Once Burned, Twice Shy?

Lessons Learned from the 1997–98 El Niño

Edited by Michael H. Glantz

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Once burned, twice shy? Lessons learned from the 1997–98 El Niño

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Reducing the impact of environmental emergencies through early warning and preparedness: The case of the 1997–98 El Niño

UNEP NCAR UNITED NATIONS UNIVERSITY WMO International Strategy ISDR for Disaster Reduction

The United Nations University, 53-70, Jingumae 5-chome,
Shibuya-ku, Tokyo, 150-8925, Japan
Tel: +81-3-3499-2811 Fax: +81-3-3406-7345
E-mail: sales@hq.unu.edu
http://www.unu.edu

United Nations University Office in North America
2 United Nations Plaza, Room DC2-1462-70, New York, NY 10017, USA
Tel: +1-212-963-6387 Fax: +1-212-371-9454
E-mail: unuona@igc.apc.org

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Foreword

The world has seen an ever increasing number of natural catastrophes during the final decade of the twentieth century. Undoubtedly, climate-related disasters – floods, cyclones, hurricanes, droughts – have claimed a high toll on human society. Some rightly claim that the increased frequency and intensity of these disasters is closely linked to global warming and an overall change in global climate. It is also important to consider that these disasters cause not only physical damage but also ravage society on both human and economic scales. Indeed, the social dimension of these disasters is much more pervasive than appears on the surface and lingers long after the physical factors have disappeared from the scene. Human society needs to take all these social aspects into account to fully prepare for and mitigate the impacts of all natural disasters.

In an effort to initiate and undertake such evaluation, a number of United Nations agencies and an international research organization teamed up to take a closer look at the 1997–98 El Niño. It was quite appropriate to look at the "El Niño of the Century" as a climatic event that triggered a number of disasters virtually the world over. Some of the estimated figures for overall damage caused by that El Niño are indeed quite staggering – starting with a minimum of US$32 billion and going as high as US$96 billion. It may be argued that these figures do not fully account for the human factor or for the trickle-down economic impacts. Even as a crude estimate, these figures and related impacts on human lives are sufficiently high so that we need to evaluate carefully the responses to the last event and systematically prepare for the next one.

This study is unique in a number of ways. Firstly, it provided a systematic evaluation of how societies reacted to the 1997–98 El Niño. This includes reaction and response of the national governments and institutions, public media, international organizations, the research community and the general public. The flow of information before, during, and after the event was thoroughly analyzed to identify strengths and weaknesses. The important influence of national politics on the response to El Niño-related events was also analyzed. Secondly, the studies in each country were done by local multidisciplinary teams, which in itself reflects the importance of El Niño to various sectors of society. Thirdly, the study was organized and managed by a diverse group of organizations – led by the UN Environment Program (UNEP), these included the United Nations University (UNU), the National Center for Atmospheric Research (NCAR), the World Meteorological Organization (WMO), and the International Strategy for Disaster Reduction (ISDR). Each member brought its own strengths to the project, making it a rich experience.

The UNU has always attached high priority to issues related to both climate change and disaster mitigation. A number of initiatives developed over the years have addressed these important global issues and have made a significant contribution as a bridge between the scientific community and the UN system. Most recently, UNU – in collaboration with other UN agencies – has undertaken training of negotiators participating in the climate change negotiations. Similarly, UNU was a major contributor to the International Decade for Natural Disaster Reduction (IDNDR) through research and training activities focused on developing countries. This experience has proven quite useful in the context of the study described in this book.

At the completion of the series of evaluations in each of the 16 countries studied, a number of important issues and recommendations have emerged. It is most interesting to note similar findings surfacing in all the countries – which were spread around the globe, but fall into the developing country envelope. Indeed, a number of problems have to do with ineffective governance, poor infrastructure, lack of communication and monitoring resources and insufficient regional and national coordination. These problems are more pronounced in the developing world and are not confined to responses to El Niño. The most important finding of the study relates to the close link between sustainable development and improved responses to El Niño-related disasters.

A number of other important findings are discussed in much greater detail in the book. I will mention but a few of the salient ones here. It was found that accurate, usable, and local forecasts are critically important to developing countries in order to cope with the problems triggered by El Niño. It was also obvious that nearly all the countries do not possess sufficient capacity to provide such forecasts. Therefore, the researchers argue that by forming regional institutions to pool technical and financial resources, a more efficient approach can be adopted. Such regional institutions can also be helpful in prioritizing the needs of the region and identifying areas at the highest risk. It is encouraging to see that an organization in the southern Pacific has already taken up this role (i.e., Permanent Commission for the South Pacific – CPPS). Similarly, ASEAN has adopted a similar approach to deal with El Niño-related problems.

Another important recommendation is that the capacity of developing countries should be built up in order to better understand the extreme climate events that impact different sectors of society and so that more reliable forecasts can be made available in a timely fashion. The UNU, in partnership with NCAR, WMO, and ISDR, has responded to this need and has developed a comprehensive program to undertake such capacity development activities. We anticipate that perceptible differences in capacity will be apparent in a short period of three to five years. An important contribution of this proposed program will be to develop multidisciplinary, academic "Climate Affairs" programs in educational institutions. The climate affairs program will encompass a broad spectrum of issues ranging from ethics and policy formulation to the impacts of climatic events and the science behind them. It is indeed an exciting, and yet challenging, prospect to be involved in shaping up a new approach to look at climate.

The contributors to this study deserve our duly earned gratitude and recognition for undertaking a comprehensive and systematic study. The partner organizations also deserve due credit for bringing together the necessary resources for contributing to the study. I sincerely hope that the clear message sent by the study will be taken on board by all the stakeholders. We must be much better prepared when the next El Niño comes our way.

Hans van Ginkel
Rector, United Nations University

Preface

This assessment reviewed forecasts and impacts of the 1997–98 El Niño, as well as the climate-related early warning and natural disaster preparedness systems in the following locations in order to improve their ENSO (El Niño-Southern Oscillation) and other climate-related coping mechanisms; Cuba, Costa Rica, Panama Canal, Ecuador, Peru, Paraguay, Ethiopia, Kenya, Mozambique, Bangladesh, China, Philippines, Vietnam, Indonesia, Papua New Guinea, and Fiji. Based on the lessons drawn from these 16 studies, the project identified research and policy needs and presented ideas for developing regional and national disaster preparedness plans for ENSO's warm (El Niño) and cold (La Niña) events and their impacts.

Each study team leader was allowed to select the method of presentation of his/her report. No common template was provided to them, in order to allow the teams to tell their stories as they wished, highlighting key sectors in society, and problems and prospects with regard to the future responses to El Niño (or La Niña) forecasts and impacts. It is important to note that these studies are not government studies, but were undertaken by researchers and scientists associated with climate and climate-related issues within these countries. They do not represent official government reports.

The idea behind the adage "once burned, twice shy" is that when someone has had a bad experience, he or she is likely to shy away from putting himself/herself in that same position again. They have learned from experience what to expect if they were to repeat the first experience in the same way.

This raises a question about whether societies that are forced to cope with recurring natural hazards learn from history. Some do learn and others don't. The point is that not every natural hazard has to become a natural disaster. In fact, this adage *should* apply as well to societal (political, economic, social, or cultural) responses to El Niño forecasts and to El Niño impacts. In the case of El Niño, we will have to wait and see if societies are still "shy" once they have been "burned." Most likely, we will not have to wait too long before this perspective is tested by reality – by the next major El Niño episode.

I think it is safe to assume that the most intense El Niño of the twentieth century, the 1997–98 event, served as the most recent and most effective wake-up call to governments, industries, and the public around the globe that a shifting of warm water in the tropical Pacific Ocean along the equator from the west to the central and eastern part of the basin can affect weather systems and, therefore, human activities worldwide. Clearly, the countries around the Pacific Rim and those around the tropics are most directly and visibly affected by such a warm-water shift.

The overriding purpose of this project has been to identify what worked and what did not work with regard to societal responses to the forecasts and impacts of the 1997–98 El Niño event. The approach taken was to look back to see what might have been done differently, had an accurate (hypothetically perfect) forecast been available several months in advance of the onset in March 1997 of El Niño. As a result of such an assessment in 15 countries and in the Panama Canal Zone, several lessons were identified in each country study, and many of the lessons proved to be similar among the countries as well.

Problems in coping with the impacts of an El Niño event, and possibly of other natural hazards as well, centered on the following: jurisdictional disputes among government agencies, forecast reliability, lack of education and training about the El Niño phenomenon, political, and economic conditions (or crises) existing during the event, lack of resources to cope in a preventive or mitigative way, lack of donor sensitivity to the local needs, poor communication, lag time between forecast and impacts and between impacts and responses, responses and reconstruction, and so on.

The sad fact is that many of the lessons highlighted in this assessment are similar to those that have been identified for other countries facing a wide range of natural hazards. That means that the word is out, so to speak, about what the problems are and how to address them, at least in theory. What seems to be lacking are the actions to remove the weaknesses and to reinforce the strengths of society's responses to these hazards. It is time for governments to confront the obstacles to needed changes in the way they respond to natural hazards. In this regard, social, economic, and political solutions must be sought. It is not enough for policy makers to rely just on a blind faith in new technologies such as high-tech early warning systems. The questions that should now be addressed in open forum are questions such as the following: What are the solutions needed for a more effective response to El Niño-related societal and environmental impacts? Why are many of those solutions known by governments, researchers, and individuals but not yet applied?

While one can find plausible reasons to excuse many of the inappropriate responses taken by governments, industries, or individuals to the 1997–98 El Niño, that should not be the case when it comes to the El Niño events in the future. The 1997–98 event can be said to have served as a "dry run" or a test response by societies around the globe to the forecasts and impacts of El Niño. True, there are good some reasons why governments responded the way they did (a war going on, low credibility in the forecast, unclear teleconnected impacts of El Niño, etc.). However, government awareness of the El Niño phenomenon and what it can do to societies and economies is now relatively high. *As we are now between El Niño events, the time is right for societies to improve their understanding of the phenomenon and to devise ways to better identify and cope with its potential direct and indirect effects*. This brings to mind another old adage: the time for a farmer to fix the leaky roof of his farmhouse is when it is *not* raining. Unfortunately, there is no urgency for the farmer to fix the roof once it has stopped raining. Similarly, the time to prepare for an El Niño event is when there is no El Niño under way. And, with respect to El Niño, once an event ends, there is little pressure on governments to address them, at least for a few more years.

Michael H. Glantz
Boulder, Colorado

Acknowledgments

The successful completion of this project has depended on the contributions of many people and their organizations. First and foremost, the dedicated efforts of Project Liaison D. Jan Stewart merit high praise from all involved, from the team leaders to the funding agencies to the Principal Investigator. The team leaders and their country teams must also receive high praise for their continued interest in and concern for the success of this multinational, interdisciplinary assessment.[1]

The Core Advisors to the project made considerable contributions to the spirit and the letter of the report, beginning with the proposal preparation phase. These advisors include Alex Alusa (UNEP's Project Administrator), Zafar Adeel (UN University), Michael Coughlan (World Climate Program Director at the WMO), Wolfgang Wagner, Rudolf Slooff, and John Harding (IDNDR, now the ISDR). Dale Jamieson (Carleton College, Minnesota) and Mikiyasu Nakayama (Tokyo University of Agricultural and Technology) served as advisors to the Principal Investigator on methodology. William Kininmonth provided scientific support and guidance to the project throughout its duration. In addition, he merits accolades for his preparation of the *WMO Retrospective*. The WMO graciously provided conference facilities for the First Meeting of the Team Leaders (8–10 July 1999) in the new building in Geneva. The UNU's International Institute for Software Technology in Macau, China, provided conference facilities for the Mid-Course Evaluation Meeting (6–9 March 2000).

The UN Foundation[2] provided support for 10 of the country case studies. Support for the six additional studies that were immediately added as integral parts of this assessment was as follows: the Chinese Academy of Sciences and the Chinese Natural Science Foundation of the People's Republic of China supported the China case; the team leader and team members of the Bangladesh Public Administration Training Centre (BPATC) supported their country study entirely on their own resources; the Paraguay and Peru studies were supported by the US NOAA Office of Global Programs; the Indonesia study by the NOAA Office of Global Programs and USAID/OFDA; and the unique Panama Canal study was sponsored by UNEP's Water Unit.

The National Center for Atmospheric Research's Environmental and Societal Impacts Group (ESIG) served as the focal point for the project, as well as the development of the proposal with UNEP. Various NCAR and UNEP services have made major contributions to the ability of the Project Office to complete this 19-month assessment from conception to publication: Regina Hogan and Victoria Holzhauer (NCAR, budgets), Brygida Kubiak (UNEP, budgets), Jennifer Oxelson (NCAR, website design), Jacinta Obonyo (UNEP, Atmosphere Unit), Justin Kitsutaka (graphics), Ms. Sudo Sumiko (UNU), Autumn Moss and Shannon McNeeley (NCAR, research assistants), Tanya Beck and Jan Hopper (NCAR, administrative assistance), and the NCAR Image and Design Center staff.

Zafar Adeel (UNU) deserves special credit. He oversaw the production and dissemination of the brief Executive Summary of this El Niño project, which was prepared for release at the Millennium UN General Assembly in New York City in the fall of 2000. It was officially released on 27 October 2000 at a UN press conference led by UNEP's Executive Director Klaus Töpfer, WMO's Secretary-General G. O. P. Obasi, Zafar Adeel of the United Nations University (on behalf of UNU Rector Hans Van Ginkel), and the project's Principal Investigator. Without a doubt, Terry Collins, media consultant, was instrumental in getting the word out on the project's findings and the launching of the Brief Summary. (The Brief Summary is available in Portable Document Format (PDF) on the website at www.esig.ucar.edu/un).

I would also like to acknowledge the enduring patience of my wife, Karen Lynch, who has had to put up with El Niño-related travel of, and excuses from, her husband for much more than the past 19 months.

Notes

1. See Appendix 2 for the complete chart of the conditions under which the study authors conducted this research.

2. The UN Environment Program (UNEP), in cooperation with the National Center for Atmospheric Research (Boulder, Colorado, USA), was awarded a grant by the UN Foundation to carry out a 19-month study of the impacts of the 1997–98 El Niño event in 16 countries in four major areas: Asia, Southeast Asia, Sub-Saharan Africa, and Latin America. The study began in mid-May 1999 and concluded in mid-December 2000. This study is a partnership among United Nations agencies in addition to UNEP and NCAR's Environmental and Societal Impacts Group: The World Meteorological Organization's (WMO) World Climate Program, the International Decade for Natural Disaster Reduction (IDNDR; now the International Strategy for Disaster Reduction), and the United Nations University's Environment and Sustainable Development Program.

