4 indicators and are first accomplished before 2nd level indicators can be attained. **Second level indicators**, on the other hand, contribute to the attainment of 3rd level indicators. **Third level indicators** also contribute to the description and attainment of the Dashboard indicators. **Dashboard indicators** are the final measures of overall attainment of the M&E domains.

In the M&E matrix, Indicators are read from right to left of the matrix or from 1st level indicators to dashboard indicators. Note that some of the indicators should be 1) routinely collected and such should be adopted and institutionalized by responsible agencies and 2) there are those that are collected once. Specifically, the Planning Team needs to:

1. **Commit to the monitoring and evaluation of indicators.** Commitment may be done through an ordinance or resolution or administrative order.
2. **Review and identify M&E areas or domains based on the matrix.** The team must be able to assess which of the M&E domains have already been established or have some accomplishments and which are relatively new.
3. **Identify persons responsible for the monitoring and evaluation.** Because the domains and indicators are many, it is proposed that a team be created to comprise people who will be responsible for implementing the M&E. While there will be persons collecting information at the level of the

community such as those doing the work and are familiar with the M&E indicator and how the information for these indicators will be collected, a team responsible for overseeing the implementation of the M&E is essential.

4. **With the use of the CC ME matrix, identify the indicators that will apply or that you will need to collect to your level.**
5. To adopt the ME matrix, identify indicators in the matrix that is already routinely collected at your level.
6. Because there is a hierarchy of indicators, adopt and institutionalize those that you still do not have and classify them according to whether they will be routinely collected or not. To accomplish nos. 4-6, it will be helpful to use a table or checklist in summarizing the information.

CC M/E Domains and Indicators	With data	Without data	Method of collection for indicators without data that is regularly collected	Frequency of collection (daily, monthly, quarterly, bi-annually and annually)	Means of data collection	Persons or sub-teams responsible for collecting data	Partner agencies for data collection (government or private sector groups)

1. **Identify mechanisms by which information/ data can be collected** (see last column of the table). Indicators may measure specific change in behavior or attainment of specific activities or interventions. Examples include:

- Routine survey of sampled households in the community (HH are sampled especially if it concerns the whole province or a group of provinces). Examples of indicator data that can be collected through this method include (see matrix):
 - Compliance to program IECs e.g. 4 o'clock habit (dengue); water disinfection and hand-washing (cholera and typhoid); Use of treated bed nets (malaria)
 - % of HH with sanitary toilets
 - % of HH with proper garbage disposal
 - % of HH with SAFE source of water
 - % of Establishments with sanitary permits
 - # of live larvae found in selected households (Breteau index)

- Routine survey of community environment through the use of an observation checklist. Examples of data that can be collected through this method include (see matrix):
 - Low lying areas; Presence of areas with stagnant/ swampy water in the municipality/ city
 - Flooded areas in the community
- Review of routinely collected information at the Rural Health Unit or Health Center and identification indicators can be used for climate change. Examples of indicator data that can be collected through this method include (see matrix):
 - #/% confirmed dengue cases
 - #/% confirmed leptospirosis
 - # of probable cases of malaria
 - # of probable dengue cases
 - # of deaths due to malaria disaggregated by age and sex
 - Availability of 1st-line and 2nd-line drugs for malaria, leptospirosis, cholera, dengue
 - % of Fully Immunized Children (FIC)
 - % exclusively breastfed children until 6 months
- Collection of records or documents at the LGU, DOH and DOST-PAGASA levels that specify that the indicator has been achieved. Such may be IEC (information, education and communication) materials, memorandum of understanding or agreement, written guidelines, ordinances/ resolutions or other forms of policy instruments, plans, project reports, budgets and meeting minutes. Examples data that can be collected through this method include (see matrix):
 - MOA among PAGASA/ local synoptic station, DOH and NDCC/ PDCC/MDCC
 - Trained PAGASA and LGU HR on local data analysis
 - Timely weather related information/ trends/ warnings shared by PAGASA to DOH and NDCC and LGUs through PDCC
 - Daily weather forecast information provided by PAGASA and shared with DOH and NDCC and LGUs through PDCC
 - PAGASA data used by LGU for planning for early response
 - # of capacity building seminars at LGU level on health emergencies and early response and adaptation

