



Paving the Way for Climate-Resilient Infrastructure

Guidance for Practitioners and Planners





UNDP is the UN's global development network, advocating for change and connecting countries to knowledge, experience and resources to help people build a better life. UNDP has a presence in 176 countries and territories, working with them on their own solutions to global and national development challenges. As they develop local capacity, they draw on the people of UNDP and our wide range of partners.

September 2011

Copyright © 2011 United Nations Development Programme

All rights reserved. This publication or parts of it may not be reproduced, stored by means of any system or transmitted, in any form or by any medium, whether electronic, mechanical, photocopied, recorded or of any other type, without the prior permission of the author or the United Nations Development Programme.

The views and recommendations expressed in this report are those of the authors and do not necessarily represent those of UNDP, the United Nations or its Member States. The boundaries and names shown and the designations used on maps do not imply official endorsement or acceptance by the United Nations. Sole responsibility is taken for errors of omission or commission.

Design: Anvil Creative Group (NY, www.anvilcreativegroup.com)

Paving the Way for Climate-Resilient Infrastructure

Guidance for Practitioners and Planners

Official Proceedings

International Conference: Strategies for Adapting Public and
Private Infrastructure to Climate Change

San Salvador, El Salvador
June 30, 2010

These proceedings should be referenced as: United Nations Development Programme (2011). *Paving the Way for Climate-Resilient Infrastructure: Guidance for Practitioners and Planners*. New York, New York: United Nations Development Programme.

Contents

ACRONYMS AND ABBREVIATIONS	v
FOREWORD	vi
ACKNOWLEDGEMENTS	viii
EXECUTIVE SUMMARY	ix
PART I: OVERVIEW	xvi
Chapter 1: Introduction	3
Chapter 2: Workshop Context, Richard Barathe, Gerson Martínez, Herman Rosa Chávez	7
Chapter 3: Workshop Objective and Scope, Pradeep Kurukulasuriya	11
Chapter 4: A ‘No-Regrets’ Risk-Based Approach to Climate Proofing Public Infrastructure: Improved National and Subnational Planning for Resilience and Sustainable Growth, Paul B. Siegel	17
Motivation, objective, approach	17
Conceptual framework for climate proofing infrastructure	20
Annex 1: Further Reading: Lessons Learned on Climate proofing Infrastructure	32
Annex 2: Recommended Readings	44
Annex 3: References and Other Sources of Useful Information	45
Annex 4: The Central American Probabilistic Risk Assessment (CAPRA) Initiative	50
PART II: TECHNICAL PRESENTATIONS	51
Chapter 5: What a Country Should Think About and Then Do to Address Climate Change and Infrastructure Risks, Robert Kay	54
Chapter 6: Internalization of Climate Risks in the Context of Planning and Urban Development, Roberto Sanchez-Rodriguez	64
Chapter 7: A Framework for Risk Assessment and Risk-Informed Decision-Making for Infrastructure Development, Michael H. Faber	80
Chapter 8: Probabilistic Risk Modeling: Basic Principles and Applications, Travis Franck	94
Chapter 9: An Economic Framework for Evaluating Climate Proofing Investments on Infrastructure, Matthew J. Kotchen	106
Chapter 10: Supporting El Salvador to Reduce Infrastructure Risks within a Green, Low-Emission and Climate-Resilient Framework for Development — Strategy for Adapting Public and Private Infrastructure to Climate Change, Stephen Gold	116

FIGURES, TABLES, AND BOXES

Executive Summary

Figure 1.1: Conceptualization of spatial, sectoral and cross-cutting dimensions of climate change	xi
---	----

Chapter 3

Figure 3.1: Moving from short-term and ad hoc adaptation toward longer-term and deliberative adaptation	12
Figure 3.2: Moving towards an updated concept for climate-resilient infrastructure	13
Figure 3.3: Linking climate change adaptation and disaster risk management	13
Figure 3.4: UNDP's approach to supporting countries on climate change	14
Box 3.1: Key content and organization of the conference	15

Chapter 4

Figure 4.1: Probabilistic risk modeling (a)	22
Figure 4.2: Probabilistic risk modeling (b)	23
Figure 4.3: Probabilistic risk modeling (c)	23
Figure 4.4: Components of probabilistic risk modeling (d)	24
Box 4.1: Definitions of climate proofing	25

Chapter 5

Figure 5.1: Conceptualization of spatial, sectoral and cross-cutting dimensions of climate change	56
Figure 5.2: Adaptive potential in infrastructure life cycle	57
Figure 5.3: UNDP Adaptation Policy Framework	59
Figure 5.4: Adaptive potential by life cycle phase	60
Table 5.1: Adaptive decision points for each life cycle phase	61
Table 5.2: Prioritization of adaptation options by barriers	62