Part I

Introduction

El Niño (EN) can be defined briefly as the anomalous appearance from time to time of warm sea surface temperatures in the central and eastern equatorial Pacific Ocean. The Southern Oscillation (SO) refers to a seesaw-like pressure pattern in the western part of the tropical Pacific. El Niño originally referred to the appearance of warm water off the coast of Peru and Ecuador, where the upwelling of deep cold ocean water normally occurs. By the 1970s, it was realized that these two Pacific basin phenomena interact, affecting climate processes around the globe. The basin-wide phenomenon is referred to as ENSO (El Niño-Southern Oscillation). ENSO has both a warm and a cold phase. The cold phase is referred to as La Niña.

El Niño reappears at intervals of two to ten years with an average return period of four and a half years. Once an El Niño event begins, it can last from 12–18 months, and sometimes as long as 24 months. However, the socio-economic and even political impacts on society of El Niño-related climate anomalies such as droughts, floods, fires and frosts, and infectious disease outbreaks, can last much longer.

El Niño events can reach different levels of intensity from weak to very strong, depending on how warm the ocean surface water gets in the tropical Pacific, and how long it remains well above average. El Niño's impacts in different locations around the globe will vary. The severity of those impacts is determined not only by the intensity of the event, but also by the degree of vulnerability in a given society. Societal vulnerability changes over time and can vary from one event to the next.

How a country responds to the direct and indirect impacts will in large measure be a function of how vulnerable it is at the time of impact. Policy makers and researchers need to know, when trying to sort out the impacts of an El Niño event from other causes, the conditions that existed at the time of the onset of the event. The same country plagued by the same natural hazard of the same level of intensity but at two different times will most likely be affected in different ways. At one time an El Niño may be of short duration and low intensity and have little impact, while at other times the impacts could be major and long-lasting if, for example, the economy is faltering or food prices in the local marketplace are high, or there is a political or military conflict in progress, or if an El Niño-related drought has been preceded by a drought that was caused by regional variations in climate during non-El Niño conditions.

While climate researchers might think that a government's most important consideration should be how to cope with climate-related impacts, there are other social, economic, political, and environmental processes under way that adversely affect people and ecosystems. A review of the conditions in the 16 countries in the late 1990s before, during, and after the onset of the 1997–98 event highlights a wide range of socio-economic and political pressures on these governments. For example, Ecuador had four different presidents in office between 1996 and 1998 as a result of military coups and elections. In Fiji, a coup attempt took place based on cultural-political issues, which challenged the existence of that democratic society. Control of the Panama Canal was in the process of reverting back to the Republic of Panama from the United States. Major floods occurred in Bangladesh and Mozambique. Papua New Guinea was the only country during the 1997–98 El Niño that suffered a famine. Ethiopia was at war with neighboring Eritrea during its climate-related extreme conditions. Costa Rica underwent a democratic change in government and, along with it, a change in disaster policy and personnel. Cuba exhibited less concern about El Niño in early 1998 and more concern with the forecast of the onset of a La Niña event, because a La Niña event tends to spawn an above-average number of hurricanes in the Atlantic Basin. The point is that the attention of governments and their agencies was not necessarily focused solely on the potential impacts of the El Niño event that had eventually developed. Making matters worse is the inequitable distribution of knowledge as well as resources that a given country might need to possess in order to mitigate, if not prevent, El Niño's impacts.

In Part II, the integrated overview of the 16-country case studies' findings and lessons identified (if not learned) during this El Niño assessment was based on the reports prepared by 16-country study teams. Key issues were identified in each study, and similar findings were then clustered and melded together into specialized sections of the overview. The overview was prepared by the Principal Investigator (Glantz), who relied almost exclusively on the findings in the individual country studies.

The 16 executive summaries are presented in Part III. These team reports *do not* represent official government positions. Team members were selected for their contribution (e.g., expertise, experience) to a multidisciplinary perspective of climate/society/environment interactions. Their country assessments were objective and were not designed to push forward any hidden agenda. At the end of each country study's executive summary (presented alphabetically) are country-specific lessons derived by the study teams based on their research. Their lessons are action-oriented in that, if acted upon, could lead to more effective societal responses to future El Niño or La Niña events, as well as to other climate-related hazards.

As a final note, several of our study's findings proved to be similar to those that have appeared in other reports on societal responses to early warnings of climatic, oceanic, and geological hazards, among other life-threatening hazards (Lee and Davis 1999). This is, at the same time, comforting and troubling. In a sense, it is *comforting* that several similar conclusions about disaster preparedness have been derived from previous studies of different natural hazards, using different research approaches in countries not included in our study. The *troublesome* fact is that many of the actions suggested in these reports for governments have most likely been either set aside or left un-addressed by societies and their governments for a variety of bureaucratic, political, ideological, or economic reasons. How, then, can researchers in this study apply their findings and their expertise to develop ways to *convert awareness* of climate-related (and specifically El Niño-related) impacts on society, economy, and environment into *real action* that attempts to resolve issues rather than ignore them (until the *next* time the climate-related hazard appears)?

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Part II

Integrated overview of study findings

Michael H. Glantz

In each country every year there are likely to be climate variations that are considered to be anomalies. Such anomalies frequently go beyond the range of what is considered to be normal. It is the climate anomaly that most concerns societies, because human activities are geared toward what individuals perceive to be their region's normal climate. When what is considered to be normal does not occur, individuals, corporations, and governments are put in the position of having to decide how best to respond. The truth of the matter is that farmers do not want climate conditions to be either too favorable for agricultural production (leading to over-production and low prices for their products) or too unfavorable (leading to crop failure or bankruptcy for some farmers). El Niño events are major disrupters of what most people view as their normal climates. In those locations where an El Niño's appearance can reliably be associated with regional or local climate variations such as droughts and floods, El Niño forecasts can provide decision makers not just with an early warning, but with the *earliest* possible warning of an increased risk to such adverse climate conditions.

The 1997–98 El Niño

During mid-1997, sea surface temperatures across the central and eastern equatorial Pacific Ocean became much warmer than normal, as a major El Niño event developed. In fact it was so intense that scientists have since labeled it "The El Niño of the Twentieth Century." Rain-producing cloud systems, i.e., deep tropical atmospheric convection, in the region of the western Pacific Ocean shifted eastward. As a consequence, flood-producing heavy rainfall occurred in many parts of the usually dry western coastal regions of South America. Also, as the rain-producing cloud mechanisms shifted eastward, drought conditions prevailed over the western Pacific and Southeast Asian regions. This El Niño event dissipated in May 1998 and ended in June, as unexpectedly and as rapidly as it had developed more than a year earlier. Sea surface temperatures in the tropical Pacific rapidly returned to normal and then, a few months later, to cooler-than-normal conditions referred to as a La Niña event.

The adverse societal impacts of the intense 1997–98 event made El Niño a household word just about everywhere on the globe, even in remote rural areas. The event also brought international attention to the risks posed to society and the environment by the climate-related extremes that it can spawn, particularly in the developing world. Loss of life, destruction of infrastructure, depletion of food and water reserves, displacement of communities and outbreaks of infectious disease all occurred as manifestations of climate-related natural disasters that occurred concurrently with the 1997–98 El Niño event.

The United Nations (UN) General Assembly took notice of the intensity and worldwide extent of natural disasters associated (rightly or wrongly) with the 1997–98 El Niño and requested that the Secretary-General, as reflected in Resolutions 52/200 and 53/185, develop a strategy within the framework of the International Decade for Natural Disaster Reduction (IDNDR) to prevent, mitigate, and rehabilitate the damage caused by the El Niño phenomenon. In December 1997, the Inter-Agency Task Force on El Niño was created within the framework of the International Decade for IDNDR. The Task Force was established for cooperative work between UN member agencies and their partner agencies outside the United Nations system. It provided a platform for combining efforts to improve the general understanding of the El Niño phenomenon, for disseminating early warnings prior to the events, and for channeling technical assistance and capacity-building resources to member states threatened or affected by El Niño- and La Niña-related disaster impacts. The UN Task Force on El Niño demonstrated the immense value of multidisciplinary approaches in the efforts to reduce global disasters. The members of the Task Force recognized the need for long-term risk reduction to avoid the repetition of the disastrous social, economic, and environmental impacts of the final El Niño of the twentieth century. The International Strategy on Disaster Reduction (ISDR), as the successor agency to the IDNDR, has been designated to maintain this interagency mechanism for concerted action on El Niño.

The World Meteorological Organization (WMO), with the UN Environment Program (UNEP), the Intergovernmental Oceanographic Commission (IOC) of the UN Education, Scientific and Cultural Organization (UNESCO), and the International Council for Science (ICSU), working with the IDNDR Secretariat within the framework of the UN Task Force on El Niño, organized the scientific program for the First Global Assessment of the 1997–98 El Niño Event. This international seminar on the 1997–98 El Niño event took place in Guayaquil, Ecuador in November 1998, and was sponsored by the Government of Ecuador, the UN Task Force on El Niño, and the Permanent Commission for the South Pacific (CPPS).

Interestingly, this global seminar took place in the same city – Guayaquil – where, 24 years earlier in 1974, the first international workshop on "The Phenomenon Known as El Niño" had been convened in response to the devastating regional impacts (in western South America) of the 1972–73 El Niño event.

The following pages summarize in a collective way the findings of the 16-country case study teams. It represents an attempt to integrate their insights into a common text. It is followed by a few key country-specific key findings, as well as the WMO and ISDR highlights. While this assessment focused on 15 countries and the Panama Canal, its findings are clearly applicable to all other countries and sectors of societies that are influenced by quasi-periodic changes in sea surface temperatures in the tropical Pacific Ocean.

El Niño definitions

The term "El Niño" means different things to different people. In Spanish, *el niño* means small boy or child. With initial capital letters, El Niño refers to the infant Jesus. To Peruvians, it has an additional meaning: a particular warm ocean current that moves southward along their coast every few years or so. They gave this ocean current the name of El Niño at some time before the beginning of the twentieth century. Although its exact origin and "birth date" remain unknown, the first time it was noted was in 1892.

The popular contemporary version of how it got its name relates to the fact that warm waters appear off the coast of Peru seasonally, beginning at around Christmas (i.e., during the Southern Hemisphere summer, which is the Northern Hemisphere winter). The warm surface water temporarily replaces the usually cold water for a few months along the Peruvian coast. The cold water along the coast is the result of coastal upwelling processes. As a result of such upwelling, deep, cold, nutrient-rich water wells up to the ocean's sunlit surface (called the euphotic zone).

Occasionally, the warmer water that seasonally appeared off the coast of Peru and Ecuador (a region referred to as the eastern equatorial Pacific) would linger longer than a few months, sometimes lasting well into the following year. These prolonged "invasions" (more correctly, appearances) of warm surface water have led to pronounced disruptions of regional coastal ecosystems involving fish, fish-eating bird populations, and economic activities related to fishing and agriculture. El Niño-related torrential rains in northern Peru and southern Ecuador associated with these invasions would occasionally bring devastation to various towns and cities.

As of the beginning of the twentieth century, the connection had not yet been made between El Niño and the various changes in the natural environment around the tropics from the east coast of the African continent to the west coast of South America. Initially, El Niño's impacts, but not necessarily the El Niño phenomenon, were of concern only in Peru and Ecuador, where they were viewed as manifestations of a local short-term oceanic or atmospheric variation.

Periods of cold sea surface temperatures in the central and eastern tropical Pacific are followed by periods of warm sea surface temperatures, which are followed (but not always) by cold or near-average sea surface temperatures, and so on. There are various possible sequences among the three possible states of ocean temperatures: El Niño (warm), La Niña (cold), and average (often referred to as normal). For example, in the early 1990s one El Niño was followed by another, whereas the 1997–98 El Niño was followed by a La Niña event that began in mid-1998 and lasted into the early months of 2000. The historical record also shows that an average year can also be followed by another average year and not necessarily by either an extreme warming or cooling of ocean temperatures in the Pacific. Suggestions by various scientists about when an El Niño can be expected to return (called its return period) is encompassed by 2–10 years, with some researchers suggesting 3–7 or 4–7-year return periods.

Media coverage of the 1997–98 El Niño, now considered to have been the strongest El Niño of the twentieth century, made matters of definition confusing. For example, forecasters claimed success for their forecasts of the onset of an El Niño, when in fact they had successfully forecast some of its impacts, but not its onset.

After each event, researchers know more than they did before the event occurred. That is a fact. But it seems that each event raises some new unconsidered aspects of El Niño or its worldwide impacts. So, although researchers know more in absolute terms, relatively speaking, they know less because the El Niño research problem seems to get bigger.

As scientists continue to discuss El Niño research and theories, and the media continue to report on them, public knowledge increases by bits and pieces about the interactions between Pacific Ocean sea surface temperatures and the global atmosphere. Today, the public around the globe has been shown that these recurring changes in the central equatorial Pacific region have much more far-reaching consequences than those that take place along the Peruvian coast. The scientific literature has, since the early 1980s, increasingly referred to the broader Pacific basin-wide changes in sea surface temperature and surface pressure oscillations as ENSO in order to distinguish it from the Peruvian-defined and locally occurring El Niño. ENSO, a term coined in the early 1980s by El Niño researcher Gene Rasmusson, refers to the El Niño-Southern Oscillation phenomenon, which is a combination of the interaction between ocean temperature changes (El Niño or EN) and atmospheric processes (Southern Oscillation or SO). Interestingly, some researchers have used the terms El Niño and ENSO interchangeably, even within the same scientific article! Other scientists, however, have become dissatisfied with the term ENSO and prefer to use the terms El Niño (warm event) and La Niña (cold event).

