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CLIMATE RISK MANAGEMENT FOR THE HEALTH SECTOR IN NICARAGUA

Prepared by the International Institute for Sustainable Development (IISD)

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CRISIS PREVENTION AND RECOVERY

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FOREWORD

Climate change has the potential to exacerbate conflict, cause humanitarian crises, displace people, destroy livelihoods and set-back development and the fight against poverty for millions of people across the globe.

For example it is estimated that over 20 million people in the Mekong Delta and 20 million in Bangladesh could be forced to move as their homes are affected by salt water incursion from rising sea levels. Entire populations of some low lying island states, such as Nauru or the Maldives may have to be relocated. In countries like Honduras, where more than half the population relies on agriculture, climate induced risks, such as Hurricane Mitch in 1998, which caused over US$ 2 billion in agricultural losses, will continue to pose a staggering potential for damage. Similarly, climate risk assessments in Nicaragua show that changes in rainfall patterns, floods and drought could put human health at risk by increasing the prevalence of respiratory and water borne diseases and malnutrition.

Long-term incremental changes will mean that people everywhere must learn to adapt to weather or rainfall patterns changing or shifts in ecosystems that humans depend upon for food. Perhaps more worrying however, is that climate variability and change will also bring unpredictable weather patterns that will in-turn result in more extreme weather events. Heat waves, droughts, floods, and violent storms could be much more common in the decades to come. Climate change is "loading the dice" and making extreme weather events more likely. These disasters will undermine the sustainability of development and render some practices, such as certain types of agriculture, unsustainable; some places uninhabitable; and some lives unliveable.

As climate change creates new risks, better analysis is needed to understand a new level of uncertainty. In order to plan for disasters, we need to understand how climate change will impact on economies, livelihoods and development. We need to understand how likely changes in temperature, precipitation, as well as the frequency and magnitude of future extreme weather will affect any sector, including agriculture, water-use, human and animal health and the biodiversity of wetlands.

This report is a product of the Climate Risk Management – Technical Assistance Support Project, which is supported by UNDP's Bureau for Crisis Prevention and Recovery and Bureau for Development Policy. This is one in a series of reports that examines high-risk countries and focusses on a specific socio-economic sector in each country. The series illustrates how people in different communities and across a range of socio-economic sectors may have to make adaptations to the way they generate income and cultivate livelihoods in the face of a changing climate. These reports present an evidence base for understanding how climatic risks are likely to unfold. They will help governments, development agencies and even the communities themselves to identify underlying risks, including inappropriately designed policies and plans and crucial capacity gaps.

This series is part of a growing body of climate change adaptation resources being developed by UNDP. The Climate Risk Management – Technical Assistance Support Project has formulated a range of climate risk management assessments and strategies that bring together disaster risk reduction and climate change adaptation practices. The project is designing a common framework to assist countries in developing the necessary capacity to manage climate-induced risks to respond to this emerging threat. The climate risk assessments discussed in this report and others in the series will feed into a set of country-level projects and regional initiatives that will inform the practice of climate risk management for decades to come.

Addressing climate change is one of UNDP's strategic priorities. There is a strong demand for more information. People at all levels, including small communities want to understand the potential impact of climate change and learn how they can develop strategies to reduce their own vulnerability. UNDP is addressing this demand and enabling communities and nations to devise informed risk management solutions. UNDP recognises that climate change is a crucial challenge to sustainable development and the goal of building resilient nations.

As the full effect of climate change becomes apparent, it is assessments such as these that will become the lynchpin of national responses and adaptation strategies for many years to come. Like the threat from many disasters, there is still time to prepare for the worst impacts of climate change in developing countries if we expand our understanding now.

This knowledge must be combined with real preparedness and action at all levels. Only then will we be able to stave off the worst impacts of climate change in the most vulnerable and high risk countries of our world.

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The general methodology and analytical framework of the CRM TASP was conceptualized by Maxx Dilley, disaster partnerships advisor, and Alain Lambert, senior policy advisor, with key inputs from Kamal Kishore, programme advisor, Disaster Risk Reduction and Recovery Team, BCPR, in consultation with Bo Lim, senior climate change advisor, Environment and Energy Group, BDP. Within BCPR, the project implementation process has been supervised by Alain Lambert, Rajeev Issar and Ioana Creitaru, who provided regular inputs to ensure in-depth climate risk assessments and identification of tangible risk reduction and adaptation options. From BDP, Mihoko Kumamoto and Jennifer Baumwoll provided their input, comments and oversight to refine the assessment and recommendations. The overall project implementation has benefitted immensely from the strategic guidance provided by Jo Scheuer, coordinator, Disaster Risk Reduction and Recovery Team, BCPR, and Veerle Vandeweerd, director, Environment and Energy Group, BDP.

The climate risk assessments under the CRM TASP have been undertaken with the funding support of the Government of Sweden.

Building upon the CRM TASP general framework to tailor the process to country-level analysis, IISD developed a more detailed methodological framework for assessing climate risks and identifying climate risk management options in seven countries, including Nicaragua. Within IISD, Anne Hammill supervised the overall project implementation. Marius Keller supervised all in-country activities in Nicaragua and is the lead author of the present report.

For their valuable contributions to the project implementation and climate risk assessment process, the project team would like to thank Dr. Wilbert Lopez and his team at National Autonomous University of Nicaragua, Dr. Susana Altamirano and Byron Guzmán of the Ministry of Health (MINSA), Alicia Natalia Zamudio-Trigo of IISD, Miguel Reyes and Zoila Hernandez for their valuable research efforts; Suyen Pérez and her team at the Ministry for Natural Resources and Environment (MARENA) and Leonie Arguello and Maria Fernanda Sanchez of UNDP Nicaragua for accompanying and assisting in the coordination of the project as well as for their feedback on this report and other project outputs; and Dr. Jesus Marín of MINSA, Gabriela Abarca of MARENA, and the participants of the final review meeting for useful comments and feedback on various drafts of this report.

LIST OF ABBREVIATIONS AND ACRONYMS

BCPR	Bureau for Crisis Prevention and Recovery
BDP	Bureau for Development Policy
CATHALAC	Water Center for the Humid Tropics of Latin America and the Caribbean (Centro del Agua del Trópico Húmedo para América Latina y el Caribe)
CCAD	Central American Commission on Environment and Development (Comisión Centroamericana de Ambiente y Dasarrollo)
CEPAL/ECLAC	Economic Commission of Latin American and Caribbean (Comisión Económica para América Latin y el Caribe)
CEPREDENAC	Coordination Center for the Prevention of Natural Disasters in Central America (Centro de Coordinación para la Prevención de los Desastres Naturales en América Central)
CRiSTAL	Community-Based Risk Screening Tool – Adaptation & Livelihoods
CRM TASP	Climate Risk Management Technical Assistance Support Project
ENSO	El Niño Southern Oscillation
FAO	United Nations Food and Agriculture Organization
GDP	Gross Domestic Product
GRUN	Government of Reconciliation and National Unity (Gobierno de Reconciliación y Unidad Nacional)
HDI	Human Development Index
IFAD	International Fund for Agriculture Development
IISD	International Institute Sustainable Development
INETER	Nicaraguan Institute for Territorial Studies (Instituto Nacional de Estudios Territoriales)
IPCC	Intergovernmental Panel on Climate Change
MARENA	Ministry for Natural Resources and Environment, Nicaragua (Ministerio del Ambiente y los Recursos Naturales)
MDGs	Millennium Development Goals
MINSA	Ministry of Health (Ministerio de Salud)
NASA	National Aeronautic and Space Administration
PNDH	National Human Development Plan (Plan Nacional de Desarrollo Humano)
SICA	Central American Integration System (Sistema de la Integración Centroamericana)
SILAIS	comprehensive health service system (sistema local de atención integral en salud)
SINAPRED	National System for Disaster Prevention, Mitigation and Attention (Sistema Nacional para la Prevención, Mitigación y Atención de Desastres)
UN	United Nations
UNDP	United Nations Development Programme
UNFCCC	United Nations Framework Convention on Climate Change
WHO	World Health Organization

EXECUTIVE SUMMARY

This report presents the main results of an assessment of climate risk and risk management capacity in the health sector in Nicaragua, conducted under the Climate Risk Management Technical Assistance Support Project (CRM TASP) of the United Nations Development Programme (UNDP). The combination of different scientific and participatory research streams, including literature reviews, community consultations, statistical analyses, and policy and capacity assessments, provided a basis for identifying climate-related health risks and prioritizing measures to manage them.

As the poorest country in Central America, Nicaragua faces massive development challenges. Nicaragua's health sector suffers from low expenditures, leading to low staff levels, infrastructure shortages, and generally low capacities for dealing with climate-related health impacts. Access to clean water and sanitation is limited, and undernourishment is high. The current National Human Development Plan (GRUN, 2008; 2009) emphasizes poverty reduction and citizen empowerment, and it outlines a range of short-term development objectives, several of which are related to health as well as to water and sanitation. In addition, several of the Millennium Development Goals (MDGs) that Nicaragua has signed on to relate to health.

Nicaragua's climate is tropical. The Pacific slope has a clearly marked rainy and dry season, whereas it rains more, and all year, on the Atlantic side. Climate variability is mainly driven by the Intertropical Convergence Zone and El Niño Southern Oscillation (ENSO) and manifests itself in tropical cyclones and storms, heavy rainfall, and floods, as well as irregular droughts. Observed trends show that average temperatures have increased by about 0.9° C throughout Nicaragua since 1960; rainfall has decreased by about 5 to 6 percent per decade, but heavy rainfall events have increased. Climate scenarios project continued warming of 3° C to 4° C by the end of the century. Rainfall trends are less clear but tend to be negative, and extreme events remain hard to project, although their overall frequency and intensity will probably increase.

Every year cyclones, floods and droughts claim dozens of lives, affect tens of thousands of people, or cause millions of dollars in damages. Climate change could increase these impacts. Climate conditions can affect some of the fundamental pillars of health, such as air temperature, water quality and quantity, food and nutrition, biodiversity, shelters and infrastructure, and mental health. Statistical analysis has helped identify seasonal patterns for diarrhœal disease, dengue and leptospirosis, which suggests that floods and standing water resulting from heavy rainfall have a clear influence on the epidemiology of these diseases. Interannual trends further suggest that extreme events such as storms and droughts also influence the prevalence of these diseases in any given year. Climate change could worsen impacts mainly through increased water scarcity.

The vulnerability of human health to climatic conditions appears to be mainly dependent on access to clean water and sanitation, while other relevant factors include availability of health services, occupation, community organization, knowledge and awareness, food security, infrastructure safety, and gender equity. The weakness of these factors in many areas of Nicaragua leads to significant climate-related risks to human health in the form of increased prevalence of water-borne diseases, such as diarrhœa, and vector- and rodent-borne diseases, such as dengue and leptospirosis; increasing malnutrition and related diseases due to climate impacts on agricultural productivity; and the destruction of health infrastructure. Such local-level impacts can also put at risk the achievement of larger development goals, including reducing maternal and infant mortality, expanding access to water and sanitation, and reducing malnutrition. The strain on public budgets due to climate-related health costs can also threaten the achievement of other goals. It is important to take decisive action to avoid vicious circles of increasing vulnerability and decreasing adaptive capacity in the coming years.

Nicaragua has authorities and structures that are clearly designated for both disaster risk management and climate change. There are liaison officers among these structures, but no established mechanisms for inter-institutional coordination with the health sector. Similarly, climate risks are recognized as a threat to development in the 'National Human Development Plan,' but not in the 'National Health Policy.' In sum, while Nicaragua already has an institutional basis for managing climate risks, significant deficiencies remain in terms of climate vulnerability and risk assessments, prioritization of risks and risk management options, coordination among agencies, information management, and implementing climate risk management actions.

To reduce climate risks in health, we recommend efforts to increase access to clean water and sanitation, improve water management and efficient water use, expand flood controls and promote reforestation of water catchment areas and riverbeds, expand health services, raise awareness and conduct education campaigns, strengthen community organizations, and promote investments in climate and health data monitoring and early warning. Actions in other sectors, such as agriculture and infrastructure, also have an impact on health. Further research could expand and deepen knowledge of climate-related health risks geographically and in terms of analysed diseases. On the policy level, we recommend that climate risk considerations be appropriately integrated into health policy documents, that cooperation between health and climate agencies be institutionalized, and that governmental capacities in the area be strengthened. A comprehensive climate risk management programme to holistically implement these recommendations should be established.

INTRODUCTION

Climate risk management is the systematic approach and practice of incorporating climate-related events, trends and projections into development decision-making to maximize benefits and minimize potential harm or losses. Climate change is altering the nature of climate risk, increasing uncertainty and forcing us to re-evaluate conventional climate risk management practices. Historical experience with climate hazards may no longer be a sound basis for evaluating risk; observable trends and longer-term, model-generated projections must also be taken into account if development is to be truly sustainable.

Recognizing this shifting reality, UNDP, through its Bureau for Crisis Prevention and Recovery (BCPR) as well as the Environment and Energy Group of its Bureau for Development Policy, designed the CRM TASP to assist countries in identifying climate-related risks, risk management priorities and capacity needs as a basis for programme development, policy and planning. The International Institute for Sustainable Development (IISD) was commissioned to implement the project in seven countries in Africa and the Latin America and Caribbean region, including Nicaragua, in close collaboration with UNDP Country Offices, governments and other partners.

In each country, the main outputs of the project are the prioritization of climate-related risks, a focused risk assessment for a priority sector or area, and the identification of risk management options for that sector or area. This information provides an evidence base for examining the adequacy of the institutional and policy environment for implementing risk management solutions. The present report summarizes the main results of the research conducted in Nicaragua, where the project stakeholders chose health as the focus sector.

APPROACH AND METHODS

Three key principles guide the implementation of CRM TASP in each country. First, the project builds on existing climate risk information and aims to fill critical knowledge gaps. Second, the main research phase focuses on one key sector, in order to produce useful and concrete recommendations. Third, with a view to building capacity to identify, prioritize and manage climate risk, IISD works closely with in-country partners who execute important parts of the research. These principles are put into practice in each country through a generic six-step implementation process (see table 1).

TABLE 1. PROJECT STEPS AND METHODS

PROJECT STEP	PURPOSE	METHODS USED IN NICARAGUA
1. Engagement	• Raise awareness about CRM TASP. • Secure country-level ownership and support for process.	• Inception meetings and discussions with key stakeholders.
2. Broad climate risk assessment	• Understand and synthesize existing data and information on climate risk and risk management options.	• Literature review conducted by in-country experts and practitioners.
3. Risk prioritization I	• Identify gaps and priorities for climate risk assessment and management, which can be addressed in a focused risk assessment.	• National inception meeting with key stakeholders; health identified as focus sector.
4. Focused climate risk assessment	• Understand the nature of climate risk for a specific priority sector, ecosystem or social group (health was chosen as the focus sector in the case of Nicaragua).	• Statistical analysis of relationship between monthly and annual climate and health data (Altamirano and Guzmán, 2012). • Community consultations based on the CRiSTAL tool (López et al., 2011).
5. Risk prioritization II	• Identify and prioritize climate risk management options based on the more focused assessment.	• Regional workshop based on participatory scenario development (PSD) methodology. • Policy and capacity analysis.
6. Reporting and dissemination	• Elaborate and validate results. • Secure country-level ownership of results.	• National revision workshop. • Publication of final report.