Chapter 6

Figure 6.1: Changes in the number and intensity of hurricanes in a warmer climate	65
Figure 6.2: Examples of future impacts of climate change associated with changes in global average temperature	66
Figure 6.3: Climate risks in large cities	67
Figure 6.4: Pre-Columbian Mexico City	73
Figure 6.5: Evolution of precipitation in Mexico City	74
Figure 6.6: Distribution of precipitation in Mexico City	74
Figure 6.7: Population growth in Mexico City in the last century (population in thousands [x 1000])	75
Figure 6.8: Climate models applied to different areas of Mexico City (right) and summary of model results indicating likely impacts of climate change in these areas (left)	76
Figure 6.9: Water and climate change in Mexico City; interconnectedness of factors	78

Chapter 7

Figure 7.1: Percentage of natural disaster events by country	81
Figure 7.2: Distribution of consequences (losses of lives) due to natural disasters from 1991 to 2005 by national economic category	82
Figure 7.3: Annual reported economic consequences from natural disasters from 1975 to 2005	82
Figure 7.4: The generation of consequences from exposure, vulnerability and robustness	84
Figure 7.5: Hierarchy systems modeling approach	85
Figure 7.6: Human Development Index (HDI) for 2004	87
Figure 7.7: General principle of societal resource allocation and life safety	88
Figure 7.8: The SWTP criterion	89
Figure 7.9: SWTP in \$ in El Salvador, surrounding areas, and the world	89
Figure 7.10: Complete risk modeling for typhoons (tropical cyclones), including several models based on updated data and information about events and potential damages	91
Figure 7.11: Updating wind field maps and risk maps over time for islands of Japan	91
Figure 7.12: Annual maximum wind distribution in Tokyo, 'normal' vs. with climate change	92
Figure 7.13: Probability of exceedance by portfolio loss, consideration of common cause effects (dependence of losses) vs. no consideration of common cause effects	92

Chapter 8

Figure 8.1: The Feedback-Rich Adaptation to Climate Change (FRACC) Model	97
Table 8.1: Scenario examples	97
Table 8.2: Assigning probabilities	98
Figure 8.2: Decision tree for infrastructure project (based on scenario, without policy assumptions)	98
Figure 8.3: Decision tree for infrastructure project (based on scenario, with policy assumptions)	99
Figure 8.4: Probability density functions (PDFs)	100
Figure 8.5: PDF of storms for St. Mary's Parish	101
Figure 8.6: Relevant metrics for disaster relief policy choices in coastal community	102
Figure 8.7: Recovery time vs. storm category, showing robustness of relief over time	102
Figure 8.8: Probability density function showing joint program SLR estimates	103
Table 8.3: Joint program SLR odds	103
Figure 8.9: Probability wheels of temperatures in 2100 given no policy and given policy	104

Chapter 9

Figure 9.1: Carbon dioxide emissions (in 1000s metric tons) from fossil fuels by country in Central America (2006)	107
Figure 9.2: The costs of climate proofing effectiveness	108
Figure 9.3: The benefits of climate proofing effectiveness	110
Figure 9.4: Damages relative to no climate change baseline 2100 (million \$/year)	110
Figure 9.5: Efficient level of climate proofing	111
Figure 9.6: Prioritizing among projects with a fixed budget	112
Figure 9.7: Map of Central America (left) and departments of El Salvador (right)	113
Figure 9.8: Prioritization among projects accounting for externality	113
Figure 9.9: Prioritizing among projects accounting for externality	114

Chapter 10

Figure 10.1: A partnership framework through a multi-stakeholder participatory decision-making process	119
Figure 10.2: Example of decision-making hierarchy in Uruguay	120
Table 10.1: Common climatic variables used for climate impact and risk assessment	121
Figure 10.3: Downscaling of Global Climate Models (GCMs) for two emission scenarios and two time periods in the metropolitan area of Uruguay	122
Figure 10.4: The methodological framework for assessing vulnerability	123
Figure 10.5: Global GHG abatement cost curve beyond business-as-usual 2030 (v2.1)	124
Figure 10.6: Impact of cash crops on ability to avert expected loss — Mali test case	125
Table 10.2: Example of green, low-emission and climate-resilient roadmap for wind power	126

DEFINITION

Climate proofing

Climate proofing refers to the explicit consideration and internalization of the risks and opportunities that alternative climate change scenarios are likely to imply for the design, operation and maintenance of infrastructure. In other words, integrating climate change risks and opportunities into the design, operation, and management of infrastructure.