During the course of the 1990s, but especially as a result of the occurrence of the extraordinary El Niño event in 1997–98, the general public, in many countries, has become familiar with the term El Niño. The use of the term El Niño is favored by the media. As various media representatives have stated, ENSO is a difficult concept to explain in simple terms to the general public. As a result of the public's initial exposure in the media during the early 1980s to the "newly discovered" mysterious climate-related phenomenon called El Niño, the larger basin-wide changes in the equatorial Pacific are referred to as El Niño. The box below encompasses

> **El Niño\ 'el nē' nyō** *noun* [Spanish] \ 1: The Christ Child 2: the name allegedly given by Peruvian sailors in the 1800s to a seasonal, warm southward-moving current along the Peruvian coast ⟨la corriente del niño⟩ 3: name given to the occasional return of unusually warm water in the normally cold water [upwelling] region along the Peruvian coast, disrupting local fish and bird populations 4: name given to a Pacific basin-wide increase in both sea surface temperatures in the central and/or eastern equatorial Pacific Ocean and in sea level atmospheric pressure in the western Pacific (Southern Oscillation) 5: used interchangeably with ENSO (El Niño-Southern Oscillation), which describes the basin-wide changes in air-sea interaction in the equatorial Pacific region 6: ENSO warm event *synonym* warm event *antonym* see La Niña \ [Spanish] \ the young girl; cold event; ENSO cold event; non-El Niño year; anti-El Niño or anti-ENSO (pejorative); El Viejo \ 'el vyā hō \ noun [Spanish] \ the old man
>
> M. H. Glantz

a wide range of meanings and terms attributed to the El Niño phenomenon by researchers, the media, and the public.

El Niño's teleconnections

Scientists refer to the process of associating a specific societal impact thousands of miles away from the Pacific Ocean with the ENSO cycle's warm or cold extreme as one of "attribution." They refer to the relationship itself as a "teleconnection." For some countries or regions within them, the association of climate-related anomalies with El Niño or La Niña events is very strong and the attribution is, therefore, considered reliable enough for use in decision making. However, for other countries such associations are likely to exist, but are of varying degrees of reliability and, therefore, may be less clear. Teleconnections can be further categorized by their timing with respect to the onset of the various phases that an El Niño goes through during its life cycle (onset, growth, peak, decay). Armed with such details, individuals as well as governments can develop appropriate seasonal responses to El Niño's possible impacts. The fact is that *any* advanced warning of the onset of either of ENSO's extremes (warm or cold) can provide usable and useful information to those prepared to use it. ENSO's extreme warm (El Niño) and extreme cold (La Niña) events can disrupt various regional and local climates around the globe to varying degrees and in a variety of ways, but especially in the tropics and, most directly, in countries that border the Pacific Ocean (e.g., Pacific Rim countries). While the ENSO phenomenon and its extremes are not yet considered to be natural hazards by the hazards research community, they clearly spawn hazards to society such as droughts, floods, fires, frosts, cyclones, and infectious disease outbreaks around the world. This means that ENSO-related forecasts can provide a society (an individual, government agency, or a corporation) with the *earliest* warning of potentially disruptive climate anomalies, even in locations where the teleconnections are not considered to be very robust.

Many government officials are beginning to believe that the frequency and intensity of climate-related disasters are increasing, because of the numerous "blockbuster" climate-related extreme events and disasters that occurred in the late 1980s and in the 1990s (e.g., Hurricane Hugo, the North American drought, Hurricanes Andrew and Georges, El Niño 1997–98, floods in Mozambique, torrential rains and mudslides in Venezuela, severe wind storms in France, record-setting cyclone winds, a succession of record-setting annual global temperatures). That 12-year period was one during which political interest in the global warming issue increased sharply. Some researchers have linked these two factors (i.e., a warmer atmosphere and an increase in the frequency of extreme events) and have suggested that climate change will increase the probability of more extreme events in the future. Researchers are also seeking to identify the likely impacts of global warming on the frequency and intensity of El Niño and La Niña episodes. They are now focusing their attention on evaluating these beliefs and suggestions. In any event, because El Niño (and La Niña) events have been linked to many natural disasters, it is important that policy makers increase their awareness and use of El Niño-related information in decision making.

Because several different kinds of hazards can occur in a country simultaneously, it can be difficult, but not impossible, to attribute with a high level of certainty a particular adverse societal impact as having been caused by a specific hazard. For example, the 1991–92 El Niño occurred at the same time as a major drought and the eruption of Mount Pinatubo in the Philippines. To what extent did El Niño, the eruption, or some combination of the two influence that drought? Likewise, the 1982–83 El Niño and the eruption of El Chichón in Mexico occurred at the same time, making it difficult to distinguish El Niño's impacts worldwide from those of the volcano's emissions into the stratosphere. These volcanic eruptions may have modified the effects of the El Niño events, but it is more likely, for example, that they simply masked our ability to observe from satellites the effect on such environmental conditions as sea surface temperatures. The January 1998 ice storm in northeast Canada exposed another example of the problem of attribution. It appears (from research) that the El Niño may have been a contributing factor to this damaging ice storm. However, it is not possible to draw a general conclusion with confidence about the influence of El Niño events on the formation of major ice storms over eastern Canada (see Figure 1).

Another often-overlooked reason that governments should pay close attention to El Niño is the subtle long-term influence it has on sustainable development. For example, the devastation caused by a drought lasting but one growing season can set in motion adverse ripples in the socioeconomic system that can continue for several years. Agricultural losses during a drought can reduce export earnings for a developing country that needs to meet its budgetary goals. Thus, a single El Niño-related drought (or any drought for that matter) could reduce a region's, if not a country's, standard of living for some extended period of time. An appropriate analogy to a developing country's attempts at development that are periodically disrupted by El Niño (or La Niña) would be that of the mythical Sisyphus pushing a boulder up a hill only to have it fall back down before reaching the summit. He must begin the process again and again never to reach the top. Therefore, not only the contemporary geo-

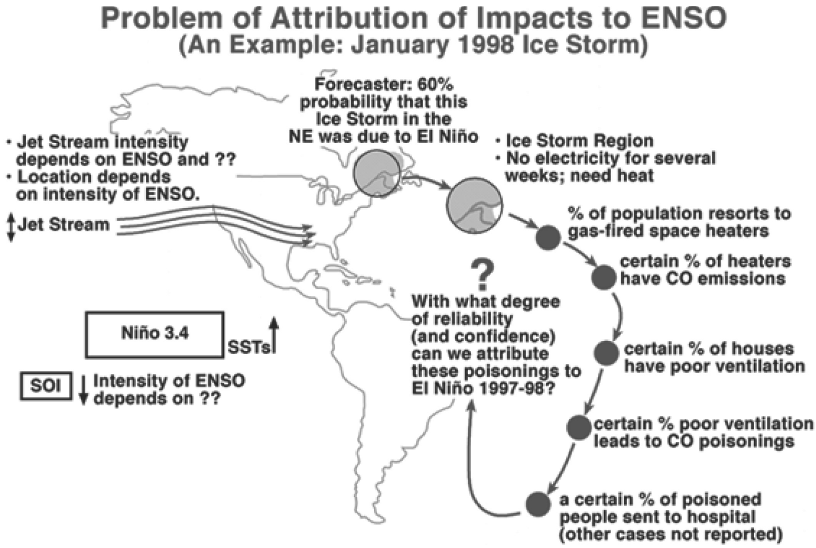

Fig. 1 **El Niño and the January 1988 ice storm in northeast North America (courtesy M. H. Glantz)**

graphic impacts of El Niño need to be understood, but also their delayed impacts over time.

Forecast impacts

A reliable El Niño forecast, however, is not enough to protect society from harm, because existing socio-economic and environmental conditions in a country ultimately determine the severity of the impacts of El Niño's teleconnected climate anomalies. Thus a country with properly located or properly constructed buildings and a well-maintained transportation or communication infrastructure is less likely to suffer damage to its built environment than one with improper construction and a poorly maintained infrastructure, when each has been affected by a climate anomaly of similar magnitude. For example, the severity of Hurricane Andrew's impacts in Florida had as much (if not more) to do with poor housing construction in southern Florida as it had to do with the hurricane's intensity (Pielke and Pielke 1997).

Whether or not a forecast proves to have been correct, people will have reacted to it, and their reactions will have real consequences. Therefore, it is very important to assess the societal responses to the forecast of an El Niño (as well as responses to the impacts of an El Niño event itself). In areas where teleconnections are strong, El Niño is expected to generate natural hazards (droughts, floods, frosts, fires) that most probably are already familiar to governments because they have had to deal with them even before they learned of their association with El Niño. By knowing about the possibility of an El Niño episode some time in advance of its onset, the value added of such knowledge is that such a forecast can provide an early warning that provides enough lead time for governments and individuals to develop strategic responses.

Need for attribution

Scientists and the media tend to refer to El Niño's environmental and social impacts as if they affect an entire country. Yet, seldom is a whole country affected in the same way by the same type of El Niño-related anomaly (e.g., drought or flood) because of its diverse topographical features. For example, during an El Niño, the Pacific coast of Costa Rica tends to suffer from drought. However, its Atlantic coastal areas usually (but not always) remain wet. As another example, northern Peru during El Niño suffers from floods, while the southern part usually suffers from El Niño-related drought. Northeast Brazil suffers from severe drought during El Niño, while southern Brazil tends to be plagued by heavy rains and flooding.

Users of El Niño information need to know the degree of reliability of the teleconnections that scientists attribute to ENSO's extremes, as well as the location and type of their possible sub-national impacts. In this regard, forecasters should include "error bars" with their forecasts – that is, what they personally consider to be the degree of reliability of their forecast. Armed with such information, governments as well as individuals can plan to mitigate expected impacts in areas that had previously been identified as at risk to El Niño's adverse influences. Under conditions of reliable attributions, governments can establish El Niño-specific forecast and disaster-response institutions.

Although many governments, corporations, and individuals become alerted to an El Niño once it has been forecast, their responses to the forecast will depend on the level of confidence that they have in the proposed linkages between El Niño's teleconnections and human activities. While the climates of some countries have reliable teleconnections to El Niño, others do not. The same applies to El Niño's impacts on different economic sectors. For example, whereas El Niño's teleconnections to China from the perspective of Chinese authorities may be perceived as weak and, therefore, unreliable, the authorities in Brazil or the Philippines consider the teleconnections to their countries to be strong. So, responses by different governments or different sectors within a country to the same forecast can vary by a wide margin.

Information (who knows what, when)

An old political adage suggests that "information is power." This adage is as relevant to El Niño forecasting as it is to politics. Whoever has a reliable El Niño forecast first is in a position to use it to his or her advantage, and sometimes to the detriment of others (Pfaff et al. 1999). Depending on how far in advance of an El Niño a forecast is received, that forecast can be used either for short lead-time (i.e., tactical) responses to climate anomalies or for responses that require longer (i.e., strategic) lead times. Furthermore, El Niño information in general (not just a forecast) can be valuable for long-range development planning in such sectors as agriculture, water, energy, manufacturing, and public health.

Transparency

Transparency refers to the openness of information and of the processes by which that information is gathered, analyzed, and disseminated. Transparency, as it relates to El Niño forecasts, can increase trust among government agencies, scientists, forecasters, the media, and the public. At the very least, it can create awareness as well as educate, alert, and prepare people for the risks they *may* (not necessarily *will*) face from El Niño-related climate anomalies.

Within many governments there are inter-ministerial rivalries and jurisdictional disputes. However, for the public good, such jurisdictional rivalries must be set aside when it comes to dealing with El Niño-related hazards. Ministries must willingly share their hazard-related information with other agencies in a timely way about potential impacts and about the mitigative strategies and tactics that their particular agency might be considering to pursue.

Transparency considerations also apply to forecasters and researchers. They must present an honest appraisal to governments and the media about the state of the art and of the science of El Niño forecasting and an honest picture of their knowledge of the ENSO phenomenon. Transparency between governments and donors is also necessary, so that the needs and expectations about disaster assistance of both are well understood and more accurately assessed.

Economic development and impact studies

There is a need to develop a "culture of climate" in various El Niño-affected countries, if not everywhere. A culture of climate requires that the public as well as government authorities learn of the various ways that climate (i.e., variability, fluctuations, change, and extremes) affects human activities and the ecosystems on which societies depend. The more they and their citizens know about how climate, environment, and human activities interact, the better they will be able to take steps to minimize the adverse aspects of climate anomalies and to take advantage of climate-related opportunities. Government policy makers must realize that climate variability and extremes affect their policies in both good and bad ways. Policy makers must also realize that El Niño information (including forecasts) can be used not only for disaster early warning but can also be used to enhance the prospects for sustainable development over the long term. Hence, government authorities need to be encouraged to support the study of climate-society-environment interactions.

Researchers need to undertake an inventory of climate resources in their countries. Broadly defined, such an inventory includes more than just meteorological data. It includes an identification of climate-related costs as well as benefits to society. It must also include domestic and foreign sources of climate information and climate-related development assistance. Doing so would require a focus on climate impacts on regions, institutions, hazard management, and economic sectors. Impact studies encompass climate's impacts on both managed and unmanaged ecosystems and on society.

Positive impacts

It is important for government agencies and researchers to identify the positive aspects of El Niño, instead of focusing only on the negative. While some parts of their country or sectors of their economy are negatively affected by an event, other parts might actually benefit. This does not mean that one balances out the other from the perspective of those directly affected – those who lose, lose; those who win, win. However, a system could be devised before an El Niño event occurs in which there is a sharing of potential gains in one part of the country with those who are adversely affected in another part. Some efforts have already been undertaken to identify climate- and El Niño-related winners and losers (Glantz 1990). This topic deserves the attention of government leaders who want to identify the true costs or benefits to the nation of El Niño-related climate anomalies.

Public forecasts

It is important to provide people in all parts of a country (rural as well as urban) with El Niño information, including information on the forecasts and impacts. Those in major urban centers are most frequently made aware of potential anomalies and impacts, and earlier, than those living in the rural areas. This can be remedied by using the radio (as opposed to a major reliance on TV or the Internet), which people in rural and poor areas are more likely to have available. In this age of high tech and the globalization of communications, it is still very important to make full use of the radio as an important primary as well as "backup" channel of communication.

Often climate experts provide their forecasts in terms of probabilities, which many individuals do not readily understand. The information provided to the public should be presented in plain language. Different methods must be developed to convey timely climate information to the public (including its policy makers) in a way that helps it to receive the intended climate message and warning.

El Niño-related teleconnection information can be used to create maps of "at-risk" populations, regions, and sectors of society. Such baseline information is useful for the development of El Niño-related responses by individuals, groups, and governments. The preparation of at-risk maps requires national as well as international financial and moral support for national studies related to El Niño (and La Niña).