In Nicaragua, the participants of an inception meeting held in March 2011 chose health as a focus sector for the climate risk analysis, mainly based on the recognition that it has been previously prioritized among other sectors and because, contrary to areas like agriculture and water, climate risks in health have yet to be studied in detail. For example, the first 'National Communication to the United Nations Framework Convention on Climate Change' (UNFCCC) (República de Nicaragua, 2001) identified health as one of five sectors relevant to climate change adaptation. The 'National Human Development Plan' (GRUN, 2009) establishes health as a strategic sector. The 'National Strategy on Environment and Climate Change' (GRUN, 2010) doesn't explicitly prioritize sectors, but it mentions health as an important theme in the context of climate change adaptation. Furthermore, the Ministry for Natural Resources and Environment (MARENA) conducted extensive consultations in preparation for its second 'National Communication to the UNFCCC,' in which health came out as a priority sector. Climate variability and change can affect human health significantly, for example through the spread of water- and vector-borne diseases such as diarrhœa and dengue. Yet the specific knowledge on the risks and risk management options in Nicaragua is limited to a short study on malaria presented in the first 'National Communication to the UNFCCC' and to a discussion paper on health and climate elaborated in the context of the UNDP project 'Capacity Development for Policy Makers to Address Climate Change.' Therefore, in-country stakeholders felt that focusing the CRM TASP on health could strengthen the knowledge base in a crucial area.

CRM TASP undertook several research tasks. An initial **synthesis study**, conducted by national experts, provided some general background on climate risks and impacts. A **statistical analysis** linking monthly and annual climate and health data in three municipalities with high prevalence of dengue, diarrhœa and leptospirosis provided a quantitative exploration of which climate conditions may have favoured the spread of these diseases in the past. It was carried out by Nicaraguan consultants Altamirano and Guzmán (2012). A team from the National Autonomous University of Nicaragua conducted **community consultations** in the same municipalities as the statistical analysis to allow for a validation of the quantitative results from a qualitative perspective, giving more specific insights into factors of vulnerability that may favour the spread of diseases, and local capacities that help communities to deal with both vulnerability and risk. The results of both studies were presented at a workshop with participants from both the climate and health sectors, mainly from governmental agencies. The workshop was held in December 2011 and was based on the participatory scenario development methodology (Bizikova et al., 2009, 2010). It allowed participants to explore climate and health linkages collaboratively and propose strategies for managing climate risks in the health sector. A policy and capacity analysis completed the climate risk assessment.

KEY CONCEPTS

In this report, 'climate risk' refers to the probability of harmful consequences or expected losses resulting from the interaction of climate hazards with vulnerable conditions (UNISDR, 2004). 'Climate hazard' refers to a potentially damaging hydrometeorological event or phenomenon that can be characterized by its location, intensity, frequency, duration and probability of occurrence. This report considers both events with an identifiable onset and termination, such as a storm, flood or drought, and more permanent changes, such as a trend or transition from one climatic state to another, as hazards (Lim et al., 2005).

'Exposure' is a second element of climate risk. It refers to the presence of people and assets in areas where hazards may occur (Cardona et al., 2012). Finally, 'vulnerability' refers to the potential for a system to be harmed by something, and in the CRM TASP this 'something' is a climate hazard. When assessing vulnerability, we need to recognize the hazard specificity of people's vulnerability; indeed, the factors that make people vulnerable to earthquake are not necessarily the same as those that make people vulnerable to floods (UNDP 2004). We understand vulnerability to be a function of a system's sensitivity and its adaptive capacity, as depicted in Figure 1.

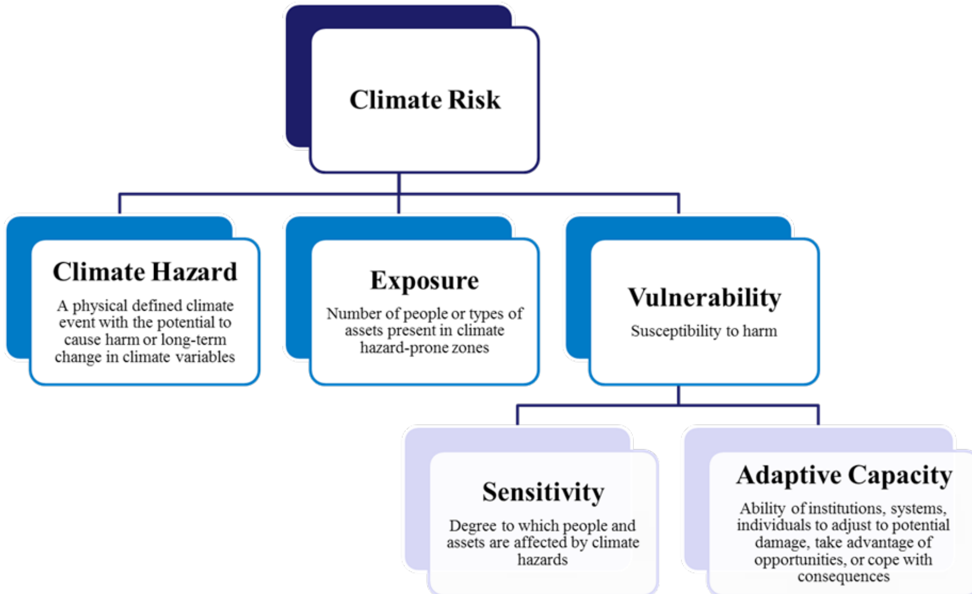

Figure 1. Components of climate risk

REPORT STRUCTURE

This report has six sections. After this introduction, 'Development Profile' (pp. 14–19) describes the current **development conditions**, trends and objectives, with a subsection on health, sets the baseline against which climate risks can be assessed. 'Climate Profile (pp. 20–25) on **climate conditions, variability and change**, describes mainly the hazard side of the risk equation. Next, 'Climate Impacts and Risks' (p. 26–35) provides an overview for the country and a detailed analysis **for the health sector**, building on the various primary research tasks described above. 'Institutions and Policies for Climate Risk Management' (pp. 36–39) looks at the **institutions, policies and initiatives** that exist currently to deal with climate impacts and risks. Finally, 'Recommendations for Climate Risk Management' (pp. 40–44) concludes with actions to reduce the risk of negative impacts on health, as well as on the necessary changes regarding institutions and policies to facilitate the implementation of such actions, and provides direction for further research.

DEVELOPMENT PROFILE

The general development conditions of a country play an important role in determining climate risk, particularly the vulnerability of its sectors. Factors like incomes or social capital are key elements of adaptive capacity, and determine in part how well people can deal with climate hazards. This first section lays the basis for the subsequent risk analysis by summarizing development conditions, trends and challenges, as well as the vision, objectives and priorities for future development. Conditions, trends and priorities of the health sector are given particular attention.

NATIONAL DEVELOPMENT CONDITIONS, TRENDS AND CHALLENGES

The Republic of Nicaragua is the largest Central American country by area. Its territory of 129,494 km2 is bounded by Honduras to the north, the Caribbean Sea to the east, Costa Rica to the south and the Pacific Ocean to the west. It is administratively divided into 15 departments and two self-governing regions on the Atlantic coast, as well as 153 municipalities. Nicaragua is geographically divided into three main regions: the Pacific lowlands to the west, the central highlands, and the Atlantic region to the east (MARENA, 2001).

Figure 2. Map of Nicaragua (courtesy of United Nations, 2012a)[1]

[1] The boundaries and names shown on this map do not imply official endorsement or acceptance by the United Nations.

In 2011 an estimated 5,869,000 people lived in Nicaragua (UNDP, 2011b). The rural population represented 43 percent of the total in 2010, down from 50 percent in 1981 (World Bank, 2012). Current population growth is estimated at 1.4 percent annually (UNDP, 2011a). By 2050, Nicaragua's population will grow to between 6.6 and 9.2 million, according to the United Nations (UN, 2012a). Even though fertility rates are decreasing, urbanization will increase due to rural-urban migration (UNDP, 2010b).

Poverty and human development

Nicaragua is the second-poorest country in Latin America, after Haiti, and the poorest in Central America (IFAD, 2011). In 2010, gross national income in terms of purchasing power parity was US$2,790, almost three times less than the regional average (World Bank, 2012). Yet even this low average is very unequally shared across the population. Nicaragua's Gini coefficient, a measure of inequality where higher values correspond to greater inequality, stood at 52.3 in 2011 (UNDP, 2011b). This reflects the fact that 46.2 percent of the population lived below the national poverty line in 2005, down from 50.3 percent in 1993. Rural poverty is significantly higher, at 67.9 percent in 2010, compared with 29.1 percent in urban areas (World Bank, 2012).

In line with this divide, poverty is also more concentrated in the eastern, more rural half of the country. According to the National Institute of Development Information (2007), extreme poverty was 70.9 percent and 63.1 percent in the Northern and Southern Autonomous Atlantic Regions, respectively; over 50 percent in Jinotega and Río San Juan; between 40 percent and 50 percent in most central departments; and lowest in the Pacific region. Due to these differences, many farm workers are migrating towards the Pacific region (IFAD, 2011).

Education remains a problem. The median child goes to school for only 5.8 years, much less than the regional average median of 7.26 (see table 2). Only 18 percent of the population enjoys tertiary education, and 22 percent of those above 15 years old are illiterate. The country spent 3.9 percent of total Gross Domestic Product (GDP) on education in 2011 (UNDP, 2011a). Life expectancy in the same year stood at the regional average of around 74 years. For further health indicators, please refer to subsection 2.3.

Nicaragua ranks 101 out of 146 countries in UNDP's Gender Equality Index. In 2011, women occupied 20.7 percent of the seats in the National Assembly. Only 47.1 percent of women participate in the labour market, compared with 78.4 percent of all men, and 30.8 percent of women enjoy secondary education, compared with 44.7 percent of men (UNDP, 2011a). Maternal mortality has dropped from 140 out of 100,000 in the year 2000 to 100 in 2008 (World Bank, 2012).

UNDP's Human Development Index (HDI) summarizes the development state of countries by ranking them according to life expectancy, schooling and income. Nicaragua currently ranks 129, slightly above Guatemala but below all other Central American nations (see table 2).

TABLE 2. HUMAN DEVELOPMENT INDEX VALUES AND COMPONENTS FOR CENTRAL AMERICA (DATA SOURCE: UNDP, 2011A)

COUNTRY	HDI RANK (2011)	HDI VALUE (2011)	LIFE EXPECTANCY (YEARS, 2011)	MEDIAN YEARS OF SCHOOLING (2011)	EXPECTED YEARS OF SCHOOLING (2011)	GROSS NATIONAL INCOME PER CAPITA (CONSTANT 2005 PPP USD)
Belize	93	0.699	76.1	8.0	12.4	5,812
Costa Rica	69	0.744	79.3	8.3	11.7	10,497
El Salvador	105	0.674	72.2	7.5	12.1	5,925
Guatemala	131	0.574	71.2	4.1	10.6	4,167
Honduras	121	0.625	73.1	6.5	11.4	3,443
Nicaragua	129	0.589	74.0	5.8	10.8	2,430
Panama	58	0.768	76.1	9.4	13.2	12,335
Average	***100.86***	***0.67***	***74.57***	***7.09***	***11.74***	***6,372.71***

Economy and politics

Valued at market exchange rates, the Nicaraguan GDP in 2012 amounted to US$6.6 billion, or US$1,110 per capita. Agriculture, including livestock, fisheries and forestry, represented 21 percent of the economy, compared with 30 percent and 49 percent, respectively, for the secondary and tertiary sectors. Imports and exports of goods and services amount to 111 percent of GDP (World Bank, 2012). Recent economic growth exceeded 3 percent in 2007 and 2008, but slumped to 1.5 percent in 2009, before appearing to pick up speed again in 2010. The economy remains highly dependent on oil imports, and so is vulnerable to oil price shocks. It is also dependent on trade with the United States (which represents 30 percent of the export market) and on remittances, which account for 13 percent of Nicaraguan GDP (World Bank, 2011).

Agriculture remains a mainstay of the economy. Almost one-third of formal employment is in this sector (World Bank, 2012). Among the rural poor, 80 percent depend on agriculture for their livelihood, producing mainly sorghum and maize in the lowlands and beans and vegetables in the highlands (IFAD, 2011). Agriculture also makes up for three-quarters of all exports, earning the country over US$1.1 billion in foreign exchange (FAO, 2011).

After decades under the successive dictatorships of the Somoza dynasty, Nicaragua went through a revolution and civil wars in the 1970s and 1980s and became a democracy in 1990. Since then, it has held free elections every four years at the national level (Winslow, 2012). President Daniel Ortega won re-election in late 2011. In terms of crime, although there are many cases of rape and murder, the level of violence is much lower than in neighbouring countries such as Honduras.

Environment

Nicaragua has access to large water resources, thanks to the two biggest Central American lakes, Lake Nicaragua and Lake Managua, even though these resources are unequally distributed across the territory. Environmental problems mainly relate to deforestation and soil degradation. Overexploitation is particularly serious in the resource-rich Pacific region. However, the central and Atlantic regions have also suffered from degradation due to forest fires and expansion of the agricultural frontier (MARENA, 2001).

NATIONAL DEVELOPMENT VISIONS, OBJECTIVES AND PRIORITIES

Nicaragua's 'National Human Development Plan' (PNDH in Spanish) was revised and updated for the 2009 to 2011 period and outlines the developmental priorities of the government. As the name suggests, the plan focuses on human development, a fact that is reflected in the prioritization of poverty eradication and the empowerment of citizens. The PNDH (GRUN, 2009) identifies the overall goal of fighting extreme poverty, as well as six further main challenges and associated development objectives. Table 3 presents these areas along with sample indicators. Note that no objectives beyond 2011 are stated in the PNDH. The government is currently reviewing the achievements of the current plan with a view to elaborating a new PNDH for the next period.[2]

[2] Personal communication with MARENA, 22 February 2012.

TABLE 3. STRATEGIC THEMES, OBJECTIVES AND SAMPLE PROGRESS INDICATORS OF THE 'NATIONAL HUMAN DEVELOPMENT PLAN' (DATA SOURCE: GRUN, 2009)

	STRATEGIC THEME	OBJECTIVE	SAMPLE INDICATORS
1.	Fight extreme poverty	Reduce the percentage of people living in extreme poverty	Reduce extreme poverty from 17.2% in 2007 to 16.2% in 2011.
2.	Macro-economy and finances	Create a stable macroeconomy to support human development; provide sustainable and efficient public finances to fight poverty; align international cooperation with national priorities; achieve economic growth through sound macroeconomic policies, increased public and private investment, and improved access to external markets.	Increase real economic growth rate to 2.5% and per capita growth to 1.2% in 2011.
			Reduce inflation to 5.9% in 2011, compared with 11.1% in 2007.
			Ensure 43.2% of public spending is directed towards poverty reduction in 2011.
3.	Well-being and equity	Increase food production for domestic consumption (food security); foster well-being and equity through the expansion of health and education services as well as access to water and better sanitation.	Ensure 75,000 families benefit from the *bono productivo* program on food security by 2011.
			Reduce illiteracy rates from 20.2% in 2007 to 3% in 2011.
			Increase access to drinking water from 2007 to 2011, from 56.3% to 64.1% in rural areas and from 72% to 86% in cities.
4.	Production	Increase electricity production and its transmission infrastructure; improve infrastructure to increase access to basic services and markets.	Increase electricity-generation capacity by 344 MW from 2007 to 2011.
			Construct 390 new km of secondary roads by 2011.
			Increase agricultural production by 10.5% in 2011.
5.	Environment and natural disasters	Promote environmental sustainability; reduce pollution; improve the prevention and mitigation of natural disasters (reduce natural disaster impacts on the country).	Reforest 81,300 ha between 2007 and 2011.
			Increase the number of early-warning systems for various hazards from 2 to 15 by 2011.
			Extend community disaster risk committees to all communities by 2011.
6.	Development of the Caribbean coast	Reduce interregional disparities by promoting the development of the autonomous regions along the Caribbean coast of Nicaragua (in terms of education, property, etc.).	Reduce illiteracy from 28.6% in 2007 to 1.2% in 2011.
			Formulate multiannual regional budget plan for at least 4 sectors by 2011.
7.	Public management	Improve the governance and transparency of public sector institutions.	Ensure that 48 state institutions provide public information to citizens by 2011.
			Reduce crime index by 5%, to 11% per year.
			Hand over 16,000 property titles per year.