- % of LGU projects and activities funded and implemented on early response and adaptation, health emergency preparedness projects and activities
 - Presence of an adaptation plan/ strategy at the level of the barangay
 - PIDSR data analyzed with PAGASA data
 - Trained NEC- DOH and PAGASA HR to analyze and interpret data
 - DOH Surveillance teams launched to investigate outbreak or health emergency situations
 - Appropriate LGU response to outbreak or health emergency
 - DOH policy on integrated vector management enacted
 - Existing and functional programs found in LGUs on integrated vector management
 - National and local CC framework and implementation plan
 - # of R&D CC project proposals submitted by LGUs and institutions to DOH
 - Congressional bill (PNHRS) for CC and health research funding passed; Continuous sourcing out funds from international community
2. **For each, remember to determine the regularity of data collection per indicator and the persons responsible.** Persons or sub-teams responsible for collecting data are very important.
 3. **While it is important to identify M/E indicators at your level, it is also essential to identify data will that other agencies will contribute to your indicators.** Coordination and collaboration with these agencies are necessary. There is also a need to identify data that will be collected with the help of other agencies in government or in the private sector.
 4. **Determine the need for new data collection tools and design them.** For new data that will need to be collected. It is recommended that a technical working group be formed to work on the data collection tools or forms.
 5. **Determine the process of reporting through the DOH PIDSR.**
 6. **Determine human resource capacity/ capability in collecting data, recording and reporting.** CC capacity building training may be necessary to develop skills in collecting, recording and reporting new information/ data. Training proposals for funding can be developed to address capacity gaps.

Reconfiguring the existing reporting system for PIDSR

Current reporting arrangements/flow of information and responsibilities at various levels

As per PIDSR Manual of Procedures (2007), the existing reporting system starts from the local/municipal/city level and goes up to the national level through a number of steps that involves the provincial and regional levels. Each level and the units involved have clearly-defined and specified functions, and the flow of information between and among these bodies is shown in Figure 27.