Forecast surprises

Each El Niño has some unique features that are not captured by the description of an average event. As a result, there are likely to be surprises when a new El Niño event appears. For example, in response to the forecast in Costa Rica of the onset of the 1997–98 event, cattle were moved from the drought-prone northwestern part of the country along the Pacific coast to the country's wetter north central region. However, an unexpected drought occurred there as well, resulting in the death of thousands of the cattle that had been relocated to that area perceived to have provided a "safe haven." El Niño-related surprises are likely to occur and should be expected because scientists do not yet know all the various combinations of ways that El Niño events can develop or influence regional climate in distant locations.

Public education

A government should support the educational needs of its public about El Niño specifically, and more generally about climate-society-environment interactions. It is, therefore, important to organize multidisciplinary climate-related educational efforts that enable government personnel, educators, the public, and representatives of various economic sectors to become more aware of these issues. For their part, governments at all levels and corporations should undertake post-disaster reviews following each major climate-related hazard and disaster, El Niño-related or not. This will improve the likelihood that the impacts of subsequent hazardous events will be mitigated, as a result of lessons learned.

Technology

Many governments do not have the human and financial resources to carry out national high-tech monitoring and forecasting activities focused on ENSO's extreme events. As a result, their meteorological services depend on the research outputs and forecasts from other countries. While the technology and expertise needed to make El Niño forecasts may be lacking in many countries, it is important for each country and the subregions within it to develop the expertise to assess the forecasts that have been produced by experts in other countries.

In addition, some countries do not have access to the latest research information related to climate's influence on society. As a result, trust must be developed between them and those who are climate-related "information donors." Information donors should assist the recipients of their climate-related information to undertake capacity building in areas related to El Niño. As part of the capacity-building process, local officials should be encouraged to understand and monitor as best they can El Niño and La Niña impacts.

Each of the 16-country study team reports called for improving the monitoring of weather and climate in their regions. Each of them also recognized the value of a well-designed network of recording stations to collect meteorological information. Study teams from sub-Saharan Africa saw great value in establishing a TAO array-like monitoring network in the Indian Ocean similar to the one developed in the Pacific in the late 1980s and early 1990s. As demonstrated during the 1997–98 El Niño event, changes in sea surface temperatures in various parts of the Indian Ocean can influence and overshadow the expected impacts of an El Niño in some African regions.

Forecasts

Forecast information

The better (that is, the more reliable) the forecast, the more likely it will be used effectively. Also, the more detailed the forecast, the more widespread will be its use. Forecasts are needed that provide adequate lead time for making plans to cope with the climate-related problems that an El Niño spawns. Some people argue that forecasts about the potential societal impacts in various parts of the globe are needed more urgently than are the forecasts of El Niño's onset. ENSO-related forecasts should be of interest to *all* government ministries and not just those concerned with disasters or with agriculture.

The lessons learned by each of the 16-country study teams for their countries centered around several of the following factors. There is a lack of belief in the reliability of El Niño-related forecasts for many regions around the globe. To date most forecasts are presented in terms of whole countries (e.g., Ethiopia, Mozambique, Indonesia, will be affected by severe drought; Peru and the USA will be affected by heavy rains and floods). Yet, such geographically generalized forecasts are at risk of being seen as failures by different regions within a country. Information about potential sub-national impacts is often absent, even though the local users of these forecasts desperately need detailed information in the forecasts for effective planning. Such detail includes information about the probable onset of the event and its likely societal impacts, its magnitude, its duration, and so forth. Armed with such details, governments could identify changes in the level of risk to its food-producing regions by determining if those regions are at increased risk for drought or flood. If so, they could plan to adjust their food exports and imports accordingly. The operations of the Panama Canal provide another example: canal operators need the earliest warning possible in order to advise shipping companies of the increased likelihood for drought-related shipping restrictions in the canal. This would provide shippers with enough lead time to plan when and what to ship through the canal, whether to ship around it or whether to ship their cargo by other means.

There are other troublesome concerns for the users of forecasts: for example, which forecaster(s) should the users believe? Now, with the advent of widespread public and government interest in El Niño and with the growing access to the Internet, users are increasingly bombarded with scores of predictions about the future state of sea surface temperatures in the tropical Pacific. How are they to distinguish between the established reliable forecasting groups and the numerous ad hoc groups and individuals that suddenly engage in the making of forecasts about the onset of an El Niño? For example, only one forecast group made a reasonable forecast of the onset of the 1997–98 El Niño (Barnston et al. 1999). But, was it based on good science or just a lucky guess? How well did that group do with previous forecasts? Why did the dozen or so forecast groups miss making a correct forecast of the biggest El Niño of the century in 1997–98? El Niño research and forecast communities must determine how best to remedy this situation, so that users can identify and rely on forecasts issued by reliable sources.

This problem is made more difficult by the fact that the forecasters of

Fig. 2 **El Niño-related newspaper headlines from around the globe (courtesy M. H. Glantz)**

El Niño have had a mixed record of success and failure (Figure 2). In the world of forecasting, such a record can lead to a popular belief that the forecasts of ENSO's extremes are not very reliable, despite the fact that there may be an occasional success. It is important to underscore the fact that the record of success for forecasting El Niño's (and La Niña's) impacts has been considerably better for some locations than it has been for forecasting the onset of the event itself.

Despite the scientific uncertainties surrounding the forecasting of ENSO's extremes, researchers must work harder to convince policy makers at all levels of government that there is considerable value in the use of basic ENSO information (referred to here as "ENSO climatology"). Such basic information can be used as a guide to proactive planning for El Niño-related disaster response and for long-term sustainable development. It is imperative that the research and forecast communities identify ways to reduce the level of public skepticism about the reliability of climate and weather forecasts.

One factor that leads to skepticism about forecasts (and, therefore, to inaction following the issuance of an El Niño forecast) is related to contradictory signals. For example, it is difficult for decision makers to believe forecasters that a drought will be coming if the country is in the midst of a rainy period, or vice versa. As another example, in the midst of a good commercial fishing season, it would be difficult, if not impossible, to convince fishermen and fishmeal processing plant owners that fish catches will drop drastically some months in the future because an El Niño episode might be emerging. Making such projections is as risky for the forecasters as it is for users who take such projections seriously enough to act on them. In many countries forecasters fear that they will have to bear considerable personal responsibility for incorrect actions that decision makers might take, if the forecasts are off the mark and disaster ensues. From the perspective of forecasters, it may be safer in many instances to avoid making assertive forecasts that might prove to be controversial later.

The public, policy makers, and educators must be introduced to the many ways that climate variability influences human activities and ecological processes. They also need to know about the various ways that climate forecasts can be used in the sustainable development of society and economy.

Societal aspects

Societal aspects of the 1997–98 El Niño, as identified in the 16-country case studies, encompass forecast use, public education, science education, research funding, preparedness at the local level, and the role of the media.

Usefulness of forecasts

It is easy to show that El Niño forecasts can be very useful to societies – to governments as well as to individuals. While people may understand to some extent the climate of the region in which they live, they are not necessarily aware of the many direct and indirect ways that its variations (some of which are associated with El Niño) can influence their livelihoods. However, society's members have to learn how best to use that forecast information for disaster preparedness in the short term and economic development planning for the long term. How to educate society about climate-society-environment interactions is a major challenge to the meteorological community and to educators at all levels.

Public education

Scientists and the media have helped to make El Niño a household word, beginning with the 1982–83 El Niño. Their task received a major boost with the onset of the 1997–98 "El Niño of the Century." This event captured the attention of potential users about El Niño in general and of El Niño forecasts specifically. As a result, people around the globe have a heightened, but not yet complete, awareness of what impacts an event can have in their regions. Many people, including policy makers, are aware of it, even if that awareness is incomplete or incorrect. No matter, because when El Niño returns they will be attuned to the fact that it could influence climate conditions in various parts of the globe. In a sense, scientists have successfully broadcast ("wholesaled") the notion of El Niño. The next stage is an even harder activity for physical and social scientists and the media, the need to educate various elements in society about the details associated with an event (i.e., they have to "retail" El Niño information). "Retailing" an El Niño forecast, for example, refers to adjusting it to the different needs of specific users. Such retailing means that public awareness, training, and education programs need to be carried out, especially in the at-risk areas.

As uncertain and as unspecific as an El Niño forecast may still be, people must be taught about the El Niño phenomenon and how best to cope with both the forecasts and the event itself. As difficult as it may be for forecasters to explain extreme weather or climate anomaly probabilities to the public, the scientific community must respond to the challenge of conveying probabilistic statements in terms that are readily understandable to the general public. It is important, however, to help people to realize that, even though they improve their understanding of El Niño and make preparations in response to an El Niño forecast, there will still be adverse impacts with which they will have to contend. Even a perfect forecast will not lead to "zero" adverse impacts. The most industrialized societies have difficulties in their attempts to protect their countries (i.e., what they have called "climate-proofing") from the vagaries of climate and from extreme climate-related events. For example, in the mid-1970s the Canadian government embarked on a program to "drought-proof" the Canadian Prairie Provinces. Yet, droughts continued to plague the region. As another example, in the year 2000 the US government sought to "weatherproof" the United States, only to suffer from the adverse (and humiliating) impacts of a major surprising snowstorm just a week after the slogan was launched. Thus, neither the Canadian nor the American ambitious program achieved its goal.

A first step toward educating people about the ENSO cycle and its extremes involves "educating the educators." Educators would, in turn, educate the public. Today, when an event is underway, the public tends to blame many of society's ills on El Niño. Yet, many of those ills may have nothing to do with the appearance of an El Niño. By "educating the educators," researchers can help the public and the media to identify by themselves which ills might legitimately be blamed on El Niño and which might be blamed on other factors such as human activities. The need for climate-related education will vary from country to country, sector to sector, and from user to user.

While El Niño is considered by many observers to be a global phenomenon, it is really in a strict sense a regional (i.e., Pacific Ocean) phenomenon with worldwide local effects. Therefore, inhabitants of affected regions need a much-improved understanding of the ENSO *cycle* and its potential direct and indirect societal and ecological impacts at the local level. Education, as an aspect of capacity building within a country, must be carried out at all levels of society and not just geared to the highest political levels. Such education would go a long way toward improving societal interactions with the climate system in general and, more specifically, with the ENSO cycle.

Education about El Niño includes identifying its positive effects as well. It would also include discussions of a principle based on the idea of "doing no harm," as a result of decisions. This is referred to as the "precautionary principle." Perhaps one of the most important challenges to social researchers is to identify mechanisms to convert awareness of the ENSO cycle and its potential impacts into effective public action to cope with them.

Although we refer to each of ENSO's extremes – El Niño and La Niña – as a discrete event, society should view them as extreme parts of the ENSO cycle – an ongoing process – much in the same way that it views the seasons. A normal range between the extremes of sea surface temperatures in the tropical Pacific is also part of this cycle. In fact, some scientists refer to ENSO's extremes as the second biggest climate-related disrupters of human activities, after the natural flow of seasonal change.

Science education

Governments must support education and training programs that produce personnel in their different ministries who can understand and use information derived from monitoring and predicting regional climate in general and, more specifically, El Niño and its impacts. They need to reinforce existing programs such as those that include the training of disaster managers, impacts researchers, and those who are responsible for identifying a country's at-risk (i.e., vulnerable) populations.

Funding

Many problems that a government faces that relate to difficulties in dealing with the forecasting of and responding to disasters center on inadequate funding. Several of the countries that are considered to be most vulnerable to El Niño's impacts are especially in need of financial assistance to carry out programs to cope with their possible occurrence. While the will of a government to take appropriate actions may exist once an El Niño event has been forecast, the financial mechanisms must be in place to enable the government to carry out those actions. Otherwise, there will be little in the way of financial means to put the government's will into action.

Along the same lines, disaster-related funding from a national government to its regional and local governments needs to be made quickly in order to enable the funds to be used in the affected regions in an effective and timely way. This would make it possible for those responsible at the local level to be proactive, as they are truly on the frontlines of disaster impact, response, reconstruction, recovery, and sustainable development. International funding responses to a disaster must also occur quickly to be used effectively by those in the affected regions. More importantly, such funds must be made available *between* ENSO's extremes, not only *during* them. This would enable preventive measures to be developed and implemented under normal, non-crisis conditions.

Media

Many people assume that a major, if not primary, function of a country's print and broadcast media is to educate the public. However, the media, in addition to providing information to society at large, are in the business of making a profit. Aside from El Niño's news content and value, the media are interested in reporting about it, as long as they perceive a value in doing so. For example, once scientists had compared the emerging 1997–98 El Niño to the devastating 1982–83 event, the media interest increased because that historical analogy to a memorable, devastating El Niño would be likely to capture the attention of the public. With today's media globalization of local news stories, coverage about El Niño's impacts elsewhere on the globe in 1997–98 served to elevate the concern of the public about possible impacts in their own countries, as well as to educate the public.

Once an event ends, however, media interest quickly wanes. El Niño researchers, and not just the national meteorological services, must strive to educate the media on the importance of El Niño to society and to encourage the media to run public education stories about the ENSO cycle between, as well as during, its extreme events. While the media does educate the public to some degree, that responsibility really falls on the shoulders of scientific researchers. They must devise ways to better educate the media on what is known and what is not yet known about the phenomenon.

Now that the public's interest in El Niño and La Niña has been heightened and broadened, it will probably become more demanding for information about them (including forecasts). The public will then become more critical about the information it receives. The best way to meet that demand would be for those concerned with El Niño to maintain a steady level of El Niño-related impacts research throughout the entire ENSO warm event – cold event cycle. This is much more beneficial than focusing on the extremes only when they are in progress.

Science issues

The levels of scientific development vary widely from country to country. They vary as well among regions within a country. Some governments have placed a high value on maintaining a strong national research establishment, while others consider that to be a lower priority than dealing with chronic societal problems such as high unemployment, widespread poverty, and poor public health. Other governments choose not to use their scarce resources in a competition with other countries to produce global climate and climate-related assessments. Rather, they have chosen to receive such assessments from elsewhere and then to modify them to meet national and local conditions and needs. In fact, the establishment in the late 1990s of the International Research Institute for climate prediction (IRI) at Columbia University (New York) was an attempt to assist researchers in other countries in the modification of global climate forecasts to reflect regional and local factors.

Scientific research importance

In the age of globalization of just about everything, it is important for governments to maintain a national scientific establishment that is capable of using research results from other countries for its societal benefit. More specifically, it is especially important for at-risk countries to improve the ability of their scientific communities to understand the ENSO cycle and its implications for decision making by individuals, corporations, government agencies, and national policy makers. This is prudent because preventive measures can then be pursued, and prevention and mitigation is often less costly than recovery and restoration.