These objectives are largely in line with the United Nations' Millennium Development Goals (MDGs). According to the United Nations' *MDG Monitor* (UN, 2012b), Nicaragua has already achieved the stipulated objectives regarding gender equality and empowerment of women and is on track to achieving universal primary education. The goal of reducing child mortality by two-thirds appears still achievable, whereas the proposed improvements in maternal health already appear out of reach. No evaluation is made regarding the other four goals, although the World Bank (2011) thinks poverty reduction and access to sanitation are on track, too, while goals on chronic malnutrition, access to water and, contradicting the *MDG Monitor*, primary school enrollment are unlikely to be achieved.

THE HEALTH SECTOR

Nicaragua's health conditions and services are improving, but lag behind advances made in other Central American nations. According to data from the World Bank (2012; see table 4 below), life expectancy was 73.4 years in 2009, almost the regional average and higher than the global average. Similarly, child and maternal mortality have decreased steadily over the past decade and are slightly higher than the regional average, but much lower than worldwide rates. However, Nicaragua is far behind both the region and the world when it comes to undernourishment rates as well as water and sanitation. Almost one-fifth of the population does not receive enough dietary energy on a continuous basis. Malnutrition is especially serious for children. In 2005, 18.8 percent of children under five were significantly too short, and 4.3 percent did not weigh enough, because of lack of nutrition.

TABLE 4. SELECTED HEALTH SECTOR INDICATORS (DATA SOURCE: WORLD BANK, 2012)

INDICATOR	NICARAGUA (2000)	NICARAGUA, LATEST	CENTRAL AMERICA, LATEST	WORLD, LATEST	LAST FIGURES ARE FROM
Life expectancy at birth	69.6	73.4	74.1	69.4	2009
Child mortality per 1,000 (under 5)	42.7	26.9	20.8	57.9	2010
Lifetime risk of maternal death	0.53%	0.33%	0.30%	0.70%	2008
Undernourishment	25% (2001)	19%	12%	13%	2008
Access to improved water:					2008
• Total	80%	85%	92%	87%	
• *Rural*	*62%*	*68%*	*84%*	*78%*	
• *Urban*	*92%*	*98%*	*97%*	*96%*	
Access to improved sanitation:					2008
• Total	48%	52%	78%	61%	
• *Rural*	*32%*	*37%*	*70%*	*45%*	
• *Urban*	*61%*	*63%*	*83%*	*77%*	
Health expenditures per capita, constant 2005 international $	129	254	550	944	2009
Public health expenditure, in % of GDP	3.7%	5.4%	4.5%	6.1%	2009

Despite recent improvements, Nicaragua trails regional and global averages in access to water and sanitation. In rural areas, just over two-thirds of the population have access to clean water, and only one-third to improved sanitation. In urban areas, water access is now almost universal, but 37 percent still lacked good sanitation in 2008. Conditions of hygiene are further compromised by inadequate waste treatment. Although solid waste is collected in most urban areas, a recent study by Soza and Blackwell (2011) finds that not a single landfill is adequately operated. Many of them are no more than open deposits. Environmental regulations enacted on the national level are not applied locally. Industrial and medical waste is not treated adequately. Furthermore, wastewater is mostly released onto streets and into courtyards and water bodies (Water and Sanitation Program, 2008).

In Nicaragua, 33 percent of lost years of life are caused by communicable diseases, a much higher share than on average in the Americas (WHO, 2012b). According to the Ministry of Health (MINSA, 2011), some of the most important diseases include respiratory diseases (3,839 cases per 10,000 in 2010), diarrhœa (515), pneumonia (423), dengue, leishmaniasis and leptospirosis. Tuberculosis has decreased in most parts of the country, but is still prevalent in the Atlantic region. HIV/AIDS has a relatively low prevalence in Nicaragua (MINSA, 2008). Malaria is unofficially considered eradicated.[3]

The Nicaraguan government spent 5.4 percent of GDP on health in 2009. This is more than in all other Central American countries except Costa Rica and Panama. However, Nicaraguan GDP per capita is the lowest in the American hemisphere, so that its per capita expenditure on health is the second lowest in the region. Nicaragua has only about 0.9 hospital beds, 1.07 nurses or midwives and 0.37 physicians per 1,000 people. Even though many Central American nations don't fare better, worldwide averages are about three times these rates.

[3] Personal communication with MINSA, 6 December 2011.

MINSA is the main supplier of health services and the administrative authority for the health sector. The main insurer is the Nicaraguan Institute for Social Security. At the subnational level, departmental comprehensive health service systems (SILAISs in Spanish) manage the health system through the organization and linking of health centres, monitoring, resource management, and promotion of social participation (MINSA, 2008).

Nicaragua's sectoral policy is outlined in the 'National Health Policy' (MINSA, 2008). It places emphasis on the following strategic guidelines:

- Prevention, through awareness-raising, monitoring of endemic diseases and preventive attention.
- Free and high-quality services for both medical attention and medication.
- Shorter waiting lists for surgery and other specialized consultations.
- Improved access to health services for the poor and extremely poor population.
- Regionalization of health services in the Atlantic region.
- Promotion of popular and traditional medicine.
- Civil society participation and governance.
- Integrated development of human resources in the health sector.
- Alignment, harmonization and appropriation of external cooperation in the health sector.

No specific goals and deadlines are mentioned. MINSA's short-term plan for 2012 contains a range of quantified, immediate, process-oriented objectives such as the participation of 40,000 health staff and volunteers in community campaigns, the coverage of 3.25 million homes by anti-epidemic spraying campaigns, and home consultations with 116,356 people with special needs with a view to promoting environmental health (MINSA, 2012). On a more strategic level, the PNDH (GRUN, 2009) mentions a number of health-related objectives. Maternal mortality should decrease from 80 to 55 out of 100,000 live births between 2007 and 2011. In the same period, infant mortality should decrease from 29 to 25 out of 1,000 live births. Access to drinking water should increase from 56.3 to 64.1 percent in rural areas and from 72 to 86 percent in cities. And access to improved sanitation should increase from 36.5 to 48 percent in rural areas and from 73.2 to 81 percent in urban areas. The PNDH emphasizes family- and community-level approaches to improving health conditions.

Several MDGs relate to health: Between 1990 and 2015, the prevalence of underweight children under five years of age and the proportion of the population below minimum dietary energy consumption should be reduced by half, the under-five mortality rate should be reduced by two-thirds, the maternal mortality rate should be reduced by three-quarters, access to reproductive health care should be universal, the spread of HIV/AIDS should be reversed and access to treatment should be universal, the incidence of malaria and other major diseases should be reversed, the proportion of the population without sustainable access to safe drinking water and sanitation should be halved, and access to affordable essential drugs should be provided in collaboration with pharmaceutical companies. As mentioned above, the United Nations (2012c) thinks the reduction of child mortality is on track in Nicaragua, but that the proposed improvements in maternal health are out of reach, and according to the World Bank (2011), access to sanitation is improving in line with objectives, but goals on malnutrition and access to water are not.

Key messages: Development profile

- Nicaragua is the poorest country in the region and faces massive development challenges with regard to poverty, inequality, education, gender, economic growth and environmental degradation.
- The current 'National Human Development Plan' places a lot of emphasis on poverty reduction and citizen empowerment and outlines a range of short-term development objectives, ranging from reducing illiteracy to handing over more property titles.
- Nicaragua's health sector suffers from low expenditures, leading to low staff levels and infrastructure shortages. Access to clean water and sanitation is limited, and undernourishment is high.
- The 'National Human Development Plan' and the 'National Health Policy' emphasize family- and community-level health measures, free access, and participation. Strategic goals for the sector include the reduction of maternal and infant mortality, increased access to clean water and sanitation, and the reduction of malnutrition.

CLIMATE PROFILE

Mean average temperatures in Nicaragua range from 18° C to 28° C, with the highest values occurring in the western Pacific region. Rainfall quantities increase from west to east. The Atlantic coast experiences rainfall all year, and average quantities exceed 5,000 mm in some areas. The Pacific region, however, has a clearly defined rainy season, from May to October, which tends to be interrupted by the *canícula*, or midsummer drought. Average annual precipitation is lower than on the Atlantic coast, but values of extreme precipitation are higher. In the areas of León, Chinandega and Corinto, between 300 and 500 mm can fall in just 24 hours (GRUN, 2011).

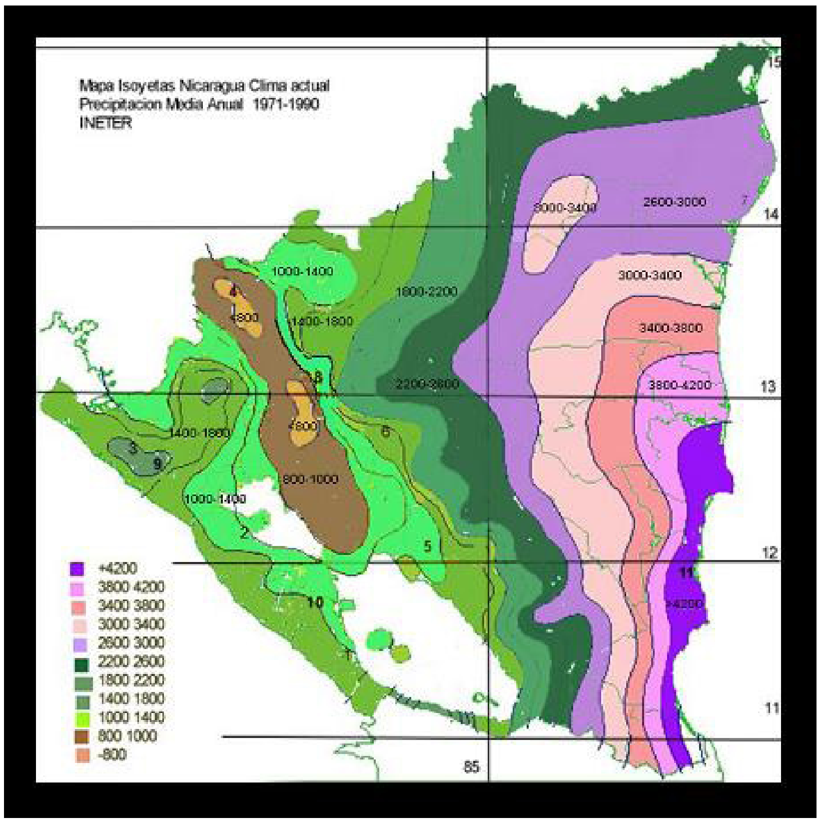

Figure 3. Annual average rainfall (reprinted with permission from GRUN, 2011)

CURRENT CLIMATE VARIABILITY AND EXTREMES

Important deviations from the average climate have been observed in Nicaragua, including in the form of climate hazards such as droughts, tropical storms, cyclones, cold fronts and heavy rainfall.

Climate variability in Nicaragua has mainly been driven by the activity of the Intertropical Convergence Zone and El Niño Southern Oscillation (ENSO). The Intertropical Convergence Zone is a worldwide band where northern and southern trade winds come together and force air up in to the atmosphere. Most tropical storms and cyclones are formed there (NASA, 2011). ENSO is a climate pattern characterized by changes in ocean surface temperatures and pressure in the tropical eastern Pacific. Warm deviations are called El Niño, whereas cold deviations are called La Niña. ENSO periods occur every four to seven years and last 12 to 18 months. They affect air circulation, precipitation and temperatures across the tropical Pacific and can cause climate hazards such as droughts, heavy rainfall, floods and landslides. In Nicaragua, El Niño leads to a significant reduction in rainfall and higher temperatures, mainly between June and August. La Niña, on the other hand, is associated with colder and wetter conditions at that time of year (McSweeney et al., 2009).

The official cyclone season lasts from June to November, although some cyclones have occurred as early as May in the past. The peak of cyclonic activity falls in the months of September and October. Tropical storms and cyclones that make landfall in Nicaragua either originate on or enter into Nicaragua from the Atlantic coast, although some storms have come through Honduras or even originated in the Pacific Ocean (such as Tropical Storm Alleta in 1982)(GRUN, 2011). According to past records, severe tropical storms or cyclones have affected Nicaragua almost every other year. Key events and their impacts are listed in the next section. Figure 4 shows the degree of past exposure to hurricanes according to the Nicaraguan Institute for Territorial Studies (INETER, 2001).

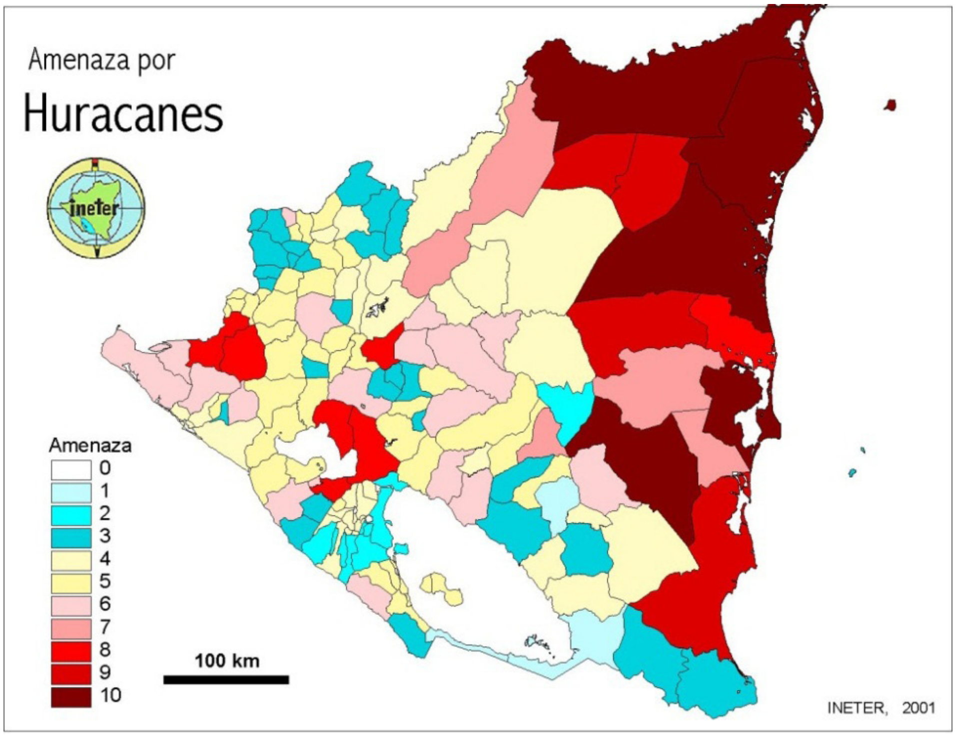

Figure 4. Hurricane-prone areas in Nicaragua (reprinted with permission from INETER, 2001)

Floods, flash floods and flood-related landslides usually occur in the context of tropical storms and cyclones, due to massive increases in rainfall during very short periods of time. Figure 5 compares monthly rainfall quantities in October 1998, when Hurricane Mitch struck Nicaragua, with historical averages. In Chinandega, for example, rainfall increased by more than five times the historical average (ECLAC, 1999). La Niña years tend to increase average rainfall and thereby heighten the chances of severe floods. It is noteworthy that heavy rainfall and floods can occur very far from the centre of a tropical storm.