Modified PIDSR Reporting and Response System Flow Chart w/ Climate Change

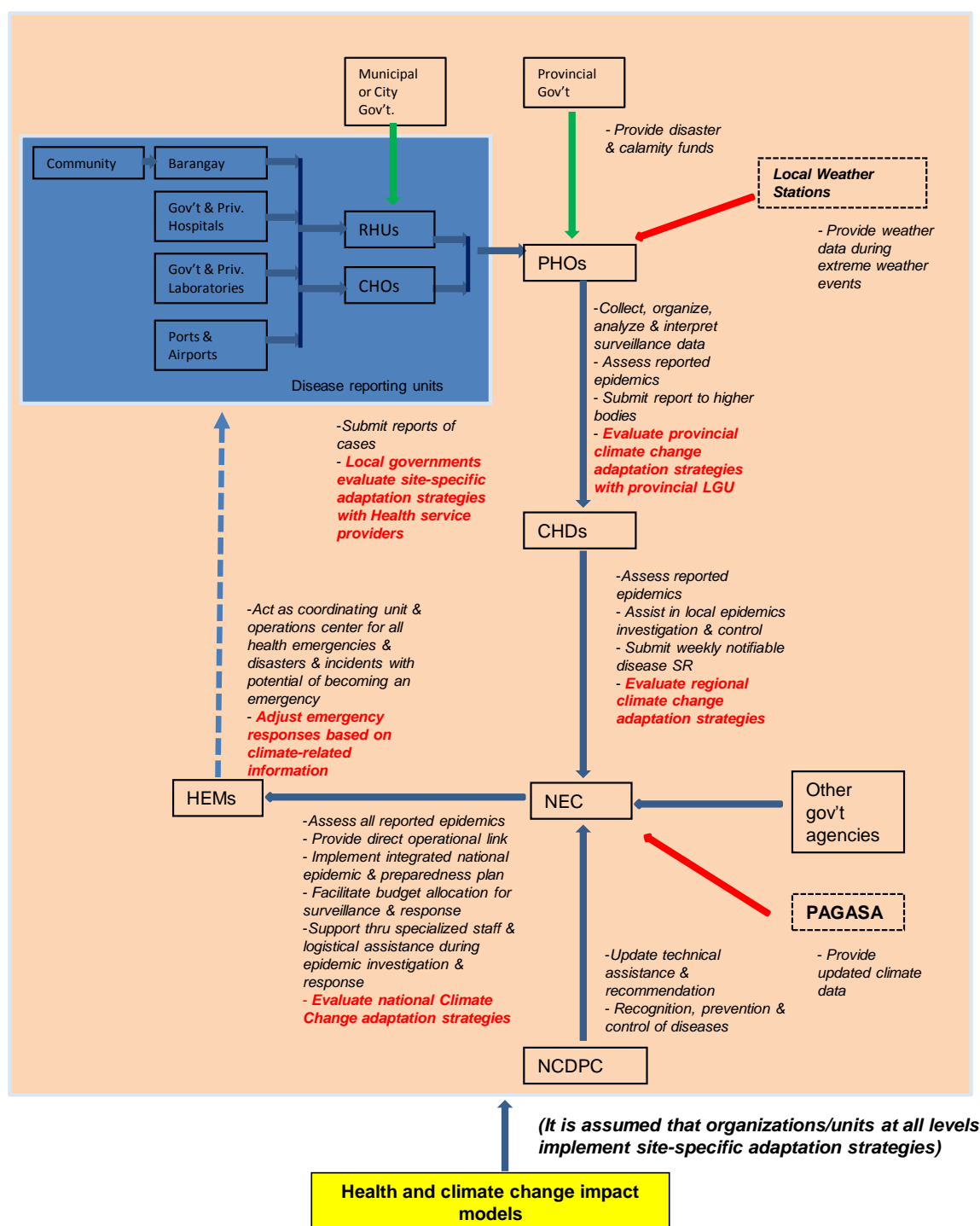


Figure 27 Proposed modification of PIDSR reporting system in the light of Climate Change

IV. CONCLUSIONS

A Vulnerability and Adaptation Impact Assessment Framework for the health sector was devised for this project and grounded the results and outputs of the study. The research team utilized this framework to test the other deliverables of the study and found that the framework works.

The categories of vulnerabilities that were culled from the review of literature and the round table discussion provided focus and specificity to the vulnerability assessment and adaptation documentation. Hence the team deems it is safe to be recommended for use in the country. While utilizable, the team avers that the framework can still be refined through pilot tests of the framework and its parts in different areas of the country and for various usages.

The following section provides more specific conclusions from the applications of the vulnerability assessment models that were derived in the project.

1. Disease impact models for dengue, malaria, and cholera were developed out of available data from the NCR and PHOs of Palawan, Pangasinan and Rizal. The robustness of the models depends on the accuracy of the health and climate data measurements or estimations. Leptospirosis and typhoid impact models were not formulated due to inadequate data. Disease impacts for 2020 and 2050 were conducted using the projection models that passed the statistical screening process. Refinements of the models may be done as additional data on health and climate change are made available.
2. Assessment and evaluation of health data showed purely medical-related data and no climate change data. This was a major problem. A remedial measure adopted was to match climate change data from PAGASA in the NCR, Palawan, Pangasinan and Rizal. The health data were also found incomplete in leptospirosis and typhoid. Also, disease cases were not available in Palawan, Pangasinan and Rizal. This could be due to lack of real disease occurrence or with disease occurrence but no documentation. Likewise, in NCR, only disease cases were available.

The Time Series Analysis also provided important insights into the climate change and impact assessments:

3. Consistent results that the observed minimum temperatures for the current month provide the most significant positive contributions to the model to predict the number of dengue cases for any month of observation.
4. **A peak of dengue incidence occurs thereafter in about a month after the start of the increase of cases. This coincides with the years when a surge of cases was experienced in NCR (as was mentioned previously: 1996, 1998, 2001, 2005 and 2006). (This is evident as crests of maximum temperature seem to frequently transpire a little earlier compared to the peaks of minimum temperature. This would be consistent with the lack of significance in estimates for dengue cases based on maximum temperature.)**

Economic impact analyses were accomplished for dengue and malaria. Other diseases such as leptospirosis, cholera, and typhoid were not covered in the economic analysis due to lack of data. Rizal was not also covered because of lack of both climate change and economic data on the selected diseases.