The national scientific establishments should be encouraged as well as supported by their governments to undertake studies on actual and perceived regional and local teleconnections related to ENSO's extremes. The carrying out of such studies would also help to strengthen national expertise in El Niño studies. This is an area of capacity building where donor assistance is beneficial and needed. To reinforce such a scientific capacity-building effort, it is important for national governments to give significant weight to the assessments and views of their national scientists. In the past, some governments have tended to give greater credence to the assessments of foreign experts than to their own national experts. This perception of expertise – that ‘‘experts come from out of town’’ – must change, because it is often incorrect.

An important, often downplayed aspect of scientific research is that researchers must demonstrate to government officials on a continuing basis the importance to their country of understanding and using information about climate variability, climate change, and extreme events. This includes El Niño and La Niña, which tend to spawn certain types of climate-related extremes in specific locations around the globe.

Scientific communication

As the impacts of an El Niño ripple through the environment, society, and economy, a cascade of uncertainties will accompany those impacts from first (direct) to second (indirect) to third order (called ‘‘knock-on’’) effects. The increase in the levels of certainty that surrounds these various knock-on effects must be accurately conveyed by scientists to the users of El Niño information.

In addition to scientific research (Figure 3) on the physical and societal *impacts* of El Niño, it is very important to encourage research on the socio-economic *setting* of each country at the time of onset. The impacts of El Niño can clearly be mitigated or worsened by the existing conditions of the country’s political system, infrastructures, environment, and

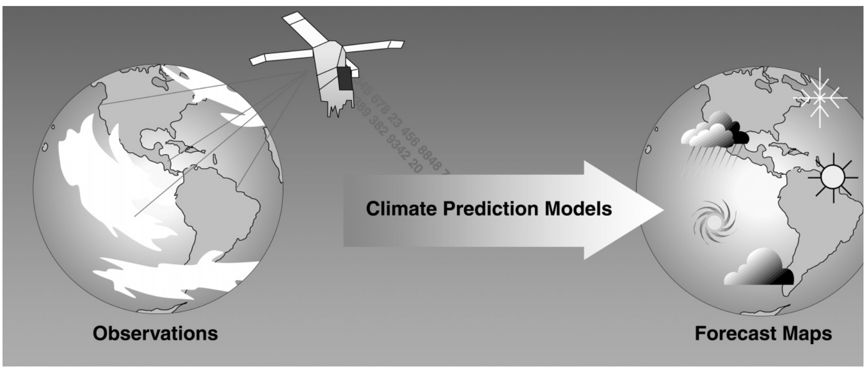

Fig. 3 **Reliable data are at the crux of researchers’ continuing efforts, not only to understand El Niño, but also to predict when future events will arise and what their impacts will be (http://www.atmos.washington.edu/gcg/RTN/Figures/RTN20.html)**

economy. Because these socio-economic and political conditions vary over time, an El Niño of the same magnitude in the same place but at a different time can generate totally different impacts. Thus, there is a strong need for multidisciplinary studies that involve the physical *and* social sciences *and the humanities*.

Many regional and local El Niño-related impacts are hazards that are most likely already known to the inhabitants of a region (e.g., droughts, floods, frosts, fires, heat waves). El Niño or La Niña episodes can weaken the "normal" intensity of the hazard and reduce its impacts, or they can intensify them. Thus, in most instances, governments are already aware to some extent about how to respond in a tactical (ad hoc) way to their known hazards. The El Niño connection to a specific hazard provides decision makers with a degree of forecast and earliest warning skill that would otherwise be absent. However, they do not often know the exact timing of the different phases of El Niño, or its duration or intensity and, therefore, they do not know exactly how an El Niño episode will influence the characteristics of their known climate-related hazards.

Institutional response

Once a president or a prime minister (i.e., a head of state) publicly expresses concern about El Niño, his or her government tends to become quickly mobilized to deal with it. Clearly, this was the case at the onset of the 1997–98 event in Peru (see, for example, Fujimori 2001) and in Ecuador, China, Vietnam, the Philippines, and Ethiopia.

Interagency cooperation

Various government ministries need to be involved in El Niño-related activities from research to response, because no single ministry is capable of coping with the wide range of potential impacts. Different agencies have different experience and expertise that would likely be required at various times throughout the ENSO warm event – cold event cycle. However, only one agency should be responsible for final actions, so that lines of authority and responsibility are clearly identified. Involved agencies should include those related to disaster management, climate-sensitive sectors such as agriculture, water, energy, public safety, and health, as well as those concerned with economic development. Non-governmental organizations (NGOs) should also be included from the outset in El Niño-related activities.

As noted earlier, cooperation should be fostered among decision makers at the highest levels of government. Ministerial rivalries (which exist in every country) must be put aside in the face of possible El Niño-related disasters. The establishment of an inter-ministerial task force devoted to ENSO (as was done in several countries such as Peru and the Philippines) could help to better coordinate overlapping ministerial efforts and to reduce chronic jurisdictional disputes. Good cooperation and communication among a country's scientific institutions could go a long way toward producing a coherent message about El Niño to policy makers and to the public.

Government and private institutions must review their operations that were carried out during the 1997–98 El Niño event in order to identify their strengths, weaknesses, and institutional constraints and conflicts in their responses to the forecasts and to the impacts of a major El Niño event. Although limited national resources (such as time and people) make it difficult to review past events, their impacts, and a government's responses, "hindcasting," a process undertaken to distinguish between those strategies and tactics that worked and those that did not, must be supported by governments. A Chinese proverb underscores this point: "To know the road ahead, ask those coming back."

Often, donor agencies tend to treat the recipients of disaster aid as being in a relatively inferior bargaining position. However, for effective and timely disaster reduction and eventual recovery and sustainable development planning, international donors and recipients must interact as equal negotiating partners. Donors and recipients alike must rethink the validity of the generally accepted, but questionable, budgetary distinctions that they make between emergency disaster relief and long-term development assistance.

National governments in a geographic region should consider creating a supranational regional organization devoted strictly to the ENSO phenomenon, as has been done by the countries along the Pacific coast of South America. Peru, Ecuador, Chile, and Colombia formed the CPPS (Permanent South Pacific Commission) and in 1974 they created ERFEN (Regional Study of the El Niño Phenomenon). ENSO's warm extreme is an important disrupter of national economies and national well-being. Its impacts do not respect international borders. Regional El Niño-related (and La Niña-related) disaster plans can be developed less expensively than if each country in a region were to go its own way, as has generally been the case. Even if neighboring countries are at odds over a variety of issues, the threat of adverse ENSO-related disasters can spark a modicum of "disaster diplomacy." This appears to have been the case in Central America, following the devastation caused by Hurricane Mitch in late October 1998. It also appears to be the case for US-Cuban relations with regard to hurricanes in the Atlantic Ocean, Caribbean Sea, and Gulf of Mexico (Glantz and Jamieson 2000).

Setting (social, economic, and political)

When it comes to discussing possible ways to reduce the influence of El Niño's impacts on a country's socio-economic and political background that existed at the time of its onset, many comments appear to be no more than political rhetoric (i.e., ''motherhood'' statements). Few people could find good reasons to disagree with such platitudes: ''strengthen the economy,'' ''reduce poverty,'' ''saving lives is the highest priority,'' ''maintain the infrastructure.'' The reality, however, is that when it comes to the potential impacts of natural hazards, including those sparked by El Niño, such motherhood statements are highly relevant to reducing vulnerability to natural hazards. For example, it is not difficult to show that transportation infrastructure that has not been maintained (as in Kenya, for instance) will be likely to face destruction during El Niño-related severe floods. Nor is it difficult to show that an unstable political system (as in Ecuador at the time) cannot effectively cope with the societal impacts of El Niño-related anomalies. Thus, what a society is like at the time of an El Niño episode has a great deal to do with the level of damage it is likely to sustain as a result of that event.

Reassessing the way things are

Many adjustments are likely to be required in the ways that societies operate to make El Niño's forecasts, as the earliest warnings of possible climate-related problems, more effective. Such societal adjustments might include, for example, a review of bank credit policies, a strengthening of infrastructure for transportation, communication, and public health, and making assessments to identify and devise ways to protect the currently at-risk populations, regions, and socio-economic sectors. Also, the nature and degree of present-day environmental degradation must be taken into account in these assessments because the impacts of El Niño can magnify existing degradation in different locations.

As with other sectors of society, in the case of public health many factors can interact to make an existing poor human health situation much worse in the event of an El Niño, e.g., existing poverty (such as in Bangladesh where cholera outbreaks accompany an El Niño, see Pascual et al. 2000), an economic ''meltdown'' (as was the case in Asia in the late 1990s), inadequate public health facilities, and even IMF's restructuring policies (as was the case during the 1991–92 El Niño in Zimbabwe; see Betsill et al. 1997). Thus, a corps of national researchers, financed by their governments and international donors, are needed in order to distinguish more clearly between impacts that can be linked to a naturally occurring El Niño episode from those that result from human activities.

The inter- and intra-national "brain drain"

Developing countries face a seemingly intractable problem, a brain drain problem, as trained personnel leave their countries to join UN and other international organizations and non-governmental organizations. The South-to-North brain drain issue must be addressed in an international forum to identify ways to minimize in an equitable way the outflow of expertise from the developing to the industrialized world. The brain drain also occurs within countries, because trained personnel are forced to take additional jobs in order to support their families. They are forced to do so, because the pay for their scientific research work is often insufficient to meet the basic family needs.

Political change

A change in government is yet another obvious, but often overlooked, factor affecting a country's ability to respond to recurrent hazards (such as those spawned by El Niño and La Niña). When a government is changed, whether by violent or non-violent means, the incoming government often discards many of the policies put in place by its predecessor. That's politics. However, when it comes to disaster preparedness, including that for El Niño responses, it is imperative for the incoming government administration to *first* reassess the effectiveness of its predecessor's policies *before* discarding or neglecting them for no good reason other than domestic politics.

Conflicting interests

In just about every country there are jurisdictional disputes and political rivalries among various government ministries and agencies. These conflicts must be minimized, if not set aside, when dealing with El Niño, so that they do not interfere with either the timely flow of information or the undertaking of effective mitigative actions. There may, for example, be differences of opinion between a nation's weather service and its ministry of agriculture about whether a forecast of drought is reliable or whether a drought already exists. There are likely to be differences in policy responses between agencies dealing with emergency assistance and those dealing with long-term sustainable development activities. Conflicts also exist between donors of disaster aid and recipients of that aid over approaches to coping with El Niño-related impacts. In fact, there are even rivalries, subtle though they may be, among donor agencies representing different countries or international organizations, but each with its own objectives. Provincial governments and municipalities, too, find themselves engaged in disputes with their national government over local resource needs and the resource allocation for disaster preparation or recovery in their areas. In this regard, there is a need to improve the level of trust between these levels of government.

Conflicting interests among citizens (or economic classes) within a country, for example, between the "haves" and the "have nots," are worsened in times of climate-related emergencies. It is often the poorer populations that live in at-risk areas such as floodplains or on steep, unstable hillsides and, as a result, tend to suffer an inordinate proportion of damage to life and property. During such times of emergency need, government actions could serve to close that gap between these two groups by providing, with donor support, appropriate and timely assistance.

As noted earlier, it is important to recognize the fact that, no matter how well a society might prepare for the potential impacts of an El Niño event, it is still likely to suffer significant damage. Making the public aware of this fact should help to minimize criticism of governmental responses to those impacts once the emergency has ended. Governments have to cope with many issues and problems simultaneously – climatic, hydrological, geological, political, demographic, economic and military – often with very limited resources. In a paired comparison between these problems and climate issues, problems related to climate might not, at the time, be considered to be as important as other pressing social, economic, political, or military issues.

In addition, there are varied impacts within a country and sometimes an expected climate anomaly (such as a drought or a flood) does not occur but an unexpected one does. Governments cannot prepare for all possible El Niño-related hazards, so they must weigh the risks, making difficult choices about which hazard(s) is (are) the one(s) to which they are most likely to have to respond.

Diverting limited available resources to deal with potential El Niño-related problems that might arise in future months or years is a difficult action for many government decision makers to take, especially if there are no visible signs (as yet) of their negative impacts. Regardless of the recognized value of proaction to deal with its impacts, considerations of El Niño's impacts are often delayed in favor of other pressing issues ... until the next event has been forecast or, in some cases, until the impacts of the next event begin to appear. Sometimes proposed proactive responses will not be pursued because previous forecasts of an El Niño's impact had not proven to be correct. For example, considerable skepticism has developed in Mozambique because of the loss of credibility as a result of a missed El Niño-related drought forecast for southern Africa in 1997–98. In that period Mozambique's climate turned out to be near normal even though the government had prepared for a drought. The forecast failed because forecasters did not take into consideration the unusually warm sea surface temperatures in the western Indian Ocean. How will this "missed" forecast influence the country's response to the next El Niño-related drought forecast? Yet, it is important to educate the public that a missed forecast does not mean that a forecast system does not work. Forecasts are based on probabilities, and a number of them are expected to be "missed."

Management issues

There are several management issues generated by El Niño-related impacts and forecasts. First, there should be transparency in those agencies dealing with those impacts and forecasts. Transparency means that there will be openness and honesty in information about the El Niño phenomenon, about the forecast, and about its potential impacts. It also means that potentially at-risk regions, populations, and sectors would be identified and notified in a timely way. A country's disaster plans and policies need to be backed up by adequate expertise and funding. In order to do so, national expertise should be maintained, if not strengthened, over time so that government agencies can call on it for ENSO-related experience and advice whenever the need arises. Funding from donor agencies is an extremely important aspect of national disaster response for a variety of reasons: it would help to build national expertise (capacity building); it would show commitment of donors to effective disaster reduction; it would enhance the prospects for long-term planning instead of fostering a reliance on ad hoc decisions; it could enhance logistical efficiency; it could enable a government to maintain its infrastructures (transportation, health, communications); and so forth.

It is important for the donors and the recipient governments to improve their trust, dialogue, and relationship with each other in order to enhance the timeliness of response and appropriateness of assistance. Recipients have a responsibility to get funding to the at-risk regions in time for decision makers in those regions to prepare to cope with the potential impacts. Local people must be involved in the planning at the national level for responses to El Niño forecasts and impacts. If expertise is lacking at that level, then a comprehensive education and training program needs to be put in place.