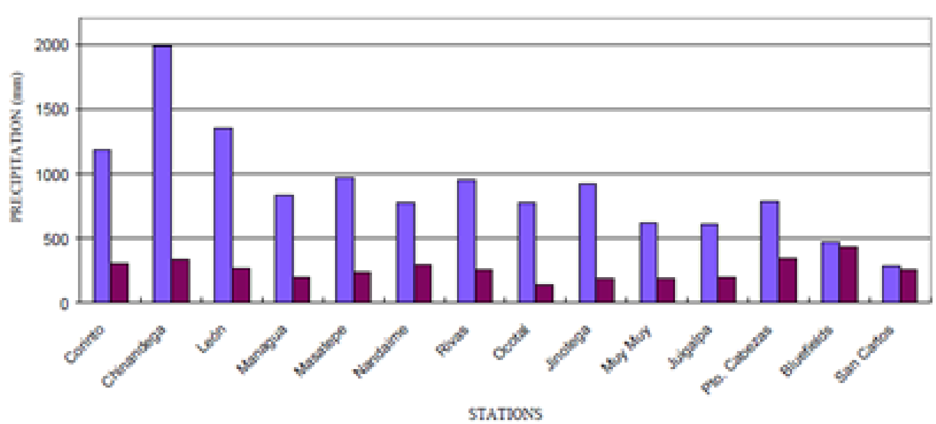

Figure 5. Excess rainfall during Hurricane Mitch. Lighter bars represent precipitation in October 2008; darker bars represent historical averages for October (reprinted with permission from ECLAC, 1999)

Apart from the regular dry periods, from November to April and from mid-July to mid-August (*canícula* or midsummer drought), the Pacific and central regions are often subject to irregular droughts during the rainy season. These can last several days or weeks and are usually associated with El Niño years, during which precipitation can decrease by up to 35 percent, according to past records, in the most affected areas. The most severe El Niño years for Nicaragua in the past decades include 1972, 1976 to 1977, 1991, 1992, 1993 and 1997 (MARENA, 2008). Figure 6 shows the areas most affected by droughts, according to INETER (2001).

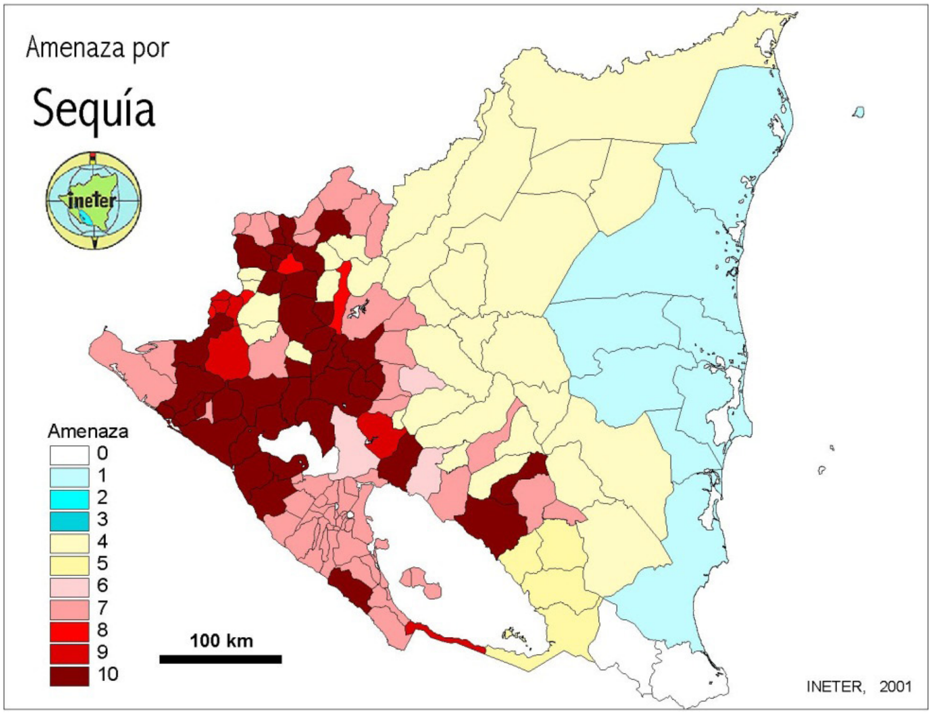

Figure 6. Drought-prone areas in Nicaragua (reprinted with permission from INETER, 2001)

Related to droughts, regular heat waves affect mainly the Pacific region (INETER, 2001). Droughts are also thought to increase the hazard of forest fires, although these tend to occur more often along the agricultural frontier in the eastern half of the country.[4]

OBSERVABLE CHANGES IN CLIMATE

According to Aguilar et al. (2005), temperatures in Central America have increased by 0.2° C to 0.3° C per decade over the last 50 years. For Nicaragua, McSweeney et al. (2009) mention an increase of 0.9° C since 1960, which translates into a rate of about 0.2° C per decade, slightly higher than global average warming. The increase is similar across all seasons. The frequency of hot days and hot nights increased by 16.4 percent and 11.7 percent, respectively, between 1960 and 2003. The number of cold days and nights has decreased.

Over the past 15 years, mean annual rainfall has decreased, mainly in the wet season. As an average since 1960, the decrease amounts to 5 to 6 percent per decade. However, there has been an increase of 2.2 days with heavy precipitation per decade. 'Heavy precipitation' is defined as daily rainfall exceeding the threshold that was only exceeded on 5 percent of rainy days in a reference climate. Similarly, observed maximum one- and five-day rainfalls have increased by 8 mm and 14 mm, respectively, on average per decade since 1961, during both the wet and dry seasons (McSweeney et al., 2009).

[4] Personal communication with MINSA, 6 December 2011.

Local trends can differ, however. Altamirano and Guzmán (2012) have collected climate data for the cities of Managua, León and Chinandega, on the Pacific slope, for 1980 to 2010. There appears to be a significant upward trend in Managua of about 0.7° C over three decades, which may be more pronounced than elsewhere due to an urban heat-island effect. Temperatures have also increased by about 0.3° C in Chinandega, whereas they have remained stable in León. Variation about the annual average has been limited to about +/–0.8° C in all three sites. Precipitation trends are positive for all three sites, especially for León. However, trend increases are well within the climate variability of +/–1,000 mm for León and Chinandega and +/–600 mm for Managua.

PROJECTED CLIMATE TRENDS

The 'Second National Communication to the UNFCCC' (GRUN, 2011) presents climate projections up to the end of the 21st Century, based on runs with the HADCM3 and ECHAM4 models using the IPCC's A2 and B2 emissions scenarios,[5] and compared with statistical averages from 1961 to 1990. Figure 7 shows the different projections and to what extent they overlap. Temperature increases for the period from 2071 to 2099 in all four combinations of models and scenarios are within a range of 3° C to 4° C. Only the ECHAM4 projections start early in the century. They indicate a relatively steady increasing trend, suggesting that by mid-century, warming could be about 1° C to 3° C. The two models project different spatial patterns. While HADCM3 predicts the warming will be more pronounced on the Pacific coast, ECHAM projects the highest rates for the northern border with Honduras. Both models predict warming that is higher in the rainy season.

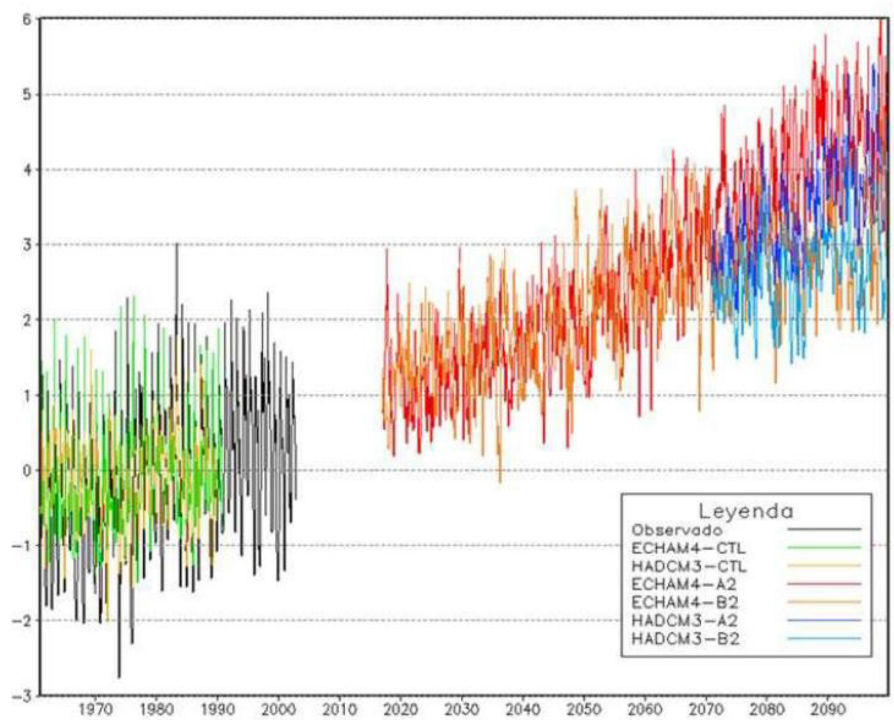

Figure 7. Projections for temperature increases in Nicaragua (reprinted with permission from GRUN, 2011)

5 As per the IPCC's 2001 'Special Report on Emissions Scenarios,' the B2 scenario assumes some degree of emissions mitigation through more efficient energy use and better-positioned solutions. The outcome of these processes would be lower generation, and therefore lower concentrations, of atmospheric greenhouse gas emissions. On the other hand, the A2 scenario assumes slower economic growth, less globalization and a steadily high rate of population growth. The outcome of this scenario is atmospheric greenhouse gas concentrations that far exceed current levels (ECLAC, 2010).

Rainfall trends are less clear. The ECHAM4 model, for which projections start in 2020, suggests higher climate variability over the century and a slight reduction in averages by the end of the century. HADCM3 projections, on the other hand, foresee a significant reduction of around 50 percent under either scenario. The models project different spatial patterns, but agree in that the southern border may see some precipitation increases and the north will see decreases. They also suggest that, if anything, the differences between the dry and wet season will become more pronounced (GRUN, 2011).

These projections are largely in line with other projections, such as those of Christensen et al. (2007), the Water Center for the Humid Tropics of Latin America and the Caribbean (CATHALAC, 2008) and the United Nations Economic Commission for Latin America and the Caribbean (ECLAC, 2010), which are based on various emissions scenarios and climate models.

Sea level rise is expected to continue, although no national-level projections are available. McSweeney et al. (2009) apply a regional adjustment to the global projections by Meehl and Stocker (2007). For the Pacific coastline, they project a 0.13 m to 0.51 m increase by 2090 relative to 1980–1999 sea levels. For the Atlantic coast, the projected increase for the same period is slightly higher and ranges from 0.18 m to 0.56 m.

Extreme events are more difficult to project. According to Magrin and Garcia (2007), many regional studies do indicate that extreme events will occur more frequently in the future. Simulations from Christensen et al. (2007), based on the A1B scenario, indicate that a higher number of very hot days and more dry extremes will occur in Central America. CATHALAC (2008) undertook projections for cyclonic activity under the A2 (high emissions) scenario, using the PRECIS[6] model, and found that while events may become more intense, their frequency will not vary significantly. It should be noted, however, that the methodological foundations for such projections are still weak (Smith et al., 2010). A link between anthropogenic climate change and ENSO has not been established. Changes have been observed in the intensity of El Niño events and the location of the surface temperature abnormality since 1970, but these changes have not been conclusively linked to human-induced global warming (Trenberth and Hoar, 1997; Lee and McPhaden., 2010; McPhaden et al., 2011).

STATUS OF CLIMATE AND HAZARD INFORMATION

A relatively complete picture of current and future climate hazards and trends can be obtained from the available data and information. The main driving factors and general characteristics of today's climate variability are well-understood, and the main zones of influence are known for key hazards such as droughts, cyclones and floods. Recent and robust climate projections are available for temperatures and rainfall.

Deficiencies remain, however. The 'Second National Communication to the UNFCCC' (GRUN, 2011) notes the importance of improving the density and quality of the weather station network. Data collection needs to be more detailed, accurate and rapid in order to provide timely climate information to different users. As of 2007, only 10 out of 21 major watersheds hosted a weather station. Only two watersheds had a flood-prediction system. As a result, the capability to monitor, track and analyse climate data and generate early warnings for impending extreme events is severely limited.

The study of current and future risks is compromised, too. Return periods and probabilities have not been calculated. Climate projections are also less reliable if climate models rely on observations from few weather stations. Apart from the lack of sufficient and reliable data, risk analysis is also limited by the scarcity of human resources—experts who can conduct such studies.

[6] PRECIS (Providing Regional Climates for Impacts Studies) is a regional climate modelling system developed by the Hadley Centre in the United Kingdom's Met Office. For more information, see: http://precis.metoffice.com.

Key messages: Climate profile

- Nicaragua has a tropical climate. The Pacific slope has a clearly marked rainy and dry season, whereas it rains more, and all year, on the Atlantic side.
- Climate variability is mainly driven by the Intertropical Convergence Zone and ENSO, and it manifests in tropical cyclones and storms, heavy rainfall, and floods, as well as irregular droughts.
- Observed trends show that average temperatures have increased by about 0.9° C across Nicaragua since 1960. Rainfall has decreased by about 5 to 6 percent per decade, but heavy rainfall events have increased.
- Climate scenarios project continued warming of 3° C to 4° C by the end of the century. Rainfall trends are less clear but tend to be negative, and extreme events remain hard to project.
- Not enough weather stations and flood prediction systems exist in Nicaragua, limiting the capability of providing early warnings, risk analysis and climate projections.

CLIMATE IMPACTS AND RISKS

Taking into account casualties and GDP losses, Nicaragua was the third-most-affected country in the world by the impacts of extreme weather events in the period from 1991 to 2010. Over these 20 years, more than 40 events occurred in Nicaragua. These killed over 150 people per year on average and led to annual economic losses of almost 2 percent of GDP (Harmeling, 2011). Tropical cyclones, storms, and associated hazards such as floods and landslides, as well as droughts, have been the major threats. This section summarizes some of their most important impacts.

Table 5 presents records of the human and economic impacts of some of the major climate disasters that have occurred in Nicaragua over the past five decades. These numbers are incomplete, especially for slow-onset disasters such as droughts, and sometimes conflict with information from other databases. Detailed information about impacts on specific sectors, such as health, is hard to come by, except for particular events. Trends cannot be identified with certainty because data reporting has most probably improved. Nevertheless, the records make for impressive proof of the frequency and magnitude of climate impacts. Over the last two decades, almost every year a disaster with dozens of casualties, tens of thousands of affected people and/or millions of dollars of economic damages has occurred.