5. The results in NCR and Palawan indicate that malaria and dengue in 2020 would require about 1% of its annual income for the diagnoses and treatments of malaria and dengue. In 2050, the allocation for funding for the same diseases would reach no less than 2% of the provincial income.
6. However, Pangasinan in 2020 would need about 18% of its income only for diagnoses and treatments of malaria and dengue. In 2050, the budget requirement for both diseases would be reduced to 4% owing to the reduced number of malaria and dengue cases, which is not attributed to preventive measures that would be implemented, but to the changes in the climate indicators. Such climate change nonetheless, may be good from the point of view of reducing disease occurrence.
7. Considering the five diseases for budgeting purposes, the provincial government may allocate in the future roughly a total of 2.5% of the income of Palawan in 2020 and 5% in 2050 assuming that the average cost requirement of each disease would more or less be the same with malaria and or dengue. On the other hand, Pangasinan would allocate roughly 45% of its income in 2020 to address the five diseases and 20% in 2050.
8. Considering the substantial savings that could be generated from applying preventive measures, the two provincial governments may consider investing on financing

preventive measures to lessen the cost impacts of the diseases, thus lessen the burden of the provincial governments in addressing these diseases.

9. Provincial and municipal governments should not wait for the diseases to reach epidemic levels before they address the malaria and dengue outbreaks as well as other diseases that would emerge and be aggravated by climate change conditions. It is most certainly beneficial to prevent disease outbreaks before they even emerge.
10. Applying effective preventive measures against dengue would result in significant savings on the part of the provincial government in the amounts of PhP 10.9 M in 2020 and PhP 31.69 M in 2050.

V. RECOMMENDATIONS

1. The most critical recommendation that this study provides is that there is a need to improve the data bases and information systems that feeds into climate change vulnerability and adaptation assessment for the health sector. Currently, there are no linked data between health outcomes and meteorological information. Timely disease surveillance and case finding may be triggered by accurate weather and climate information that should be provided to health and LGU managers at all levels.
 - Governments should engage more actively with the **scientific community, who in turn must be supported to provide easily accessible climate risk information.**
 - Climate risk information should put current and future climate in the perspective of national development priorities.
 - Information needs of different actors should be considered and communication tailored more specifically to users, including the development community
2. Another major recommendation is to create systems to strengthen mainstreaming adaptation within existing poverty alleviation policy frameworks. There is a lack of research on the extent to which climate change, and environmental issues more broadly, have been integrated within national policy and planning frameworks. National Adaptation Programmes of Action or NAPA was a project funded by the Least Development Countries Fund (LDC Fund) and commissioned by the UNFCCC to the 48 least developed countries need to be utilized for this purpose.

This is critical. Examples of efforts from Sri Lanka, Bangladesh, Tanzania, Uganda, Sudan, Mexico and Kenya are presented, highlighting a number of key issues relating to current experiences of integrating climate change into poverty reduction efforts (IDS, 2006).

As previously discussed climate change stakeholders at all levels are increasingly engaging with the question of how to tackle the impacts of climate change on development in poorer nations. There are growing efforts to reduce negative impacts and seize opportunities by integrating climate change adaptation into development planning, programmes and budgeting, a process known as mainstreaming. Such a coordinated, integrated approach to adaptation is imperative in order to deal with the scale and urgency of dealing with climate change impacts (IDS, 2006).

In developed countries progress on mainstreaming climate adaptation has been limited. Many countries have carried out climate change projections and impact assessments, but few have started consultation processes to look at adaptation options and identify policy responses.

Experiences so far highlight a number of barriers and opportunities to mainstreaming climate change adaptation in developing countries. These are focused around information, institutions, inclusion, incentives and international finance, and result in a number of recommendations for national governments and donors.

In the context of climate change, mainstreaming implies that awareness of climate impacts and associated measures to address these impacts, are integrated into the existing and future policies and plans of developing countries, as well as multilateral institutions, donor agencies, and NGOs.

Developing countries, despite having contributed least to greenhouse gas emissions, are likely to be the most affected by climate change because they lack the institutional, economic, and financial capacity to cope with the multiple impacts.

Poorer developing countries are at risk as they are more reliant on agriculture, more vulnerable to coastal and water resource change, and have less financial, technical, and institutional capacity to adapt.

Under the United Nations Framework Convention on Climate Change, countries have to report on steps they are taking to address climate change (mitigation) and its adverse impacts (adaptation). Submitted reports are called National Communications and the chapters on adaptation contain information on baseline conditions and their linkages, which might include climate-related disaster effects and response capabilities, population, food security and agriculture, climate and health, environmental problems, and financial services available for management of climate risks.