One could argue that the ENSO cycle merits its own autonomous management structure. A well-defined El Niño emergency management structure encompassing national to local levels should be developed and maintained, even though El Niño (warm) events recur on an irregular time interval (recurring at some time between two and ten years). Administratively, a lead agency, among equals, should be identified. Agencies involved in this structure must take their responsibilities seriously, as their particular expertise is likely to be required at different times during the ENSO cycle. Part of its responsibility would be to periodically review national and local disaster management plans. This can be done at low cost by, at first, evaluating their country's responses to the 1997–98 event or earlier events that had affected their country.

Communications

Throughout all levels of government from national to local, there is an urgent need to improve the efficiency and transmission (especially timeliness) of early warnings and forecasts of climate-related impacts associated with ENSO's extremes. The Internet provides a useful tool for closely watching changes in the ENSO cycle of warm and cold events. However, it should serve only to complement national efforts and not be viewed as a replacement for them.

Communication is essential between decision makers and scientists: scientists can learn about the needs of decision makers in government agencies and in various climate-sensitive social and economic sectors. For their part, decision makers can learn about the many ways that climate influences a disaster's severity as well as their country's long-term economic development prospects. Realistic communications mean that scientists would refrain from the use of scientific jargon to ensure that decision makers understand well the limits and value of using climate and climate-related information. This would strengthen the confidence that decision makers have in their country's scientific community. This would help to reduce their dependence on foreign expertise.

During climate-related emergencies, local governments and citizens are in need of uninterrupted contact with national agencies and international donors. A communication system must be developed that can withstand or bypass the disruptions that often occur during times of climate-related disasters, in general, and El Niño-related disasters, specifically.

People everywhere have criticized their national weather services for a wide range of reasons, often for what they perceive to be poor forecasting accuracy. The weather services, however, usually provide statistics to support their claims of the relative accuracy *over time* of their forecasts. Thus, the national weather services must improve their communications with the general public in an effort to demonstrate their multifaceted value to society, despite the scientific uncertainties that are inherent in the atmospheric and oceanic processes that they analyze.

A considerable amount of human and financial resources go directly as well as indirectly toward research on El Niño and, more generally, into the physical and biological sciences. Much less goes to the social science research community for research on El Niño-related socio-economic and political impacts. Yet, each of these research communities contributes in significant ways to the understanding of the ENSO phenomenon or its impacts on society and environment. Because there is a disciplinary divide among these communities, communication and appreciation of each other's contributions to societal well-being must be improved. For their part, government agencies and NGOs must strive to improve the quality of their communications and interactions, because many of their activities and concerns are complementary, if not overlapping, when it comes to hazards related to ENSO's warm and cold extremes.

The donor community often tends to impose its perception of national needs during disasters, when in fact it may not be the best judge of a specific country's local needs. Thus, governments need to improve their communications with donors and vice versa, so that national requests for assistance are considered to be in balance with the needs at hand.

Forecasting by analogy (FBA)

Forecasting by analogy (FBA) is an approach used to identify strengths and weaknesses in societal responses to climate-related impacts that occurred in the recent past. Such an assessment enables societies to maintain their identified strengths and to reduce the weaknesses in their actual responses to those impacts. In this assessment, researchers looked for societal responses to the 1997–98 "El Niño of the Century" in order to identify various ways to reduce their society's vulnerability to El Niño-related disasters and to improve society's ability to recover (i.e., ensure societal resilience) once the disaster has passed. The FBA approach is based on the premise that societal institutions in the near future will be like those of the recent past and, therefore, lessons learned as a result of "hindcasting" will be useful to decision makers, at least for the near future.

Forecasting by analogy can provide a government (and society in general) with quantitative and qualitative information on the impacts of previous El Niño events. While there is no certainty about the similarity of future impacts to those of the past, a historical retrospective does provide a glimpse of a range of possibilities of El Niño-related impacts for which a society might better prepare.

All governments should take the opportunity to look back to the 1997–98 El Niño event, and to the lengthy 1998–2000 La Niña event as well. A retrospective assessment would help them to gain insights into how such changes in sea surface temperatures in the tropical Pacific Ocean might affect their local climate regimes for good and for ill. FBA can provide disaster agencies with an opportunity to review how well their contingency plans worked in 1997–98 and, if necessary, make adjustments to them. This can be done agency by agency as well as at the inter-ministerial task force level.

Such retrospectives can provide ideas in a preliminary way about the strengths and weaknesses of their institutions when confronted by an ENSO extreme. For example, given the known linkages between an El Niño and the increase in forest fires in Indonesia (and the resultant haze throughout Southeast Asia), that government must maintain fire prevention programs and enforce compliance with them. National researchers should be encouraged and supported financially (domestically and internationally) to undertake their own comprehensive national assessments.

FBA assessments provide a government with insights into regions, sectors, and populations that are likely to be at increased risk during an El Niño event. For example, since the early 1970s, many researchers have focused on El Niño's impacts on Peruvian fisheries but few, if any, had given any thought to its devastating impacts on Peru's textile industry as the result of an unexpected warm winter in the country. As another example, the 1997–98 El Niño had a negative effect on the mining sector in Papua New Guinea, because the Fly River went dry as a result of a severe prolonged drought. As a result, supplies could not be shipped by river transportation into or out of the mining region. Thus, FBA can help government agencies and corporations to produce El Niño (and La Niña) vulnerability maps. However, it would be misleading for decision makers to rely only on information about the last El Niño (or La Niña).

Countries in the process of strengthening their scientific establishments can in the meantime use FBA techniques to provide an improved understanding of climate-sensitive physical processes and of how those processes interact with human activities and ecological processes, and to identify potential El Niño-related problems before they occur. El Niño events come in different strengths, and various aspects of society are constantly changing. As a result, the impacts from one event to the next will not be exactly the same, even though there are likely to be some similarities.

Capacity building

Many countries are in need of human capacity building in the area of climate impacts research in general and in ENSO-related sustainable development and disaster planning, specifically. Government agencies, policy makers, and the wide range of users of climate and weather information need to be made aware of the many not-so-obvious ways that climate variability affects their activities. Knowledge of the ENSO cycle is important to them, because it has predictive skill associated with it. It therefore lends itself to strategic decision making.

Educators at all levels in a country's educational system should encourage their students to study climate-society-environment interactions. Governments should encourage their personnel to do the same, especially during those periods when there is no imminent threat of a disaster. While climate may prove not to have been the most important factor at a given point in time, its influence on human activities must be taken into serious consideration early in the decision-making processes.

Building national capacity with regard to climate issues (climate change and variability as well as ENSO and other climate-related extreme events) can reduce a country's dependence on outside expertise, if not for monitoring or forecasting, at least for analyzing the information it receives directly from abroad or by way of the Internet. This would help to improve the level of trust and respect between disaster-aid recipients and donors, when it comes to coping with disasters.

Global forecasts, and even regional ones, issued at the onset of an El Niño event do not provide enough detailed information for forecast users at the local level. More attention should be given to identify methods to convert global forecasts of ENSO to local forecasts which will have credibility at those levels. Local capacity building geared toward the interpretation of global forecasts and analyzing them for local use is an important aspect of disaster reduction.

While the earliest of warnings about climate-related problems can be made available to the public, people require education and training to interpret and use such warnings. For effective disaster mitigation, this expertise needs to be in place *before* the onset of a potentially disruptive El Niño event.

Capacity building at the national level can create and foster multidisciplinary expertise about El Niño, while at the same time broaden the country's existing disciplinary expertise. Both perspectives (disciplinary and multidisciplinary) are needed for effective proactive participation in national and international activities related to climate issues (e.g., research programs, education and training activities, workshops, conferences, and scientific visits).

Forecasting-by-analogy studies (such as retrospective assessments or hindcasting exercises) can be accomplished at little, if any, cost to national governments and can build a solid foundation for the sustained societal understanding of climate-society-environment interactions. They can provide a government with a "nothing to lose, something to gain" situation.

Country-specific lessons identified

Sixteen sets of country responses to the forecasts and the impacts of the 1997–98 El Niño were evaluated for their strengths and weaknesses in order to identify ways to prepare for future events. From a philosophical standpoint, one can look at the 1997–98 event as having provided a "trial run" of societal responses to an intense El Niño. Whether societies have learned from their recent experiences with El Niño will be tested during the next few El Niño episodes in the early decades of the twenty-first century. The 1997–98 event served as a wake-up call to many governments around the globe that El Niño is a spawner of adverse climate conditions that can affect their societies and economies in both the short and the long term.

Some of the key lessons identified in each of the 16-country case studies are presented below. They are cited to illustrate the value of "looking back for the purpose of looking ahead." While history is not likely to repeat itself, we do believe that "history has a future" in terms of improving societal interactions with climate variability, climate change, and extreme events. The complete studies are found in the CD.

Bangladesh

- Awareness about El Niño/La Niña impacts in Bangladesh was very little before the present study. Rather, they have often been confused with those of monsoon weather phenomena. It has become clear from this study that El Niño/La Niña have a strong influence on monsoon weather changes. But it is still not quite clear to what extent El Niño/La Niña or the monsoon weather phenomena create impacts on seasonal weather changes. However, for better understanding and forecasts of El Niño teleconnections over the most prevalent monsoon regions such as Bangladesh, India, Burma, Nepal, Thailand, and Sri Lanka, there is an urgent need for a thorough study.
- There is a need for quantification of El Niño/La Niña impacts on crops, lives, and other economic activities in Bangladesh. This will enable us to find out appropriate remedial measures in coping with this grave situation.
- Bangladesh should be integrated with the international network for undertaking appropriate remedial measures against El Niño/La Niña impacts. This may include all preventive measures such as forecasts,

Fig. 4 **El Niño-related impact on the fishing industry in Vietnam (courtesy N. H. Ninh)**

monitoring, early warning, and preparedness. There should be a study on how Bangladesh, as one of the most El Niño disaster-prone areas, can be integrated with the international network.

China

- In order to better apply climate forecasts, there is a need to study the relationships between societal and human activities and climate processes.
- It is necessary to improve the communications between the meteorological community (weather services, research institutes, universities) and the public in order to close the gap that exists between scientific research and its application to society and economy.

Costa Rica

- In some sense, the issuing of a warning raises an expectation of responsibility on the part of the warning agency. There is an expectation

on the part of those warned that the warning agencies will remedy the problems which arise. The lesson learned is that the warning of a possible disaster causes a series of actions which may be negative over the long run, and there is an expectation of responsibility for these negative impacts.
- The level of detail of the El Niño forecast is so low that in some cases it tends to mislead rather than inform. While correct in the forecast of a drought in Guanacaste, cattle were moved to an area where no drought was forecast, but which later occurred, creating an intensified crisis.
- Much of the discussion regarding the forecast of El Niño uses concepts and language which are not entirely meaningful to the general public. More effort is necessary to interpret meteorological information about El Niño and present it in language specific to different sectors; for example, agriculture, hydroelectricity, or potable water services.

Cuba

- It is necessary to maintain a high scientific level of research and monitoring of El Niño and La Niña.
- Because each El Niño or La Niña event has some unique aspects that are not captured in its average description, surprises are to be expected in terms of societal and environmental impacts.
- A better job has to be done to educate all levels of society – the public, the media, educators, and policy makers.

Ecuador

- Political, socio-economic, and military problems will have to be dealt with by governments at the same time as they are coping with an El Niño forecast or its impacts.
- In times of El Niño-related disasters, it is imperative that rival agencies and ministries work together following the pre-established chain of command: starting with the national civil defense, which is better prepared to cope with disasters than any governmental agency alone.
- Governments must be educated about the importance of weather and climate information, not only for disaster response but for development purposes as well. In other words, there is a need to overcome the "lack of weather/climate information" culture.

Ethiopia

- Involvement of the Prime Minister's office gave a level of credibility and importance to the El Niño forecasts.
- There is a tendency to refer to whole countries when referencing El Niño's impacts. But it is seldom that an entire country will be adversely affected in the same way by an El Niño event, given the variability in topographic features. For example, Ethiopia is known for its local, small-scale climate regimes. It is important for governments to identify in advance the regions and sectors that are vulnerable to the ENSO extremes.
- There should be an improved capacity in the regions, in terms of skill improvement, access to information, and resources capability, to issue their own regional forecasts in order to make the forecast relevant to the local areas that have their own microclimates. This could reduce the time spent in communication between the regions and central government. Education and training programs at the local and regional levels related to El Niño would also improve the country's ability to mitigate El Niño's impacts.

Fiji

- A national drought plan of action would be beneficial for responding effectively to future El Niño-related droughts and other water shortages. An improved El Niño forecast capability would provide the earliest warning about drought.
- The impacts of El Niño-spawned severe drought in Fiji burdened the poorer segments of the population more directly and most heavily.
- Because the drought tended to magnify chronic nutritional problems caused in part by low income and the lack of food and micro-nutrient deficiencies, there is a need for improved data collection to identify the at-risk regions and populations in order to improve disaster response for other hazards, as is presently done for cyclones.

Indonesia

- Generalization of anticipated impacts of El Niño across large geographic areas of a country can be counterproductive. This may adversely affect the distribution of scarce national resources for mitigation activities in areas where they are needed most. At the same time, in some areas generalization may affect the credibility of forecasts. There are sig-

nificant variations in impacts (and climate-related as well as social and economic vulnerabilities) across different sectors and geographical locations of a country. Based on historical data and analyzes, these variations could be studied and taken into account in dealing with the impacts of future El Niño events.
- The role of intermediary organizations (such as agro-meteorological departments, forestry research organizations, crop production forecasting agencies) in translating forecasts into usable or actionable information should be adequately recognized. The 1997–98 El Niño event has brought into focus the role of meteorological agencies in providing timely and accurate forecasts. However, the intermediary institutions have received relatively little attention. Capacity building of these organizations, backed by research on past events, will be extremely important in turning forecasting products into actionable information.

Kenya

- The state of a country's economic and political condition at the time of the onset of an El Niño will be a major determinant in the impacts on society of that event; roads and bridges are in need of constant maintenance and the poor have few resources available for responding to disaster.
- It is important for a government to identify all of its climate-related hazards and to design plans to deal with them regardless of their probability of occurring.
- In fact there are many agencies in society that carry out early warnings about climate-related problems. Their expertise should be channeled into a central coordinating unit to increase the effectiveness of monitoring and warning.