TABLE 5. RECORDED IMPACTS OF MAJOR CLIMATE DISASTERS IN NICARAGUA DATA SOURCE: CENTRE FOR RESEARCH ON THE EPIDEMIOLOGY OF DISASTERS, 2011)

EVENT	YEAR	KILLED	AFFECTED	ECONOMIC DAMAGES (MILLION USD)
Flood	1960	325	-	-
Hurricane Edith	1971	35	4,650	0.38
Flood	1979	-	30,000	-
Flood	1980	-	40,000	-
Tropical Storm Aletta	1982	71	52,000	356
Hurricane Joan	1988	130	360,278	400
Flood	1990	4	106,411	-
Tropical Storm Bret	1993	37	123,000	-
Drought	1994	-	75,000	-
Hurricane Roxanne	1995	38	15,085	-
Hurricane Cesar-Douglas	1996	42	10,724	10
Drought	1997	-	290,000	2
Hurricane Mitch	1998	3,332	868,228	987.7
Coastal flood	1999	11	107,105	0.5
Drought	2001	-	188,000	-
Hurricane Michelle	2001	16	24,866	1
Flood	2002	-	13,546	0.05
Landslide	2004	29	5,769	-
Hurricane Felix	2007	188	188,726	-
Flood	2007	10	24,000	-
Tropical Storm Alma	2008	13	25,000	-
Floods	2008	17	14,188	-
Hurricane Ida	2009	-	19,897	-
Flood	2010	66	71,000	-
Flood	2011	9	150,000	-

As table 5 illustrates, hurricanes, storms, floods and landslides—phenomena that are often associated with one another—are among the most recurrent climatic extremes that affect the Nicaraguan population and economy. Hurricane Mitch, in 1998, was the most violent event by far, killing over 3,300 people and causing economic damages of almost US$1 billion, which amounted to 45 percent of GDP. It is noteworthy that the hurricane's eye did not enter national territory. Damages in Nicaragua were mainly associated with the heavy rains and related flooding and landslides. In the most affected regions, monthly rainfall for October amounted to up to five times the average (see section 3.2). Eighty-three percent of all casualties were victims of a mud avalanche on Casita Volcano in Chinandega, in the northwest of the country. The hurricane also led to losses of over 140,000 tons of staple-food production, worth around US$48 million and produced by some 56,000 smallholders, thereby affecting food security (ECLAC, 1999). Other major hurricanes include 1988 Hurricane Joan, with 130 dead and over 360,000 affected, and 2007 Hurricane Felix, which killed 188 and affected over 180,000. Felix and other tropical storms that occurred in 2007 led to economic damages worth 5.2 percent of GDP (Ramirez et al. 2010). Floods can occur in the context of storms or heavy rainfall and lead to the loss of soils, sediments and crops; water-borne diseases; and infrastructure damage, and can provoke landslides, as well (GRUN, 2011).

As slow-onset disasters with many indirect effects, droughts are less visible in disaster statistics than rapidly unfolding events like hurricanes. Yet even incomplete records show they have affected Nicaragua regularly and severely. A drought associated with the 1997–1998 extreme El Niño event led to losses of around one-third of the cultivated area of staple foods such as maize, beans and sorghum (Ministerio Agropecuario y Forestal de Nicaragua, 2002). The most affected areas are usually the northwestern departments belonging to the dry corridor of Central America. A 2009 drought caused staple-food production in seven municipalities of the dry corridor to drop by over 50 percent on average, and over 90 percent for individual communities (Acción contra el Hambre, 2010).

Other relevant climate-related hazards that affect Nicaraguan territory include heat waves and forest fires. Heat waves occur mostly in the low-lying areas on the Pacific slope and affect human health and crop productivity, among other things (INETER, 2001). Forest fires are sometimes directly caused by human interference, but are often ignited by storms or favoured by dry weather conditions. They contribute to deteriorating soils and forests, with many indirect effects on crop productivity and human health (Instituto Nacional Forestal, 2008).

Climate change can both alter the characteristics of current hazards and present new threats. Although projections for extreme events are extremely difficult, it is expected that their overall frequency and intensity may increase. Additional threats are posed by changing average climate conditions. Increasing temperatures and possibly decreasing precipitation will likely lead to more water scarcity, with damaging consequences for crop productivity, human water consumption and the power-generating capacity of hydroelectric plants. A study on a particularly vulnerable watershed on the northeastern Pacific slope shows that in the absence of adaptation measures, water consumption may exceed sustainable limits very soon (GRUN, 2011). According to Ramirez et al. (2010), the production of maize, beans and coffee, three of the key subsistence and export crops, could decrease rapidly. Coffee could even be impossible to grow towards the end of the century. Further threats may come from sea-level rise that threatens lives and livelihoods near the coast.

LINKS BETWEEN CLIMATE AND HEALTH

Extreme events and climate change affect the availability of clean air and water, food and shelter—the fundamental pillars of human health (WHO, 2009). Direct effects include increased morbidity and mortality during extreme events, such as casualties during floods and storms—as underscored by the disaster statistics presented above—and increases in cardiovascular and respiratory diseases during heat waves (Confalonieri et al., 2007). Many other impacts are indirect. The following links are among the most important (WHO, 2009; Confalonieri et al., 2007):

- **Air.** Apart from direct effects on cardiovascular and respiratory diseases, higher air temperatures can raise the levels of ozone and other air pollutants that exacerbate these same diseases as well as asthma. Air temperature also affects the reproduction rates of disease-carrying mosquitoes. Climate variability and change can also have non-temperature effects on air, with health implications that are less well-understood.
- **Water scarcity and contamination.** Floods, droughts and gradually increasing water scarcity can affect the availability of clean water, which can in turn compromise hygiene and increase the rate of diarrhœa, a disease that kills over 1.5 million children worldwide every year. Pools of standing water, which can result from both floods and droughts, can create breeding grounds for vectors: insects that may carry diseases such as dengue or malaria, which provoke illness or death. Floods can also lead to contamination of both surface and subsurface waters with chemicals, metals or other hazardous substances.

- **Food and nutrition.** Extreme events, increasing temperatures and changing rainfall patterns can reduce crop yields and thereby exacerbate food insecurity and malnutrition. The latter not only affects health directly, but also renders people more vulnerable to many infectious diseases. Lack of food can also lead to population movements, which carry the risk of an increase in communicable diseases and poor nutritional status.
- **Biodiversity.** Climate variability and change can affect ecosystems and biodiversity and thereby expand, decrease or shift the habitats of species that transmit diseases. For example, vectors carrying diseases such as dengue or malaria require specific climatic conditions to survive and reproduce. Heavy rainfall and floods can lead to outbreaks of infectious diseases such as leptospirosis because they change contact patterns among humans, pathogens and rodents.
- **Destruction of shelters and infrastructure.** Extreme events can destroy or damage homes, medical facilities, water-supply systems and other essential services and thereby increase the vulnerability of the exposed population.
- **Mental disorders.** These include anxiety, depression and post-traumatic stress, all of which can result from the impacts of disasters.

The links between climate and health are often very complex. For example dengue, the world's most important vector-borne viral disease, has been associated with both high rainfall (for increased transmission rates) and drought (explained by increased household water storage creating breeding sites). The effects of climate change on malaria are controversial. While some studies confirm the impact of rising temperatures on transmission rates, other studies find no correlation. The difficulties in associating climate change with changes in the prevalence of diseases arise to a large extent because of complex impact chains and the importance of a range of other risk drivers. Many health risks are related to climate impacts in other sectors, such as agriculture, water and biodiversity. For example, changing temperatures can shift ecological zones and therefore expand or decrease habitats for species that transmit diseases. At the same time, the fact that high rates of diarrhœal disease are mainly associated with poor sanitation infrastructure (Confalonieri et al., 2007) shows that climate-related risk can be driven by conditions of vulnerability. Furthermore, viruses, bacteria and disease vectors can also adapt to changing climatic circumstances over time, confounding the expected trends.

PAST CLIMATE IMPACTS ON HEALTH IN NICARAGUA

As part of the CRM TASP, Altamirano and Guzmán (2012) studied the impacts of past climate patterns on diarrhœa, dengue and leptospirosis. These are some of the most important diseases in Nicaragua and are expected to depend significantly on climate conditions. The statistical analysis focused on the SILAIS, or health regions, of Managua, León and Chinandega, because of the high prevalence of the three diseases in these areas. The authors looked at correlations of temperature and precipitation with the number of cases of the three diseases, both on a monthly basis to detect seasonal patterns, and with annual data, to look at the impact of specific events as well as possible longer-term trends.

Diarrhœa

The World Health Organization (WHO, 2012a) defines diarrhœal diseases "as the passage of three or more loose or liquid stools per day (or more frequent passage than is normal for the individual)," which leads to dehydration and loss of nutrition. Diarrhœa kills 1.5 million children worldwide every year and is the second leading cause of death in children under five years of age. Diarrhœal disease is caused by bacterial, viral and parasitic organisms that infect the body through contaminated food or water, or from person to person. According to MINSA (2011), 264,848 cases of acute diarrhœa were reported in 2010 in Nicaragua. Of these, 99,469 cases were reported in the SILAISs of Managua, León and Chinandega. This amounts to an increase in cases for these three regions of around 50 percent compared with the 2000 to 2009 average (Altamirano and Guzmán, 2012).

Climate variables can have an important influence on the prevalence of diarrhœa. For example, at higher temperature levels, the insects that carry bacteria reproduce more rapidly. Extreme rainfall can lead to contamination of water, which increases the breeding ground for bacteria, viruses and parasites. Droughts can also reduce the amount of available clean water and thereby increase human contact with contaminated water.

In all three sites analysed by Altamirano and Guzmán (2012), a clear seasonal pattern exists in which about 80 percent more cases of diarrhœa occur in the months of June and July compared with the rest of the year. This spike is likely driven by the first of two annual peaks in rainfall, which occurs from May to June. Also, compared with the second, higher annual peak in rainfall, which occurs in September and October, temperatures are significantly higher earlier in the year, which may favour the reproduction of vectors. Figure 8 shows monthly averages for cases of diarrhœa, rainfall and temperature for the SILAIS of León. The situation in Managua and Chinandega is comparable.

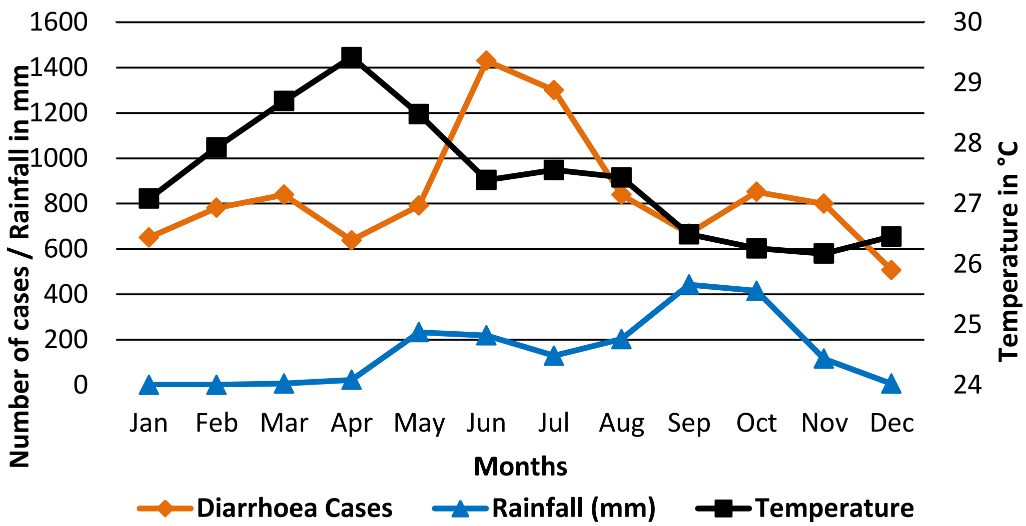

Figure 8. Cases of diarrhœa and climate data for León, monthly averages for 1993 to 2010 (data source: Altamirano and Guzmán, 2012)

Looking at annual trends has been less instructive, not least because adequate health data is only available from 1993 onwards. This makes it difficult to detect long-term trends in both climate and health variables. Moreover, extreme events such as hurricanes and floods do not necessarily leave their mark in diarrhœa statistics. This may be due to the often very local effects of such events—effects that would have to be studied in a qualitative way.

Dengue

Due to a global resurgence in recent years, dengue is now the most common mosquito-borne viral disease in humans, with an estimated 50 million infections a year worldwide. It is mainly transmitted by the predominantly urban mosquito *Aedes aegypti* and leads to flu-like illness or even dengue haemorrhagic fever, which can be lethal. There is no specific treatment for dengue (WHO, 2012a). Statistics for the three SILAISs analysed by Altamirano and Guzmán (2012) show that 13,579 cases of dengue were reported in 2010, up from less than 10,000 in 2009 and over four times the average for the period between 2003 and 2008. Previous peaks occurred in 1994, 1998–1999 and 2002.

Climate conditions can influence the spread of dengue in several ways. Temperature levels affect the survival and speed of reproduction of both the virus and the mosquitoes that carry it. At different stages of their life cycle, mosquitoes require temperatures of around 25° C to 32° C. Transmission can occur within a temperature range of around 14° C to 40° C. Higher temperatures can shorten the time between the infection of the vector and the vector's ability to infect someone. Water temperatures are particularly important, as the mosquito larvae grow in water. In warmer water they tend to develop more rapidly but will be smaller as adults, and as a result, they need to bite more often in order to feed themselves with blood. Rainfall, on the other hand, can have an effect on the available breeding area. Both heavy rainfall and droughts can create pools of water where mosquitoes can reproduce and grow. Water deposits in and around settlements are of particular importance for dengue, a predominantly urban disease (Altamirano and Guzmán, 2012).

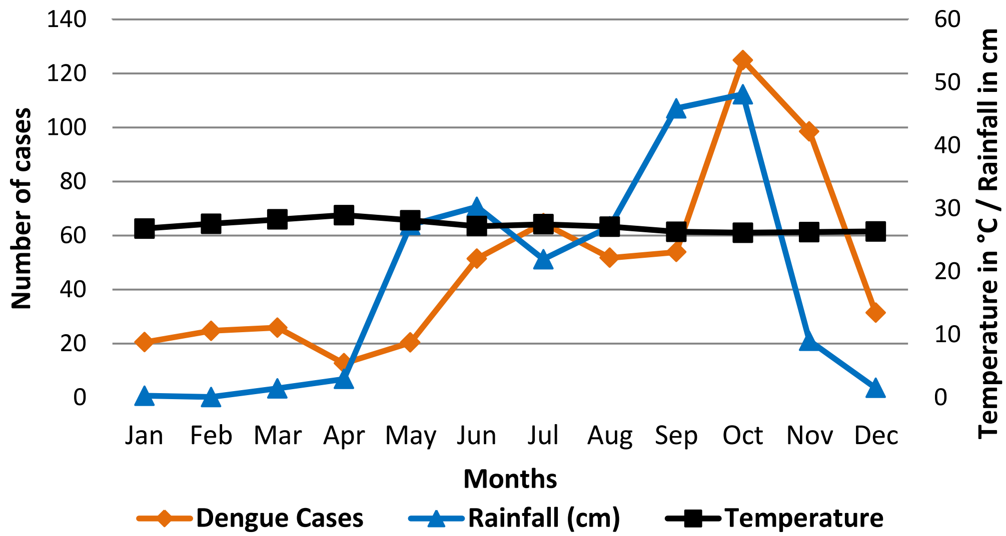

Figure 9. Cases of dengue and climate data for Chinandega, monthly averages for 1993 to 2010 (data source: Altamirano and Guzmán, 2012)

The number of suspected monthly dengue cases closely follows seasonal rainfall patterns. Based on monthly averages for the period from 1993 to 2010 and applying a one-month lag between rainfall data and the number of cases, Altamirano and Guzmán (2012) found a 78 percent, 89 percent and 93 percent correlation for Managua, León and Chinandega, respectively. While the analysis cannot prove a causal relationship, this result strongly supports the hypothesis that periods of heavy rainfall increase breeding pools for disease-carrying mosquitoes. Figure 9 shows the annual pattern for the SILAIS of Chinandega.