Acronyms and Abbreviations

AsDB	Asian Development Bank	MC	marginal cost
CAPRA	Central American Probabilistic Risk Assessment	MCA	multi-criteria analysis
CBA	cost-benefit analysis	MNSB	marginal net social benefit
CCA	climate change adaptation	MOP	Ministry of Public Works, Transport, Housing and Urban Development, El Salvador
CEA	cost-effectiveness analysis	MSB	marginal social benefit
CHIPS	Couple Hurricane Intensity Prediction System	NGO	non-governmental organization
CO ₂	carbon dioxide	NSB	net social benefit
DRM	disaster risk management	OECD	Organisation for Economic Co-operation and Development
DRR	disaster risk reduction	PNG	Papua New Guinea
ECLAC	Economic Commission for Latin America and the Caribbean	PDNA	Post Disaster Needs Assessment
EIA	environmental impact assessment	PDF	probability density function
ETH	Swiss Federal Institute of Technology Zurich	PIEVC	Public Infrastructure Engineering Vulnerability Committee
EWS	early warning system	PRA	probabilistic risk assessment
FRACC	Feedback-Rich Adaptation to Climate Change	SCCF	Special Climate Change Fund
GCM	global climate models	SNET	National Service of Territorial Studies, El Salvador
GDP	gross domestic product	SLR	sea-level rise
GFDRR	Global Facility for Disaster Reduction and Recovery	SVSL	societal value of a statistical life
GHG	greenhouse gas	SWTP	societal willingness to pay
GIS	geographic information System	TC	total cost
HDI	Human Development Index	TSB	total social benefit
IDB	Inter-American Development Bank	UNDAC	United Nations Disaster Assessment and Coordination
IPCC	Intergovernmental Panel on Climate Change	UNDP	United Nations Development Programme
ISDR	International Strategy for Disaster Reduction (see UNISDR)	UNFCCC	United Nations Framework Convention on Climate Change
JCSS	Joint Committee on Structural Safety	UNISDR	United Nations International Strategy for Disaster Reduction
LECRDS	low-emission climate-resilient development strategies	UNOCHA	United Nations Office for the Coordination of Humanitarian Affairs
LQI	Life Quality Index	USAID	United States Agency for International Development
MARN	Ministry of Environment and Natural Resources, El Salvador		
M&E	monitoring & evaluation		

Foreword

Mr. Gerson Martínez

According to the Global Facility for Disaster Reduction and Recovery (GFDRR) and the United Nations Disaster Assessment and Coordination (UNDAC), El Salvador is recognized as the most vulnerable country in the world. The 2010 UNDAC report, *Assessment of the Capacity for Emergency Responses 2010*, states that almost 90 percent of the territory in El Salvador is located in an area of high risk. These areas are home to more than 95 percent of the country's population, and approximately 96 percent of the country's gross domestic product (GDP) is linked with these locations. According to studies from the Economic Commission for Latin America and the Caribbean (ECLAC), natural disasters have caused 6,500 deaths since 1972, with an economic cost of greater than 16 billion 2008 United States dollars. Of these impacts, more than 62 percent of the deaths and between 87 to 95 percent of the economic losses were related to climatic events.

These figures are alarming and give rise to considerable concern in light of the projections that El Salvador will experience an increase in frequency and severity of natural hazards as a result of climate change, particularly in relation to extreme rainfall. The country is already witnessing such extreme events, with devastating consequences including economic and human loss.

During the two first years of this administration, the country suffered extreme weather events with exceptional levels of rainfall. On 29 May 2010, during Tropical Storm Agatha, precipitation levels were recorded at 483 mm over the course of 24 hours with maximum rainfall intensity concentrated over six hours. The period of return for this level of intense rainfall is more than 300 years.

In November 2009, the combination of Hurricane Ida and a low-pressure system in the Pacific coast also presented extremely high rainfall intensity over six hours. Like Tropical Storm Agatha, the period of return for this level of intense rainfall is more than 300 years. The disaster provoked by Ida caused the death of 200 people, and directly affected another 122,816 people. The damages and material losses were estimated at \$314.8 million, equivalent to 1.44 percent of GDP. The rehabilitation and reconstruction needs were estimated at close to \$344 million.

These two events clearly demonstrate the country's high vulnerability to natural hazards, and the necessity to take preventive action through a combination of risk management and climate change adaptation measures. The Salvadoran government, through the Ministry of Public Works (MOP), the Ministry of Environment and

预览已结束，完整报告链接和二维码如下：

https://www.yunbaogao.cn/report/index?reportId=5_13328