The following section provides more detailed recommendations for specific research outputs:

On Impact modeling

For better disease impact modeling, the following are strongly recommended:

1. Improve existing database on health and climate change through standardization of health and climate change data monitoring forms and that data gathering should be localized. Since the occurrences of diseases are localized and climate change variations

are also localized, there is a need to strengthen the PHO and LGU in each province on health and climate change indicators monitoring, modeling, and analysis. The reason for this is to enable the health sector for immediate response to address climate change health-related problems without waiting decisions from the national level.

2. Basic weather instrumentation set up containing rain gauge, thermometer, evaporation pan, relative humidity measurer, wind velocity meter may be funded out of the IRAs of each of the provinces and may be installed in the municipalities. This is important to capacitate the municipal LGUs and provincial PHOs on health and climate change concerns so that immediate adaptation measures can be implemented right where the problems are.
3. Intensify research on the environmental habitat of disease vectors including the climate change conditions favoring their growth and their life cycles. Determine to what extent does the vector live and in what conditions. Identify the types of vector, where they are and estimate vector population so that proper strategies to control their spread may be implemented without waiting for an outbreak. Knowing the vulnerable areas by barangay would be a significant step in controlling diseases. In modeling, there is a need to include environmental variables that favor the occurrences of disease vectors and their population in addition to the climatic factors
4. Vulnerability assessment at the barangay level should be mapped for effective implementation of adaptation measures.
5. The models are not advisable for national application due to differences in the environmental conditions and climatic change factors in each of the provinces. Averaging provincial data would result in substantial discrepancies between predicted values and actual disease observations due to substantial inter-provincial variations on climatic and environmental conditions. The only remedy is for each province to develop its own impact models for climate change-sensitive diseases.
6. In order to address the threats of the climate change-related diseases, preventive measures were recommended for implementation for malaria and dengue control. Thus, the provincial governments are encouraged to fund such preventive measures to restrict the possible spread of the diseases. The effective implementation of the preventive measures will result in substantial savings from the income of the provincial government.

Other recommendations that would help the provincial governments to become more responsive in addressing the threats of climate change-related diseases include the following:

7. Conduct of studies on economic impacts of other climate change-related diseases such as leptospirosis, cholera, and typhoid in Palawan and Pangasinan.
8. Conduct of studies of economic impacts of malaria, dengue, leptospirosis, cholera, and typhoid in Rizal Province and other provinces that are vulnerable to climate change.
9. Pursue studies on the costs of other adaptation measures on health to minimize or control the impacts of climate change-related diseases.

Recommendations from time Series Analysis

10. Regarding the generalizability of the results of the models developed, though the data analysis had solely used data from cities of NCR, it would be **potentially useful to also apply the results to other LGUs elsewhere (i.e. other urban areas) where communities have experienced outbreaks of dengue in the past**. It is therefore critical that local health officials should work closely with national health authorities to coordinate efforts in mitigating the effects of a rise in temperature (i.e. recorded minimum temperature) on a possible increase in dengue cases and/or the occurrence of dengue outbreaks particularly during periods when an occurrence of an El Niño/La Niña – Southern Oscillation (ENSO) condition in the Pacific Ocean is announced and experienced.

Policy Recommendations

Policy recommendations have largely been culled from the literature as a full policy analysis for climate change and health was not feasible within the project. The following section contains those recommendations deemed appropriate for the Philippines.

- Recommendations for stakeholders:
 - A multi-stakeholder coordination committee should be established to manage national adaptation strategies, chaired by a senior ministry.

- Regulatory issues should be considered from the start of the mainstreaming process.
 - The capacity of existing poverty reduction mechanisms is consistent with existing policy criteria, development objectives and management structures.
 - Policy-makers should look for policies that address current vulnerabilities and development needs, as well as potential climate risks.
 - Actions to address vulnerability to climate change should be pursued through social development, service provision and improved natural resource management practices.
 - A broad range of stakeholders should be involved in climate change policy-making, including civil society, sectoral departments and senior policy-makers.
 - Climate change adaptation should be informed by successful ground-level experiences in vulnerability reduction.
 - NGOs should play a dominant role in building awareness and capacity at the local level.
- Recommendations for incentives:
 - Donors should provide incentives for developing country governments to take particular adaptation actions, appropriate to local contexts.
 - The economic case for different adaptation options should be communicated widely.
 - **A risk-based approach to adaptation should be adopted, informed by bottom-up experiences of vulnerability and existing responses.**
 - Approaches to disaster risk reduction and climate change adaptation should be merged in a single framework, using shared tools.

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