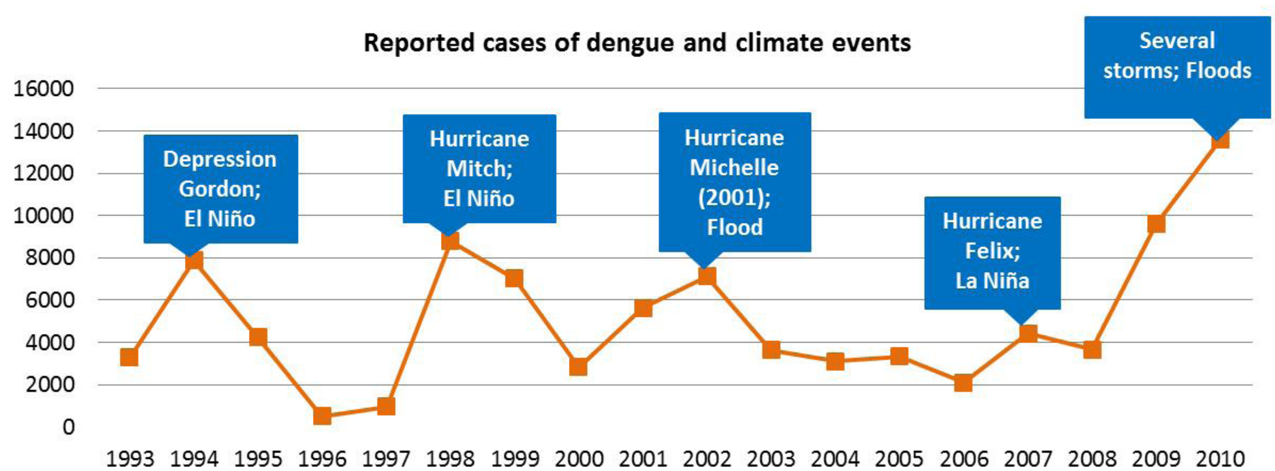

Figure 10. Reported cases of dengue and selected climate events (data source: Altamirano and Guzmán, 2012)

As figure 10 shows, past peaks in suspected dengue cases tend to coincide with important climate events. The second-highest peak on record occurred in 1998, when El Niño conditions initially brought warm and dry weather before Hurricane Mitch brought devastating rains in October. In the month of October, 1,985 mm of rain fell in Chinandega. The year 2010, the last and highest peak in dengue cases, was a very wet year, with one tropical depression and two storms and annual precipitation exceeding averages by about 50 percent in all three regions. These findings, while also not proving causation, further strengthen the hypothesis that heavy rainfall events, possibly coupled with higher temperatures, as in 1998, can lead to increased dengue prevalence. At the same time, no conclusions can be drawn from long-term trends. While dengue is an emerging disease in many countries, climate and health data records in Nicaragua are too short to detect any relevant correlations between climate change and disease prevalence.

Leptospirosis

Leptospirosis is a bacterial disease that can cause high fever, severe headaches, muscle pain, chills, redness in the eyes, abdominal pain, jaundice, haemorrhages, vomiting, diarrhœa and a rash. Humans contract it through water contaminated by urine from infected rodents or other animals. It enters the human body through skin abrasions and the mucosa of the nose, mouth and eyes. Although not well-documented, leptospirosis occurs worldwide and peaks in the rainy season in endemic regions (WHO, 2012a). Over the past two decades, three peaks in leptospirosis occurred. In 1995, over 2,254 clinic cases and 48 fatalities were reported. In 2007, 5,454 cases were reported in the three focus regions, falling to 1,228 in 2008. In 2010, the same areas counted 1,791 cases. In the years between, only a few dozen or hundred cases were reported (Altamirano and Guzmán, 2012). Altamirano and Guzmán suspect[7] that most cases of leptospirosis are unreported, as people recover without noticing the cause of temporary illness.

Climate conditions have a very direct and visible impact on the prevalence of leptospirosis. Bacteria need water or high humidity and temperatures between 20° C and 37° C. They survive best in standing water, ponds, swamps and lagoons, but die quickly under dry conditions (Altamirano and Guzmán, 2012). Because transmission requires contaminated water, cases typically peak in the rainy season, and the disease can reach epidemic dimensions during floods (WHO, 2012a).

A comparison of climate and health data shows that observations in Nicaragua are in line with expected patterns. Of the 8,952 cases that were reported in the three SILAISs of Managua, León and Chinandega between 1996 and 2010, over 80 percent occurred in the months of October and November, right after the peak of the rainy season. Furthermore, annual trends show a positive correlation between rainfall and cases of leptospirosis for all three SILAISs, and the three annual peaks mentioned above coincide with major storms and floods: In 1995, Hurricane Roxanne struck Nicaragua, in 2007 it was Hurricane Felix and a flood, and 2010 saw a tropical depression and two storms, with precipitation levels much above the average. However, several years experienced extreme events but no outbreak of leptospirosis—most notably the year of Hurricane Mitch. This may be explained by localized effects as well as potential underreporting of cases. What is interesting about this disease compared with others is the fact that peaks are very high, so that there appears to be an epidemic threshold that, if passed, leads to a rapid spread of the disease. Finding out the exact importance of extreme rainfall events in reaching this threshold, as well as the way in which climate conditions affect the presence and behaviour of both rodents and bacteria, was outside of the scope of Altamirano and Guzmán's (2012) study.

Malaria

Nicaragua's 'First National Communication to the UNFCCC' (República de Nicaragua, 2001) looked at the impacts of climate change on malaria. Higher temperatures are expected to increase the prevalence of malaria, because they increase the speed of reproduction and growth of the mosquitoes that transmit the disease. Also, below a certain temperature, the mosquitoes don't survive. Rainfall can affect the prevalence of malaria in similar ways as for dengue, as the mosquitoes need standing waters for reproduction. No statistical analysis of past relationships has been conducted, however. Furthermore, in Altamirano and Guzmán's (2012) study, malaria was not included, because its prevalence has dropped to very low levels in recent years.[8]

Heat-related issues

According to community consultations conducted by López et al. (2011), dry conditions often lead to an increased prevalence of respiratory diseases, mainly from increased contamination of the air with dust. It is also worth mentioning the results of a study by Delgado Cortez (2009), which looked at the impacts of heat stress on sugarcane farm workers, who are exposed to temperatures of up to 34.5° C. The output of workers who didn't drink at least six litres of water was almost one-third lower than that of workers who did drink sufficiently. Apart from the occupational health risk for the involved workers, this highlights the economic damages of climate-induced health stress.

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[7] Personal communication 6 December 2011.

[8] Personal communication with MINSA, 6 December 2011.

Health impacts of Hurricane Mitch

ECLAC (1999) conducted a thorough impact assessment shortly after Hurricane Mitch struck Nicaragua in October 1998. They looked at, among other things, social and economic impacts in the health sector. This detailed analysis offers insights into some of the more complex direct and indirect consequences of extreme events for health:

- The main reported causes of morbidity were acute respiratory infections, acute diarrhœa-related disease, skin diseases, impetigo, conjunctivitis, and the resurgence of vector-transmitted diseases such as cholera, dengue and malaria.
- The destruction of the health infrastructure reduced the system's response capacity at a time when demand was soaring.
- The high number of victims and displaced people and the destruction of water and sanitation infrastructure led to massive hygiene problems, which in turn facilitated the spread of respiratory and diarrhœa-related diseases as well as meningitis and dengue.
- Providing people with enough water and food in the emergency was difficult because of high demand and destroyed infrastructure.
- After the disaster, flooding, damming and landslides favoured the creation of new sites prone to the generation of vectors, which has caused increases in cases of leptospirosis, rabies, Chagas' disease and leishmaniaiasis, along with acute respiratory infections and diarrhœa-related diseases.
- Total economic losses caused by the hurricane were estimated at US$53 million, including direct damage to structures, equipment and installations and indirect costs stemming mainly from campaigns to combat hurricane-related diseases.

LOCAL VULNERABILITY TO CLIMATE-RELATED HEALTH RISKS

Many of the climate-related impacts are not solely or even mainly dependent on the climate hazards, but are also driven by conditions of environmental and social vulnerability. As indicated in the development profile, large parts of the Nicaraguan population suffer from insufficient access to clean water and proper sanitation. Treatment of solid and liquid waste is highly inadequate. The use of fertilizers and pesticides in agriculture leads to further contamination of soils and water bodies. Environmental regulations are not properly enforced. These conditions constitute a permanent health risk, especially in combination with climate hazards.

To validate the importance of these vulnerability factors for climate-related health risks at the local level, López et al. (2011) conducted consultations in six communities in the same focus regions as Altamirano and Guzmán's (2012) study, using the CRiSTAL and Climate Vulnerability and Capacity Analysis tools (see introduction):

- **Managua.** Neighbourhoods of Larreynaga and Las Torres. Both lie to the east of Managua's city centre. Las Torres borders Lake Managua, whose level has risen in recent years, while Larreynaga is crossed by a riverbed. Inhabitants depend on employment in textile factories, supermarkets, informal commercial activities, mechanical workshops and small shops.
- **León.** Communities of La Calera and Ojo de Agua. Both are located in the more mountainous areas of León, and have creeks crossing through the villages. Inhabitants depend mainly on agriculture and, to a lesser extent, on livestock breeding.
- **Chinandega.** Communities of Villa 15 de Julio and San José del Obraje. Both are located on low-lying plains near the Estero Real River. Inhabitants depend mainly on agriculture and, to some extent, on livestock breeding.

The assessments confirmed the importance of the climate hazards presented in section 3. Heavy rain, floods, droughts and dust storms were mentioned as key threats. All consulted communities reported health impacts such as respiratory diseases, diarrhœa and vector-borne diseases such as dengue, as well as malnutrition arising from impacts on agriculture and risks related to the destruction of homes, roads and other infrastructure. Coping strategies in all communities largely relied on interventions from MINSA, such as prevention campaigns. Autonomous coping capacity appears to be very limited.

Figure 11. Community consultations in San José del Obraje. Photo: Miguel Reyes García

The main result of the consultations was, however, to identify key drivers of vulnerability to climate-related health risks. Comparing the results of the six communities, the following factors stand out:

- **Access to clean water.** The consulted communities all lack universal, sustainable and sufficient access to clean water. For example, communities in Chinandega only have intermittent, and sometimes illegal, access to water mains. In other places only a part of the community is connected. People without sufficient access to water are dependent on makeshift wells, which are prone to flooding and contamination by various sources during the rainy seasons. Even water from the grid is of poor quality in some communities. Furthermore, during the dry season and droughts, both the mains and the wells can dry up.
- **Proper sanitation.** Insufficient waste management, sewage treatment and even latrines are widespread in the consulted communities. No proper drainage is available. As a result, heavy rains flood the communities with contaminated water. In Managua, untreated wastewaters are released into Lake Managua, affecting neighbourhoods near the often-flooded shore. In many places, people walk barefoot through flooded areas. During droughts, the few available sources can also be more easily contaminated because the water is standing.
- **Health services.** In some communities, health services are not easily accessible, limiting the ability of the population to respond effectively to health impacts.
- **Knowledge and awareness.** Lack of awareness about health risks is widespread, and understanding of the direct and indirect danger to health posed by, for example, floods and droughts is poor. This may be related to the lack of easily accessible health services.
- **Livelihoods.** In the community of Villa 15 de Julio, many people live from animal husbandry. Animals can carry diseases, such as leptospirosis, that are easily transmitted to and from the animals through contaminated water. WHO (2012a) confirms that leptospirosis is an occupational hazard for people who work outdoors or with animals, such as farmers and rice and sugar-cane field workers.
- **Community organization.** Some communities struggle to properly coordinate work among different groups, while others manage to organize community matters well. Such organization is essential if risk is to be reduced, as individual actions can increase health risks for others. Lack of coordination can also hamper efficient and timely solutions. According to ECLAC (1999), during Hurricane Mitch municipal governments lacked the autonomy to operate shelters, and community organizations were often not able to function under stress.

- **Food security and nutrition.** Extreme events can affect food security and nutrition, which is in itself a health risk and reduces immunity to other diseases. As a result, climate-resilient agricultural practices also reduce health risks.
- **Safe infrastructure.** Extreme events can destroy crucial infrastructure and cut communities off. Some communities have been cut off for days during hurricanes, such as Juana in 1988 and Mitch in 1998. Health risks multiply in such situations, as no supplies, water or food can be obtained.
- **Gender equality.** Inequality between genders can have many impacts on vulnerability. Women are often less educated and may not take part in important decisions. They also tend to be more aware of health issues, so their exclusion from discussions and decisions further leads to inadequate consideration of health risks.

The interaction of the climate hazards mentioned in the "Climate Profile' section (pp. 20–25) with these conditions of vulnerability can, to a large extent, explain the relationships between the climate variables and disease patterns analysed above. Dengue, diarrhœa and leptospirosis all depend in some form on contaminated and/or standing water for transmission. In particular, the occurrence of heavy rains and droughts in areas with poor access to clean water and lack of proper sanitation creates ideal conditions for these diseases.

IMPLICATIONS OF CLIMATE PROJECTIONS FOR CLIMATE-RELATED HEALTH RISKS

The only certain trend for the future climate is the continued increase in temperatures. By mid-century, Nicaragua is expected to be 1° C to 3° C warmer than today. Rainfall patterns could change as well, but projections are much less clear. Extreme events could increase in frequency and intensity overall, but no clear outlook exists for specific threats. Nevertheless, the prospect of continued increases in temperature, with possibly decreasing precipitation, will very likely worsen the problem of water scarcity, to which many of the climate-related health risks are linked. First and foremost, ensuring access to clean water will be even harder. Many important diseases such as diarrhœa, dengue and leptospirosis directly or indirectly require contaminated or standing water for transmission. Crop productivity could also decrease due to a combination of higher temperatures and less availability of water, with possibly detrimental effects on food security and nutrition and an associated loss of human resiliency to other diseases.

Higher temperatures can also have direct effects, such as more heat waves and their detrimental effect on health, especially for occupations such as farming. However, the impact of increasing temperatures alone on vector diseases such as malaria and dengue appears to be less straightforward. In low-lying and hot zones, optimal temperatures for mosquitoes already exist, so increasing temperatures may not lead to further expansion. The above analysis for dengue suggests that rainfall patterns are more important than temperatures.

As a result, the evolution of the vulnerability conditions described above may have a more decisive effect in the medium term than will climate change. The fact that malaria rates have dropped rapidly in recent years supports this point. The 'First National Communication' (República de Nicaragua, 2001) had projected that increasing temperatures would increase prevalence, so the actual decrease suggests that efforts to eradicate the disease have worked: in other words, vulnerability has been successfully reduced for malaria.