Mozambique

- Prevention! Prevention! Prevention! Recent floods in Mozambique showed that small preventive measures could have spared a great number of lives. This has to be done in connection with local communities making use of local solutions.
- Education! Education! Education! This is the only way, in the short and long run, to raise the societal knowledge and sensitivity toward this issue. Include schools at all levels as well as the media.
- Forecast! Forecast! Forecast! Last but not least, Third World states tend to neglect investments in forecasting. It is expensive (and there are always other priorities) and results do not seem evident. It is im-

portant to change this mentality; strengthening on the one hand the international and regional forecasting networks, and on the other to include (again) local participation. Forecasting cannot be considered as an aseptic technologically based activity (or something which belongs only to the rich Western countries). The human, cultural, and local factors have to be taken into account.

Papua New Guinea

- There is a need to involve a wider range of agencies, both government and non-government, in planning for, monitoring, and responding to El Niño events rather than just those focused on disaster-related activities.
- There is a need for a well-defined emergency management structure from the national to the local level, with clear responsibilities not only allocated but accepted by all agencies involved.
- There is a need to update emergency plans by reviewing them following each El Niño-related or other disaster.

Panama Canal

- The expansion of the canal watershed system along with the possible construction of new dams seems to be the best solution to guarantee a good storage and provision of water for the watershed. But for these measures to have success, they must be accompanied by good, efficient management of those water resources as well as by early forecasts of the onset of warm events.
- The continuous and accelerated changes in land use that are taking place in the canal watershed call for permanent monitoring of the basin and a constant verification of the models that simulate the response of the canal system to climate variability.
- To promptly and adequately take the necessary measures to minimize impacts in ship transits and to inform the shipping industry with sufficient advance notice on these measures, the Canal Authority needs to identify a mechanism to have available early forecasts at the onset of a warm event.

Paraguay

- Confidence has to be developed in El Niño-related forecasts for governments at all levels to take them more seriously, even though it is apparent that El Niño and La Niña events have significant impacts in the country.

- Human and institutional capacity to undertake scientific research on El Niño needs to be developed and supported, given the linkages between ENSO's extremes and climate anomalies in Paraguay.

Peru

- The ENSO cycle must be considered as a recurrent event in national planning (such as in civil defense, urban zoning, construction codes) rather than as an anomalous condition.
- Scientific institutions and government agencies must engage and educate the media to convey more clearly their messages and to minimize the risk of misinterpretations of ENSO information.
- It is misleading and dangerous to base a country's preparation for ENSO events solely on the impacts of the last event, regardless of its magnitude.

Philippines

- Resources tended to flow for disaster preparedness and response when the president or the prime minister took an interest in El Niño and set up an Interagency Task Force.
- Even with good forecasts and good disaster preparedness and response there will are likely to be adverse and costly impacts of El Niño-related impacts.
- El Niño exacerbates the impacts of known natural hazards in the country, but forecasts of El Niño's onset tend to provide additional early warning to government with regard to both emergency conditions and to long-range economic prospects.

Vietnam

- El Niño-related impact studies should be undertaken between El Niño events, and not only during them, when the focus is on disaster relief.
- There is a need for human and institutional capacity building in climate and climate-related impact assessment and disaster planning.
- There is a need not only for an improvement in the skills associated

Fig. 5 **El Niño-related storm damage in Vietnam (courtesy N. H. Ninh)**

with El Niño forecasting, but also with the forecasting of El Niño's likely impacts on society and the natural and built environments.

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Part III

Executive summaries and lessons learned

Bangladesh country case study: Impacts and responses to the 1997–98 El Niño event

Team leader:
Dr Ekram Hossain
Environmental Economist
Bangladesh Public Administration Training Center (BPATC)
Savar, Dhaka-1243
Bangladesh

Team members:
Syed Shamsul Alam
Kazi Hazan Imam
Mohammed Munjurul Hoque
(all with BPATC)

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Executive summary

Bangladesh is one of the worst victim regions of El Niño and La Niña impacts. The existing geophysical and socio-economic settings of the country continue to increase both the vulnerability to and severity of those natural events. The country's agriculturally based production system depends mainly on climatic phenomena.

Bangladesh is perhaps the only country in the world where casualties due to a cyclone could rise into the hundreds of thousands. Floods can devastate more than half the country, causing damage up to billions of US dollars. Nor'westers and tornadoes often demolish the economy and settlements in many parts of the country. Droughts destroy the country's food chain, food stock, and agro-based production systems. A large number of households become homeless due to riverbank erosion. Earthquakes cause severe damage to human settlements as well. Scientists have found reliable correlations between El Niño and La Niña events and variability of climatic phenomena in the country which, as a result, contribute to those natural disasters mentioned above.

To reduce the negative impacts of climate-related disasters and to minimize the suffering of the people, the government of Bangladesh has established a set of mechanisms including institutional arrangements for disaster preparedness and relief and rehabilitation of the area affected or likely to be affected. For making the established mechanisms appropriately and effectively operative, an exhaustive guidebook entitled *Standing Orders on Disasters* has been designed outlining the activities of each related ministry, division, and major agencies and departments. The Ministry of Relief and Rehabilitation, Bangladesh Meteorological Department (BMD), the Disaster Management Bureau (DMB), the Space Research and Remote Sensing Organization (SPARRSO) and various other organizations, both at national and local levels, come together to cope with the problems of natural and climate-related disasters. There is still a lack of scientific efforts and of modern technological know-how regarding proper management of climate-related disasters including predictions, preparedness, and mitigation measures.

Scientific research in Bangladesh relating to El Niño has not reached a satisfactory level. Research on the issue is mostly conducted as a result of individual initiatives. The researchers use data generated through both traditional and sophisticated methods by various national and international meteorological agencies. There is evidence of historical interest in El Niño and La Niña in the country before the onset of the 1997–98 event. The real credit of meteorological and agro-meteorological predictions during ancient times goes to a mythical woman named Khana. Her verses are said to be the envy of any scientist of any time. There were several other mythical persons who devoted themselves to the prediction of meteorological phenomena during ancient times. Scientifically, it was Sir Gilbert Walker who, during the British rule in India, identified effects of ENSO events in this subcontinent.

Bangladesh is mainly dependent on international meteorological agencies with respect to the flow of meteorological information, including predictions and transmission. SPARRSO was the first in Bangladesh to receive the 1997–98 El Niño information. Although SPARRSO was a bit late in transmitting this information, it received fairly wide media coverage in the country.

It has been found in this study that ENSO's teleconnections influence the climate of Bangladesh, as well as the Indian region. According to the analysis of information in the context of Bangladesh, El Niño is generally associated with drought, whereas La Niña results in increased rainfall and flooding.

Sir Gilbert Walker's studies during the early decades of the twentieth century documented the teleconnections between El Niño and climate anomalies in Bangladesh. Atmospheric pressure in the eastern tropical Pacific Ocean is usually higher than in the West Pacific and Indian Ocean. Wind flows from a high-pressure region to a low-pressure region. As a result, a huge volume of moisture comes from the Pacific Ocean to Bangladesh and India; and due to the prevailing low atmospheric pressure in this area at that time, the moisture-laden air rises, causing heavy rainfall in the region of Bangladesh and India. This difference in wind flow is named the "Southern Oscillation." It is also called the "Walker Circulation." When the sea surface temperature rises in the eastern Pacific Ocean (i.e., in the El Niño situation), then this wind flow weakens or reverses. Consequently, we see a deficit in rainfall and a possibility of drought in the region of Bangladesh. On the other hand, in the La Niña situation we face heavy rainfall, flooding, and cyclones.

The data and information presented in the Bangladesh study clearly support the view that there is a relationship between ENSO, drought, and flood. In the study of Bangladesh monsoon rainfall, there is generally a decrease in rainfall in El Niño years in each of the seasons: the pre-monsoon (March–May), monsoon (January–September), the post-monsoon (October–November) and the winter (December–February).

The time series data of yearly rainfall of four selected recording stations in Bangladesh for a period of 43 years (1950–92) show a negative and decreasing tendency in rainfall during El Niño events. The decreasing tendencies of rainfall were observed to be 70 percent at Jessore, 67 percent at Dhaka and Barisal, and 72 percent at Srimangal.

The El Niño phenomenon led to a severe drought in South Asia and there was severe shortage of rainfall in Bangladesh in 1997. Our analysis shows a positive correlation between the negative value of the Southern

Oscillation Index (SOI) and drought in Bangladesh. On the basis of historical records, experts believe that the major famines of the region have been connected with El Niño's occurrence.

Some interesting features have come out about the teleconnection between the ENSO cycle and flooding in Bangladesh. The most catastrophic floods occurred in Bangladesh in the years of 1954, 1955, 1974, 1988, and 1998. The years 1954, 1955, 1988, and 1989 were with positive SOI (ENSO cold events, or La Niña), whereas 1974 and 1987 were El Niño years. The main El Niño occurred in the preceding year, but in these years negative anomalies were not that strong. In the major El Niño years, i.e., 1951, 1957, 1972, 1976, 1982, and 1986, Bangladesh did not experience any catastrophic flooding. Thus, one can come up with the hypothesis that during major El Niño years, at least during the first year of El Niño (the year of onset), Bangladesh may be spared from catastrophic floods. The years 1963, 1965, and 1969 were moderate El Niño years and in those years moderate floods were observed in Bangladesh. Therefore, the conclusion may be drawn that during La Niña and weak El Niño years, Bangladesh may be a victim of flooding. In the case of a high positive value of the SOI, Bangladesh may face severe floods.

Research also shows that Bangladesh has not been struck by any catastrophic cyclone during strong El Niño years. And it is also observed that when the SOI index is small (positive or negative) and when the 28.5 °C isotherm stays left of 165 °E longitude, the chance for Bangladesh to be hit by a cyclone is quite high.

The 1982–83 event is considered to be one of the strongest El Niño events of the twentieth century. A significant amount of excessive rainfall in the selected stations under study was observed in the preceding and following years of this event. On the other hand, a significant rainfall deficit was observed in both El Niño years, i.e., 1982 and 1983. This resulted in a drought in Bangladesh, which caused losses in agricultural productivity and production. As a result, the poor and marginal farmer classes were negatively affected. Moreover, it created subsequent negative impacts on several socio-economic areas such as poverty, migration, social unrest, food reserves, foreign currency reserves, and overall economic development.

It is evident from our study that Bangladesh was affected in 1997–98 by El Niño and the subsequent La Niña. Due to the impact of the 1997–98 El Niño, Bangladesh experienced a 60 percent deficit in rainfall in June 1997. As a result, the southeast monsoon wind was delayed by one month and the country faced a short drought condition until June 1997. Moreover, unprecedented and unusual foggy weather during the winter and high temperatures during the southwest monsoon of 1998 were observed.

A deficit in rainfall was observed in all the selected stations under study, except one (Khulna). This deficit amounted to –5.4 percent, –20.4 percent and –6.7 percent in Cox's Bazar, Dhaka, and Sylhet, respectively. Due to the rainfall deficit and the subsequent short drought during the main growing season, Aman production decreased by 25–30 percent in 1997–98. This resulted in a food crisis and a high price for rice, a deficit in revenue collection, higher inflation, and pressure on the 1998–99 national budget for which the government had to curtail development expenditures.

The 1997–98 El Niño also created negative impacts on the country's poverty situation, rural-urban migration, and environment. Subsequent La Niña impacts resulted in a severe and prolonged flood in Bangladesh in 1998, where about 51 percent of the total land area was inundated and approximately 31 million people (i.e., 26 percent of the total population) were affected. The total loss as a percentage of the GDP was 6.64 percent, which adversely influenced the economic growth rate of the country.

It was noted that there was only one statement issued by the Agricultural Information Services, with the title "Agricultural Weather Forecast: Actions Suggested for the Farmer." This was published in the *Daily Newspaper* on 15 September 1997. After the appearance of El Niño impacts, a detailed statement was prepared by the government on damages, losses, requirements of goods, and services for relief and rehabilitation. The statement was issued on the government's website. A joint research project was undertaken by SPARRSO and the Bangladesh Agricultural Research Council (BARC) on the "Development of Models for Predicting Long-Term Climate Variability and Consequent Crop Production as Affected by El Niño-La Niña Phenomena." In response to proper disaster management in Bangladesh various institutional arrangements and mechanisms are now effectively operating at both the national and local levels.

Bangladesh could not yet develop powerful institutions like those in Western Europe and North America to forecast a complex climate-related disaster like El Niño, but the institutions established at the national level such as the Space Research and Remote Sensing Organization (SPARRSO), the Bangladesh Meteorological Department (BMD) and the Bangladesh Water Development Board (BWDB) by the government of Bangladesh for monitoring and forecasting disasters as well as El Niño, are trying their best to monitor and forecast climate-related disasters. Forecasts made by them in the recent past on climate-related disasters and El Niño episodes were almost 100 percent correct.

Although the El Niño forecasting-by-analogy approach in Bangladesh by the concerned organizations does not exactly correspond to the findings, the relationship (similarity) of the two entities is positive indeed. Since the present technology in Bangladesh is not in a position to identify the uncertain impacts of an El Niño episode, the country has to rely on the latest ideas and technology from developed countries for responding to the negative impacts of El Niño and La Niña events in Bangladesh. Regular exchange of information with specialized organizations in the developed countries and proper understanding of the mechanism of the ENSO phenomenon would enable the country to more precisely forecast, plan, and monitor well ahead of time in order to face natural disasters like cyclones, drought, and floods.

In order to strengthen the concerned organizations in monitoring and forecasting climate anomalies in the future, a further initiative would not only enable the scientists in Bangladesh to forecast and monitor this phenomenon more accurately but would also help reduce and mitigate the colossal impact of El Niño events through early warning and preparedness. This study suggests a number of policy recommendations which should be implemented in due course. For better understanding and the undertaking of appropriate mitigation measures against possible impacts of El Niño and La Niña events, more intensive studies need to be carried out *in the region*.

Top ten lessons

- Teleconnections in Bangladesh between drought and El Niño are strong. El Niño in Bangladesh is generally associated with droughts and La Niña results in increasing rains and floods.
- Information on the ENSO warm event/cold event cycle is useful for society to minimize damage from droughts and floods.
- Bangladesh is dependent on outside sources for El Niño and La Niña forecasts and monitoring. These sources are highly essential for early warning and preparedness.
- There had been little scientific research on ENSO in Bangladesh before the 1997–98 event.
- Bangladesh has to depend on getting the latest ideas and technology from developed countries; there is a need for mutual trust between Bangladesh and industrialized countries.
- El Niño's drought impacts on downstream (out-year) development expenditures persist well after the El Niño event has ended.
- Bangladesh is becoming more prone to calamities. That is why there must be a readiness on the part of the government to institutionalize effective prevention and mitigative measures.