CLIMATE THREATS TO HEALTH-RELATED DEVELOPMENT OUTCOMES

Overall, the combination of high exposure and vulnerability to climate hazards such as heavy rain, floods and droughts leads to significant climate risks for human health. Key current and future climate impacts include:

- Increases in the prevalence of water-borne diseases such as diarrhœa, as well as vector- and rodent-borne diseases such as dengue and leptospirosis, as a result of floods as well as pools of standing water that lead to water contamination in the context of heavy rainfall or droughts.
- Rising prevalence of respiratory diseases as a result of drought.
- Increasing rates of malnutrition and related diseases due to impacts on agricultural productivity of climate variability and change.
- Destruction of critical infrastructure during extreme events, hitting health services at times when demand for them increases.

Although uncertainty for projections of extreme events is high, the frequency and intensity of extreme events, especially those related to water scarcity, could increase in the future. As a result, local climate impacts on health could increase. At the same time, such impacts can also threaten the achievement of national and international development objectives for the health sector:

- The government wants to reduce maternal and infant mortality. Similar objectives are stated in the MDGs. Extreme events and the spread of diseases, facilitated by heavy rainfall or higher temperatures and drought, or by a combination of factors that include societal vulnerabilities and institutional deficiencies, make it more difficult to achieve this.
- The government wants to increase access to drinking water and improved sanitation, also in accordance with the MDGs. While achieving these goals will reduce vulnerability to climate risk, the same climate risks could make it more difficult to achieve the goals. Extreme events can destroy infrastructure and contaminate water sources. Water scarcity will increase with increasing temperatures and possibly reduced rainfall in the future.
- As part of the first MDG, the prevalence of underweight children and undernourished people should fall rapidly. Climate variability can pose a risk to food production and security and thereby put these objectives at risk. Malnutrition also renders people less immune to other diseases, which affects other health objectives.
- Other goals can be affected because general impacts of climate variability and change strain public budgets and reduce the funds available to achieve such goals.

In sum, current and future climate hazards make the achievement of a range of governmental objectives not only more important, in order to reduce vulnerability to those hazards, but also more difficult to achieve. For example, increasing access to clean water is more difficult under increasing water scarcity, but also more important, since droughts can lead to pools of standing water that are easily contaminated. It is important to avoid entering into vicious, increasingly rapid cycles, and to reduce vulnerability soon with decisive action. The next sections look at the structures that are currently in place to reduce climate risk, and how risk management could be improved in the future.

Key messages: Climate impacts and risks

- Every year cyclones, floods and droughts claim dozens of lives, affect tens of thousands of people and/or cause millions of dollars of damages. Climate change could increase these impacts.
- Climate conditions can affect some of the fundamental pillars of health, such as air temperature, water quality and quantity, food and nutrition, biodiversity, shelters and infrastructure, and mental health.
- Clear seasonal patterns exist for diarrhœa, dengue and leptospirosis, which suggests that floods and standing water resulting from heavy rainfall influence their epidemiology. Inter-annual trends further suggest that extreme events such as storms and droughts also influence the prevalence of these diseases in any given year. Climate change could worsen impacts, mainly through increased water scarcity.
- The vulnerability of human health to climatic conditions appears to be mainly dependent on access to clean water and sanitation, while other relevant factors include availability of health services, occupation, community organization, knowledge and awareness, food security, infrastructure safety and gender equity.
- Climate-related health risks put at risk the achievement of development goals in the health sector, such as reducing infant and maternal mortality, increasing access to water and sanitation, and reducing malnutrition.

INSTITUTIONS AND POLICIES FOR CLIMATE RISK MANAGEMENT

As in most countries, climate risk management is currently addressed from two main angles: disaster risk management and climate change adaptation. In addition, climate risk considerations have recently begun to be mainstreamed into important national and sectoral policy documents. The following sections describe the key institutions and policies for each of these domains.

DISASTER RISK MANAGEMENT

Nicaragua's current institutional architecture for managing disaster risks dates from the year 2000, when the National Assembly approved Law 337 to create the National System for Disaster Prevention, Mitigation and Attention (SINAPRED, in Spanish). This system integrates numerous governmental and non-governmental agencies at the national, regional and local levels. SINAPRED's mission is to 'reduce vulnerability of people at risk of suffering from disasters caused by natural phenomena and/or generated by human activities that put in danger the lives of citizens, their belongings, ecosystems and the national economy' (SINAPRED, 2012). It aims to achieve this through:

- Promotion of a culture of prevention and the proposition of safe and sustainable development scenarios.
- Incentives to incorporate risk management, through a land-planning focus, into regional, national, institutional and territorial development plans.
- Implementation of capacity development programs and strengthening of local and national response capacity against possible adverse events, with emphasis on civil protection.
- Development of inter-institutional actions to put in place mitigation measures against multiple hazards, strengthen early-warning systems and incentivizing awareness-raising programs for all actors in society that help to preserve human lives and ecosystems by means of rational use of natural resources and by implementing environment-friendly technical procedures.
- Fulfil and ensure the fulfillment of the mandates of Law 337, which created SINAPRED and which supports the Executive Secretariat, sectoral work commissions and other structures that form the system.

With these goals, SINAPRED implements the five priority actions of the 'Hyogo Framework for Action.'[9] At the local level, SINAPRED works through municipal, departmental and regional committees, as well as through sectoral work commissions (SINAPRED, 2012). According to the newest 'National Human Development Plan' (GRUN, 2009), a strategy on disaster prevention, mitigation and attention is currently under development.

Nicaragua is a member of CEPREDENAC, the regional Coordination Center for the Prevention of Natural Disasters in Central America. CEPREDENAC belongs to the institutional framework for the Central American Integration System (SICA), brings together the national emergency commissions of the seven Central American countries, promotes and coordinates international cooperation, knowledge exchange, and technical and scientific assistance, and systematizes information around disaster risks. Its main policy instrument is the 'Central American Policy on Integrated Disaster Risk Management' (CEPREDENAC and SICA, 2010), which establishes guidelines, directives and actions that are to be detailed in more specific plans, such as a five-year regional disaster reduction plan. Among the strategic themes of this policy are risk reduction in public investment; development and social compensation as a means to reduce vulnerability; addressing issues related to the environment and climate change; territorial management, governability and governance; and disaster management and recovery.

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[9] The 'Hyogo Framework for Action' is a 10-year plan adopted by 168 United Nations member states in 2005 to reduce disaster risk. It identifies five priority actions: Ensure that disaster risk reduction is a national and local priority with a strong institutional basis for implementation; identify, assess and monitor disaster risks and enhance early warning; use knowledge, innovation and education to build a culture of safety and resilience at all levels; reduce underlying risk factors; and strengthen disaster preparedness for effective response at all levels (UNISDR, 2011).

CLIMATE CHANGE

The national authority in charge of climate change issues is the Ministry for Natural Resources and Environment (MARENA, in Spanish). MARENA is responsible for the implementation of international treaties (UNFCCC, Kyoto Protocol) and has led the elaboration of national communications and the 'National Strategy and Action Plan on Environment and Climate Change' (GRUN, 2010) through its relatively small General Directorate on Climate Change. The Directorate has a person in charge of linking up the climate change agenda with disaster risk reduction and SINAPRED.

The 'National Strategy and Action Plan on Environment and Climate Change' (GRUN, 2010) describes the key environmental challenges and sets out an agenda of key actions for the period from 2010 to 2015 in the following areas: environmental education, defence and protection of the environment and natural resources, conservation, recovery and use of water sources, prevention and mitigation of and adaptation to climate change, and sustainable land use. In adaptation, measures relating to water, agriculture, climate information and disaster risk reduction are proposed. A specific adaptation strategy was elaborated for watershed No. 64 on the Pacific coast, with a view to informing policy decisions in other regions as well (MARENA, 2008).

At the Central American level, a regional climate change strategy has recently been developed under the auspices of SICA and the Central American Commission for Environment and Development (CCAD). The strategy summarizes climate information and sectoral vulnerabilities and proposes six strategic areas, of which one is themed 'vulnerability and adaptation to climate variability and change, and risk management.' Nine strategic objectives—disaster risk reduction, agriculture and food security, forest ecosystems and biodiversity, water, health, coastal-marine systems, tourism, indigenous people and public infrastructure—with over 150 measures, are mentioned under this theme. Other strategic areas are mitigation; capacity development; education, awareness-raising, communication and participation; technology transfer; and international negotiations and management (CCAD and SICA, 2010).

RECOGNITION OF CLIMATE RISK MANAGEMENT IN KEY POLICY DOCUMENTS

Climate change adaptation and risk reduction are referred to in key policy documents from the Nicaraguan government. Nicaragua's 'National Human Development Plan' (GRUN, 2008, 2009) clearly recognizes the importance of climate threats. Climate variability and change are seen as part of the larger global environmental destruction and are considered general risks for the society, the economy and efforts to reduce poverty. More specifically, the vulnerability of agriculture and food security, water and ecosystems is recognized. The plan acknowledges that disaster risk reduction has to occur on an inter-institutional basis and identifies a number of near-term objectives on disaster prevention, mitigation and attention, such as establishing early warning systems, increasing the number of local emergency committees and attending to affected families. It also specifies adaptation to climate change as one of a few key objectives for the future development of Nicaragua. It doesn't, however, identify specific actions other than sustainable practices for agriculture.

Regarding health, the 'National Human Development Plan' recognizes that natural disasters can have adverse effects (GRUN, 2009). Similarly, the 'National Health Policy' (MINSA, 2008) notes that disaster risks can be a threat for human health and that they need to be confronted through the promotion of a healthy environment and scientific studies. Yet it appears that only the more immediate effects of extreme events are alluded to, and that the more regular and complex relationships between climate and health are not taken into account.

CLIMATE RISK MANAGEMENT ACTIVITIES

Due to its long history of natural disasters, Nicaragua is aware of the need to reduce the risk of losses through prevention, mitigation and preparedness. A wide range of activities are taking place under SINAPRED within different ministries, including on forest fire prevention and control, establishment of forestry and agroforestry systems, and water regulation. The European Union has been implementing the Disaster Preparedness Programme of the European Community Humanitarian Aid Office, one of the major bilateral projects on disaster risk reduction, which has focused on preparation and response capacity development in vulnerable communities.

Nicaragua is also involved in a wide range of programs and projects on climate change adaptation. So far, activities have mainly focused on capacity development at the national and subnational levels, as well as on research in the water and agriculture sectors. Recently, two larger projects involving specific measures on the ground have been approved. The Adaptation Fund (2012) is financing a project to reduce flood and drought risks in the Estero Real watershed by means of water storage systems, climate-resilient agroecological practices and capacity development. The Inter-American Development Bank (2012) promotes risk management at the municipal level, including through support to agricultural producers on climate change adaptation. Apart from a UNDP capacity development project that ended in 2010, no climate risk projects with a health focus have been implemented so far.

ASSESSMENT OF CLIMATE RISK MANAGEMENT CAPACITY

Based on the World Resources Institute's 'National Adaptive Capacity Framework' (2009), we have conducted a short desk-based capacity assessment on climate risk management functions. The framework evaluates capacities based on the availability, systematization and mainstreaming of risk assessments and the capacity to conduct them; the existence of explicit risk management priorities and a process to revise these priorities; the existence of coordination processes and bodies; the sound management of information; the identification of risks for priority areas; and the evaluation of adaptation options and their implementation.

Assessment. A wide range of assessments on climate vulnerability, impacts and risks has been carried out to date in Nicaragua. The recently released 'Second National Communication to the UNFCCC' (GRUN, 2011) summarizes the results of assessments of water and agriculture in watershed No. 64 on the Pacific coast, as well as an evaluation of vulnerability and adaptation of coffee producers. The 'First National Communication' (República de Nicaragua, 2001) presents sectoral assessments for water, hydro-energy, forest ecosystems and health (malaria). Furthermore, Millán and Martínez (2010) recently conducted a multisectoral evaluation in the Northern Atlantic Autonomous Region. In numerous areas, participatory, local-level assessments have taken place. Nevertheless, important gaps remain in both geographical and sectoral coverage. Future assessments should be both more specific and more comprehensive, bringing together different evaluation methods to assess vulnerability and adaptive capacity from different angles, with a view to facilitating concrete interventions that can reduce risk. In addition, there is a need to monitor climate and health variables jointly in order to predict and prepare for climate impacts on human health.

Prioritization. Political documents and the body of work on adaptation and risk reduction suggests that water and agriculture are the main sectors of interest, in addition to forests, coasts, health and hydro energy. The current government has had a very clear focus on poverty reduction, suggesting that deprived people should be the prioritized. In terms of prioritizing actions, the 'National Strategy and Action Plan on Environment and Climate Change' (GRUN, 2010) identifies and prioritizes a handful of projects to address major vulnerabilities. However, no prioritization of concerns and key actions has taken place within SINAPRED. Furthermore, no explicit and ongoing institutional process has been set up to ensure the integration of sectoral objectives into relevant public and private policies and actions, or to revisit priorities periodically. It is unclear whether an explicit allocation of financial resources to reduce climate risk has taken place. Actions prioritized in the 'National Strategy and Action Plan on Environment and Climate Change' are expected to be funded entirely through external cooperation. There is also no thorough integration of climate change adaptation and disaster risk reduction, so vulnerabilities may not be addressed coherently or comprehensively.

Coordination. Vertical and horizontal processes and bodies for coordinating action on climate risk reduction exist to some extent. SINAPRED, the disaster management risk system, has sectoral subcommittees as well as regional and local levels of organization that facilitate coordinated action. MARENA's General Directorate on Climate Change has a liaison officer for disaster risk management to coordinate work with SINAPRED, as well as regional offices that support the elaboration of regional and local adaptation strategies. What appear to be missing are established interinstitutional mechanisms on climate change adaptation at the most relevant levels of decision-making. For example, discussion between the ministries of environment and health, MARENA and MINSA, on health-related climate risks have only begun in the context of the CRM TASP. No inter-institutional climate change committees exist, and the channels provided by SINAPRED do not appear to be for coordinated action on climate risk management in specific sectors or areas. The integration between disaster risk and climate change adaptation approaches could also be taken to a level beyond mutual consultation. Finally, proper coordination will also require sufficient and explicit financial resources.

Information management. Even though information is increasing on climate hazards, vulnerability and impacts, much of this information remains patchy and difficult to access. As noted earlier, the current weather data system is deficient in terms of geographic coverage and continuity of data collection as well as speed and accuracy of processing and accessibility. Much of this is true for socio-economic data, as well. For example, accurate health data is only available from about the mid-1990s onwards for many diseases, rendering impossible an analysis of longer-term relationships between climate and health. While this cannot be changed, relevant variables must be monitored continuously and accurately, and data must be made available to the public for research purposes and early warning.

Climate risk reduction. The last element considered in the 'National Adaptive Capacity Framework' is the climate risk reduction function, which captures elements of the previous functions but focuses more precisely on identifying specific risks to given priorities and evaluating adaptation and risk reduction options, as well as on their selection and implementation. As noted above, climate risk assessments have been conducted for several sectors, but a need remains for more comprehensive and specific evaluations. Risk management options have been identified and prioritized to some extent, but interinstitutional coordination could be improved on several levels for broader and more established and detailed prioritization and implementation of actions. Allocated resources for both the participating institutions and the proposed actions also appear to be lacking.

Key messages: Institutions and policies for climate risk management

- SINAPRED is Nicaragua's disaster risk management system and coordination body, and the Ministry for Environment and Natural Resources is responsible for climate change affairs.
- There are liaison officers between the disaster risk management and climate change structures, but no established interinstitutional mechanisms with the health sector.
- Climate risks are recognized as a threat to development in the 'National Human Development Plan,' but not in the 'National Health Policy.'
- Nicaragua has a good basis for managing climate risks, but important deficiencies remain in terms of vulnerability and risk assessments, prioritization of risks and risk management options, coordination among agencies, information management, and implementation of climate risk management actions.

RECOMMENDATIONS FOR CLIMATE RISK MANAGEMENT

Climate variability and change can pose significant threats to human health, yet many impacts are avoidable if conditions of vulnerability can be reduced and adaptive capacity strengthened at national, subnational and sectoral levels. Based on the risk and capacity analysis presented above, this section outlines key recommendations for specific actions on the ground, adjustments in policies and institutions to facilitate action and research, and avenues for further research.

PRIORITY ACTIONS

The following actions in and outside the health sector could contribute to reducing climate-related health risks in vulnerable areas. We have organized the actions into six themes. Some are directly based on the risk analysis or were identified in workshops by the CRM TASP and a previous UNDP project (UNDP, 2010a), as well as in López et al. (2011).

Water and sanitation

Nicaragua has recently made progress in increasing access to clean water and improved sanitation. Between 2000 and 2008, the share of the population with access to clean water increased from 80 to 85 percent, and to improved sanitation from 48 to 52 percent. However, in both regards, Nicaragua lags behind the regional average, which stood at 92 percent for clean water and 78 percent for sanitation in 2008. There is also a large gap between rural and urban areas. Only two-thirds of rural inhabitants have clean water, and just one-third have improved sanitation (World Bank, 2012). These deficiencies go a long way in explaining the high share of lost years of life caused by communicable diseases in Nicaragua (WHO, 2012b). As the detailed risk analysis above shows, the seasonal patterns of diseases such as diarrhœa, dengue and leptospirosis strongly suggest that rainfall and extreme events associated with water contamination drive, to a large extent, the prevalence of these diseases.

Further improvements in water quality are therefore probably the single most important activity for reducing climate-related health risks. Such improvements can involve actions along much of the water cycle: In many cases, the water source needs to be protected through reforestation, territorial planning, adjustments in contaminating agricultural techniques, and filters. Communities further downstream need to be connected to water mains with sufficient supply, or at least be provided with safe wells. Water purification techniques can also be used as an additional safeguard (UNDP, 2010a). Finally, water quality should be monitored systematically.

Improving sanitation will involve things such as providing every household with adequate latrines, building and maintaining appropriate sewage systems, and providing for safe waste management. All these elements have been found to be highly deficient in most of the consulted communities (López et al., 2011). MINSA (2008) notes that 70 percent of all waste in Nicaragua remains untreated. Most municipalities operate open-air landfills, and wastewater is released into rivers and lakes without treatment. These conditions constitute a permanent threat to health, as they can lead to contaminated water sources and provide breeding grounds for vectors. Climate risk reduction for health needs to take into account this crucial element of vulnerability.[10]

In line with the rural-to-urban divide in access to water and sanitation, activities should focus on deprived rural areas. However, the consultations by López et al. (2011) have also highlighted the dire situation in some neighbourhoods of Managua, the capital. Some diseases whose spread depends on contaminated water, such as dengue, are predominantly urban, so cities should not be ignored either.

Future climate change could hinder increased access to clean water because of a likely increase in water scarcity. Conflicts over water already exist today, as the case of the community of San José del Obraje shows. There, water is illegally taken from another grid, and people complain about the excessive water use on a nearby farm. All this makes efficient water use and collective, integrated water management essential.

Flood control and reforestation

Measures to control floods could also reduce the health risk posed by climate variability. This is because floods can contaminate water sources and leave standing pools of water once they retreat, which provides a breeding ground for vector-borne diseases. This will involve reforesting the water sources so as to reduce the high volatility of the flow of water downstream. It should also involve the protection of riverbeds around villages, where floods lead to the emergence of pools of standing and contaminated water.

[10] Personal communication with Gabriela Abarca, MARENA, 22 February 2012.

Reforestation also helps reduce the severity of droughts, because of steadier water flows out of forested catchment areas and a more moderate microclimate. In addition, protecting forests also helps conserve natural sources of traditional medicine, which are typically found in forests. In fact, preserving healthy ecosystems has generally been found to promote better human health.[11]

Measures related to flood control and reforestation are needed across the country, but are especially important in key water catchment areas and along rivers.

Health services

Improving the quantity and quality of health services is an obvious necessity in a country that spends only about US$250 per capita per year on health—less than half the regional average. Nicaragua has also one-third the number of hospital beds, nurses and doctors per capita than the global average (World Bank, 2012). Community consultations conducted by López et al. (2011) have shown that some communities have no local health centre. In other cases, existing services have been completely overwhelmed, and health care infrastructure has been destroyed by extreme events such as Hurricane Mitch (ECLAC, 1999). Investing more into health services should allow emergency reserves to be called upon in case of a climate disaster. It will also involve setting up a monitoring system that looks at both climate and health data and provides early warnings (see section on data monitoring and early warning below), as well as incorporating the use of that system into standard practices.

Awareness-raising and education

The accounts from disease-affected communities show that, in many cases, villagers are not aware of the health risks posed by contaminated water, such as diarrhœa and leptospirosis, nor of the increasing nature of these threats in the context of floods or droughts (López et al., 2011). MINSA, through its regional and local health centres, is maintaining voluntary health brigades and organizes 'health days' in communities. Such means can be used more extensively, and with a particular view to raising awareness about climate-related disease risks and ways to reduce them. Specific attention should be given to explaining key climate-related diseases, such as respiratory diseases, diarrhœa, dengue and leptospirosis, and associated risk factors, such as heavy rainfall and contaminated water. Promoting hygiene and other measures to ensure consumed water is clean, as mentioned above, should also be part of such education campaigns.

Similarly, linkages between climate and health could be integrated into education, both at school for everybody and in medical degrees at university to increase the awareness and knowledge of health staff about these risks.

Community organization

Communities with functioning collective organizations are better-equipped to confront climate threats, including with regard to health risk. Proper water management, which will become even more important under projected climate change scenarios and increasing population, requires participatory ways for reaching common decisions about water supply and demand. Community disaster committees can help avoid casualties and injuries during extreme events and ensure that post-disaster epidemics can be constrained by organizing food, water and shelters for everybody. They can also coordinate the implementation of prevention and mitigation measures, such as education campaigns or improvements in the water infrastructure, coordinating their efforts with agencies such as MINSA. According to the Government's development plan, every community should have had such a committee by the end of 2011 (GRUN, 2009). Finally, community organization can also facilitate the implementation of risk reduction projects by seeking consensus among inhabitants and acting as an interlocutor with governmental agencies and other external organizations.

Data monitoring and early warning

As noted earlier, collection and processing of both climate and health data is deficient in Nicaragua. Improving the collection of appropriate hydrometeorological information through a dense and continuously functioning network of weather and water-flow measurement stations is central to both short-term monitoring and longer-term risk analysis. The same is true for epidemiological monitoring, especially during extreme events (ECLAC, 1999). Collected data on both climate and diseases should be fed into a real-

[11] The International Development Research Centre maintains a varied research programme around the concept of 'EcoHealth': the relationships between ecosystems and human health.

time monitoring and surveillance system that focuses on key diseases, especially water- and vector-borne ones, and measures their outbreaks, origins, periodicity, symptoms, geographical spread and causal factors. This system could be hosted on a GIS platform that allows for the identification, monitoring, tracking and analysis of vulnerable areas and populations. Short- and long-term prevention and response plans could be tied to such a system. Access to the information should be free and open. Training and capacity development efforts are required to make such a system functional.

Other sectors

Climate risk management actions in other sectors are highly relevant for health outcomes. First and foremost, climate variability and change affects agriculture and can therefore put food and nutritional security at risk (GRUN, 2011). This in turn can have very negative effects on health, especially in children. Malnutrition is often associated with decreasing immunity against other diseases. Another relevant sector is infrastructure. During extreme events, many communities are often cut off from the outside world due to destroyed or damaged infrastructure. This can delay needed assistance, including medical help. Storms and floods can also destroy shelters, homes, medical facilities and water-supply systems. These need to be designed to withstand such extremes. It is outside the scope of this study to detail such measures in these sectors.

Summary of key climate risk management actions

Table 6 summarizes the climate risk management actions identified above along the same key themes. It also identifies the main expected benefits in terms of climate risk reduction, as well as priority regions.

TABLE 6. PRIORITIZED CLIMATE RISK MANAGEMENT ACTIONS IN HEALTH

THEME	PRIORITY RISK MANAGEMENT ACTIONS	EXPECTED BENEFITS	PRIORITY REGION(S)
Water and sanitation	Improve access to clean water (e.g. through reforestation, territorial planning, safe wells, water purification techniques)	Reduce prevalence of diseases during climate extremes	Rural areas and deprived parts of cities
	Improve sanitation (e.g. adequate latrines, sewage systems, safe waste management)		Rural areas and deprived parts of cities
	Implement collective and integrated water management for efficient water use	Reduce danger of contracting diseases from contaminated water	Dry areas
Flood controls and reforestation	Increase forest cover in catchment areas and along river beds	Regulate water flow, reduce formation of pools of standing and contaminated water, increase health benefits of forests	Catchment areas and river beds
Health services	Expand health infrastructure and staff (e.g. more community health centres)	Increase response capacity to climate-induced health risk	Remote areas
Awareness-raising and education	Awareness campaigns on the threats posed by contaminated water and their links to climate events	Increase coping and adaptive capacity to reduce climate risks among communities and health staff	Areas with high disease prevalence
	Integrate climate risk into medical curricula		Medical schools
Community organization	Establish water committees for participatory supply-and-demand management	Reduce danger of contracting diseases from contaminated water	Dry areas
	Establish disaster prevention and mitigation committees	Increase capacity to respond and to adapt	Everywhere
	Promote community leadership on risk management activities	Improve decisions and chances of implementation	Everywhere
Data monitoring and early warning	Improve monitoring of health and hydrometeorological data collection, processing and access	Provide more accurate information for early-warning systems and risk studies	Everywhere

GOVERNANCE

The priority actions and research needs identified here require adequate institutions and policies at the national level to enable and facilitate their implementation. The recommendations stemming from the conclusions of the previous section, along with Gonzalez Dominguez's (2009) suggestions on integrating climate change adaptation into health institutions and policies, can be summarized under three themes: mainstreaming of climate risk into key public policy documents; adjustments in health institutions; and capacity development. Finally, we propose the formulation of a national programme to promote a coherent and holistic approach to climate risk management.

Mainstreaming of climate risk into key public policy documents. Many of the health measures proposed in the 'National Health Policy' (MINSA, 2008) and more recent plans, such as the short-term implementation plan for 2012 (MINSA, 2012), overlap with the priority actions outlined above, though they are not explicitly designed to reduce climate risk. For example, improving water and sanitation is a high priority in policy documents at different levels. In addition, important steps have been undertaken to explicitly mainstream climate risk into national and sectoral policies. There is high-level recognition of the importance of climate variability and change, which is reflected in the 'National Human Development Plan,' for instance.

However, a lot of room remains for mainstreaming climate risk explicitly into sectoral policies. For example, in the 'National Health Policy' (MINSA, 2008) there is almost no mention of climate risk: The only reference concerns disaster impacts; however, the exact nature of these is not explained, and climate variability and change as risk factors are not mentioned. Yet as the present study documents, climate patterns can influence the prevalence of important diseases. These links should be acknowledged in the general consideration of the health context. Reducing the vulnerability to climate hazards should become an objective of the government's health policy. And practical steps such as those outlined above should be proposed. On the other hand, health impacts should be also reflected in the policy instruments of the climate change and disaster risk communities.

Health institutions. Climate risks also need to be mainstreamed into health institutions. As the previous section highlighted, inter-institutional cooperation has not occurred much in this regard. Indeed, the CRM TASP has for the first time brought together people from the climate and health communities for a substantial discussion about the linkages between the two fields. In order to devise adequate strategies, monitor climate and health data, commission and conduct further studies, and implement targeted actions, cooperation must continue at different levels of government, also bringing disaster risk specialists on board.

Capacity development. As for the risk analysis itself, the CRM TASP has contributed to building capacity within the government to analyse and mainstream climate-related health risks into its plans, strategies and actions. Yet capacity development needs to go further. Relevant agencies remain understaffed and underfinanced. Experts are hard to come by, even at the national level, which renders the follow-up necessary to the present analysis more difficult.

Towards a comprehensive climate risk management programme

The assessment in this report has shown that, while important building blocks towards managing climate-related risks in health and other sectors exist in Nicaragua, to date no coordinated and integrated institutions, policies or actions exist that would allow for holistic, effective and efficient management of these risks. We therefore recommend that a comprehensive climate risk management programme be formulated that integrates the recommendations made above through the following key elements:

- **Integration of disaster risk management and climate change adaptation approaches** with each other and into sectoral and national development planning, with a view to delivering comprehensive and coherent solutions in terms of actions, policies and research. This could take the form of permanent sectoral committees to integrate relevant governmental and non-governmental agencies that oversee the prioritization and implementation of policies and actions. For health, actions and policies can orient themselves on the above recommendations.
- **Sector- and region-specific risk assessments and management programmes** consistent with the recommendations made in this report for the health sector, but tailored to the respective needs of vulnerable areas and sectors. For health itself, the present study has only partly managed to close the knowledge gap. Other sectors, such as forestry and biodiversity, have hardly been assessed in a comprehensive way at all.

- **Data and information management.** Improvements in data collection, processing and accessibility. For health, this can take the form of a freely accessible monitoring and surveillance system for key diseases, allowing for short- and long-term prevention and preparedness against outbreaks.
- **Capacity development** for key institutions involved in climate risk management and for sectoral (i.e. health) staff, especially at local levels.

FURTHER RESEARCH

The risk analysis presented here identified some key issues regarding climate-related health risks. Nevertheless, there is ample scope for further research. First, the core elements of this analysis, the statistical study by Altamirano and Guzmán (2012), and the community consultations by López et al. (2011) all focused on 3 out of 17 SILAISs. The last study focused on two communities in each SILAIS. This leaves many vulnerable regions in which to conduct further research. Second, other climate-related diseases, especially respiratory diseases and heat stress, are likely to have very different patterns. Third, the methodology could improve. Altamirano and Guzmán's (2012) statistical analysis did not include vulnerability factors such as access to water and sanitation, which could be incorporated along with climate and health data into a statistical model that can evaluate the importance of different elements and yield more profound conclusions on risk drivers. Further insights could also be gained by looking at the linkages among climate, biodiversity and health, or by analysing the impacts of specific climate extremes such as droughts, floods and storms on health in affected sites. Finally, the existing analysis can easily be updated in the future with newer data. As reliable health records go back only about 18 years, every added year will make longer-term trends more visible and will also allow for verification of the effects of risk reduction activities undertaken.

Key messages: Recommendations for climate risk management

- To reduce climate risks in health, we recommend improved water management, flood control and reforestation, expansion of health services, awareness-raising and education campaigns, strengthening of community organizations, efforts to increase access to clean water and sanitation, and investments in climate and health data monitoring and early warning. Actions in other sectors, such as agriculture and infrastructure, also have an impact on health.
- At the policy level, we recommend that climate risk considerations be appropriately integrated into health policy documents, that cooperation between health and climate agencies be institutionalized, and that governmental capacities in the area be strengthened.
- A comprehensive climate risk management programme to implement these recommendations holistically should be established.
- Further research could expand and deepen the knowledge of climate-related health risks geographically and in terms of analysed diseases.

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