- Bangladesh requires education and training for personnel dealing with the prediction and monitoring of the ENSO cycle.
- Research facilities must be enhanced in order to improve impacts studies. International assistance in this regard is very important.
- A regional disaster management action plan should be established within SAARC (South Asian Association for Regional Cooperation) or some other regional framework.

Other lessons

- Bangladesh institutions are now interested in the planning and early warning of the extremes of the ENSO cycle.
- Effective post-disaster reviews are required after each major disaster.
- The social and geophysical settings are important for Bangladesh (the country can suffer from drought and flood in the same event (with El Niño or La Niña)).
- Undertake cost-benefit studies for El Niño response measures.
- Bangladesh takes into account folk wisdom in its consideration of climate extremes.
- More intensive public awareness and education programs on ENSO must be carried out in disaster-prone communities.
- Bangladesh needs to establish a permanent disaster management organization.
- Local responsibilities in dealing with ENSO's extremes need to be increased.
- The government of Bangladesh needs to support more national studies related to ENSO extremes.

China country case study: Impacts and responses to the 1997–98 El Niño event

Team leader: Dr. Qian Ye
Director, Center for Development and Application of Atmospheric Sciences Research
Institute for Atmospheric Physics
Chinese Academy of Sciences
Qi Jia Hou Zi Hua Yan Li #7
Beijing 100029, PR China

Team members:
Wei-Hong Qian (Peking University)
Ju-wei Zhang (Chinese Academy of Social Sciences)
Quan-shen Ge (Chinese Academy of Sciences)
Jin-Hai He (Nanjing Meteorology Institute)
Zhong-wei Yan (Chinese Academy of Sciences)
Wei Gao (Natural Resources Ecology Lab, Colorado State U)
Xiu-lan Wang (Chinese Academy of Sciences)
Ming-tian Liu (Chinese Academy of Sciences)
Xiao-dan Liu (Chinese Academy of Sciences)

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Executive summary

China is the largest developing country in the world, encompassing a vast territory and with nearly 1.3 billion people. Great differences in climate are found from region to region, owing to China's extensive territory and complex topography: tropical, subtropical, temperate, plateau and alpine. The major part of China is under the influence of the Asia monsoon. Natural hazards, especially meteorological hazards, such as torrential rains, floods, droughts, typhoons, hail and frost episodes, occur frequently. Drought, flood, typhoon, frost, and hail damages are the main climatic hazards that had and continue to have substantial influence on the country's social and economic conditions.

In 1997, people in northern China experienced a very hot and dry summer season. During the 1997–98 winter, extraordinarily heavy snow fell over the Tibetan Plateau and caused great losses of human lives and property. In the summer of 1998, a great flood occurred in the Yangtze River basin, which was ranked as the second-greatest flood in China during the past 50 years. Meanwhile, the greatest flood in the past 50 years occurred in the Songhua River basin in northeastern China. Both floods caused total damages of over 350 billion yuan (RMB) (US$45 billion) in property and an officially estimated 3,000 deaths.

Following these two natural disasters, their causes were investigated thoroughly by a team led by the Ministry of Water Conservancy with participating officials from different government agencies and scientists from various research institutions. El Niño was considered as one of the major factors to be included in the forecasting process in that year. Preliminary results, however, showed that although El Niño has its most significant impacts on climate in China's tropical regions, its impacts on climate are weaker beyond this region. In China, most forecasters believe that El Niño is a strong signal that could be used in the future for predictions of climate anomalies in China. However, there are mechanisms that are not yet well understood about the relationships (or influence) between El Niño and China's climate hazards.

Historically, scientific research in China on El Niño advanced in four stages. The first stage occurred before 1950. In this period, no studies had been undertaken in China on El Niño and the Southern Oscillation (SO) and their impact on China because of the lack of awareness worldwide of the seemingly local Peruvian phenomenon, the weakness of Chinese science and technology, the lack of reliable scientific observation instruments, and difficulties in obtaining any of the very limited number of scientific reports and information about El Niño and the SO from other countries. Research topics such as interannual variability of the Asia monsoon and global atmospheric circulation, or the interactions of the atmosphere and the ocean, were not addressed at that time.

The second stage occurred from 1950 to 1980. Beginning in the 1950s, anomalous sea surface temperature (SST) variations (which were related to variations of El Niño and the Southern Oscillation – a relationship still not known in China at that time) and their relationship with global and regional atmospheric circulation began to attract the attention of China's research community. From 1980 to the early 1990s, owing to the global impacts of one of the strongest El Niño events in the twentieth century (the 1982–83 El Niño), El Niño study in China entered its third stage. With the successful forecast of the 1998 Great Flood in the Yangtze River basin, ENSO studies in China blossomed in the fourth stage.

Mention of the El Niño phenomenon first appeared in Chinese scientific literature about six decades ago, although it was considered to be only a local natural event near Peru without any global impact. Only after the 1982–83 El Niño were the relationships between El Niño and anomalous weather events in China and its impact on China's agriculture addressed, and then only within the meteorological research community. In the early 1990s, the media in China started to cover news of the impacts of the long series of El Niño events (i.e., 1990–95) on foreign countries, especially in South America and Australia. The public, however, was still unaware of any possible relationship between El Niño events and their own daily lives, because of the lack of communication between the meteorological community (including weather services, research institutions, and universities) and the public.

In early 1997 the magic phrase, "El Niño," finally escaped from the ivory tower of the scientific community and became one of the "hottest" words on various TV programs, and in national and local newspapers around the country. Having become so concerned about the impacts of extreme climate events on China's national economic development prospects, President Jiang Zemin and other top government leaders consulted with the China Meteorological Administration (CMA) and the National Oceanic Administration (NOA) for information on El Niño and its impacts during the period of the 1998 Great Flood from June to August 1998 in the Yangtze River basin, even though the El Niño event, if not its lingering impacts, had already entered into its decaying mode by that time.

Although the Chinese weather service has made seasonal and annual predictions since the early 1950s, its predictions were provided only to the central or local government decision makers when they were making their annual work plans for agriculture, water management, and disaster relief. Such information was not available to the general public. This was so because, on the one hand, the accuracy of long-range forecasts was low because of the complexity of climate variations in China. Therefore, the weather service was not confident enough in the reliability of its long-range forecasts to release its predictions to the public. On the other hand, China's weather service for a long time has lacked the trained personnel to deal with the media and the public and to educate them on climate variability, climate change, and weather events, and particularly on the climate system's societal impacts and on the usefulness of meteorological information to society. With lessons and experiences gained from the 1997–98 El Niño event, both the meteorological community and the general public in China are starting to come together to deal with climate and its impacts on various sectors of society.

Many lessons have been learned from this study and perhaps among the most important ones are the following: (1) there are many scientific uncertainties in the understanding and forecasting of ENSO's extremes and their impacts on environment and society; (2) there is a lack of communication between researchers who try to reduce or "eliminate" these uncertainties and users who desperately need the information but either never use it or are skeptical about its reliability because of the forecast uncertainties. With respect to the scientific understanding of ENSO, many of the regional uncertainties are due to the lack of proper observation networks which require human capacity building for research. Studies focused on understanding the ENSO phenomenon are needed, especially its teleconnections to China, as is more funding for basic research.

The lack of communication among the scientific community, the media, and potential users of ENSO information including but not limited to forecasts must be dealt with for the benefit of reducing ENSO's impacts. Addressing this issue will also be useful for building a communication channel to educate the public on a wide range of scientific issues. As a scientific community, good communication and research cooperation are also needed between physical and social scientists. Trained personnel and additional infrastructure and funding are also needed to improve communication with the media and users so that the information that is provided by scientists about El Niño and La Niña events and their impacts on society and the environment is not misinterpreted.

Lessons learned

Although there have been many scientists studying the impact of ENSO within China, there is still a long way to go to confirm the teleconnections between certain weather and climate phenomena that occur in different parts of China and ENSO's extreme events (i.e., El Niño and La Niña). For example, before the early 1990s, most Chinese meteorologists believed that a cool summer would occur in northeastern China during El Niño years. They had also made some successful forecasts in the late 1980s. During the 1990s, however, the situation had been totally reversed, with warm summers occurring there in El Niño years, and in 1997 northeastern China experienced its hottest summer of the twentieth century.

Another example is the association between El Niño and floods in the Yangtze River basin. Many scientists believed that usually there was a flood in the Yangtze River during El Niño Year+1 (the year following the year of the onset of El Niño). A recent study based on a statistical analysis of historical data shows that in El Niño Year+1, the chance of having flood, drought, or normal rainfall in the Yangtze River basin is almost equal (Yan 1988, personal communication).

After the 1997–98 El Niño event, many scientists came to realize that El Niño should be considered in the making of climate forecasts in China, although its role is not as yet clearly understood.

Lessons learned by forecasters

In general, forecasters in China did not pay much attention to the possible influence of El Niño on regional climate in the country when making their operational climate forecasts. The successful operational forecasts of the Great Flood in the Yangtze River basin have apparently helped to change many forecasters' views on El Niño. They received great praise with the correct forecasts, praise both from government and the general public. However, they also suffered greatly because they could not answer questions from decision makers and the general public about the impacts of El Niño. This was because of the lack of studies on the impacts of climate variability on Chinese society and economy. Since that time, outreach programs have been developed. Because of the lack of trained personnel, funding, infrastructure, and effective cooperation among the different agencies, the results from these programs are yet to be realized.

Lessons for decision makers

During the 1997–98 El Niño, because of its great impact both on domestic and global matters, many high-level government officials, including President Jiang Zemin, called upon the Chinese Meteorological Administration to learn more about El Niño and its possible effects in China. Considering the great loss of property and lives caused by the 1998 Great Flood, the government policy makers realized that there are great gaps between scientific research and its application to society and the economy. As a result, they decided to invest more of their research funding in basic scientific research, and at the same time, required all researchers to pay more attention to applying research findings to society's needs.

Although the ability to respond to natural disasters is quite efficient and effective in China, the government found that China lacks early warning systems based on scientific studies and analysis to help protect against disasters in a more effective and economical way. To build up a reliable climate-related early warning system, a high-quality scientific research program with a better monitoring system is first needed to obtain forecasts with reduced uncertainties. Second, a better communication channel(s) should be established between government representatives and scientists about the state of climate science and the limits of prediction of natural phenomena such as ENSO's extremes. Third, an organization is needed which can better coordinate efforts to cope with natural disasters among different government agencies.

China can benefit from educational programs that teach the general public how to prepare for the worst-case scenario once an ENSO extreme event has been forecast. Although the 1997–98 El Niño made El Niño a household word throughout China, a continuous and high-quality education program is needed to educate people about the lessons from past events, which should not be forgotten, and the benefit that could be obtained from climate. The development of a climate affairs program at Chinese education and training centers is one such promising approach.

Lessons for the meteorological community

The Chinese meteorological community has realized that relying only on improving the accuracy of forecasts by focusing on basic research is not enough to ensure a forecast's value to society. It is equally important to users, including government decision makers, business people, and the general public to help them to understand the meaning, limitation, application, and value of ENSO-related forecasts. The more understanding that can be fostered of climate (and, more specifically in this case, El Niño and its impacts), the more support, financial as well as moral, can be obtained from the wide range of potential users. Obviously, with the fast rate of development of its economy, Chinese society has become increasingly affected by the vagaries of climate. Society needs to know more about climate, climate variability, and climate impacts. The meteorological community has a responsibility to meet these needs.

Costa Rica country case study: Impacts and responses to the 1997–98 El Niño event

Team leader:
Dr. Jeffrey R. Jones
GIS (Geographical Information Systems) Laboratory Chief
Tropical Agronomic Center for Research and Education (CATIE)
Turrialba, Costa Rica

Team members:
Sebastian Wesselman (Project Manager, CATIE)
Markku Kanninen (Global Climate Change, CATIE)
Francisco Jimenez (Agrometeorology, CATIE)
Rosanna Lok (Anthropology Consultant)
Patricia Ramirez (Consultant)
Eladio Zarate (Instituto de Meteorología Nacional)
Manuel Jimenez (Consejo Regional de Cooperación Nacional)
Ezequiel Garcia (Consejo Regional de Cooperación Nacional)

Executive summary

With the announcement of the 1997–98 El Niño at the beginning of 1997, Costa Ricans began a massive response at the national level. National media, government ministries, agriculture and fisheries began preparations based on prior experiences with El Niño phenomena since 1982. As such, Costa Rica represents an intriguing case study of early warning and response to climatic anomalies. Significantly, not all prevention strategies worked as planned, and some had unforeseen consequences. These experiences provide a revealing window on the possibilities of response to early warnings, and the limitations of such strategies.

One initial conclusion of the review of the 1997–98 El Niño response is that Costa Rica in fact has adopted a "culture of preparedness," as recommended by international disaster prevention efforts, such as the

International Decade for Natural Disaster Reduction. This preparedness is especially clear in contrast to the lack of preparation on the part of other Central American countries.

A more sobering observation is the delicate policy decision concerning climate prediction. As probabilistic statements, forecasts have a likelihood of error; the impact of mispredictions must be carefully weighed against the benefits of early preparation. Uncertainties surrounding El Niño's forecasts led to very different approaches on the part of the various organizations involved in the the early analysis of the 1997–98 event, with different institutions favoring more and less speculative forecasts.

Global and historical context of El Niño for Costa Rica

El Niño-Southern Oscillation (ENSO, or ENOS in Spanish) is a climate phenomenon arising out of the interaction of global-scale air masses and the tropical Pacific Ocean. While first noted and named El Niño by Peruvians and Ecuadoreans because of the coincidence of coastal ocean warming with the Nativity (El Niño – The Child) the phenomenon extends in some form along a great length of the American shorelines of the Pacific.

The connection between El Niño and extreme climate variations in Costa Rica was not explicitly recognized until the mid-1980s, when a fortuitous conversation between Dr. Michael Glantz, a leading El Niño researcher, and Patricia Ramirez, a leading Costa Rican climate researcher, identified the coincidence of periodic Costa Rican droughts with years of El Niño. At that time, Ramirez was studying droughts in western Costa Rica for the purpose of improved agricultural adaptation to climate variability, since periodic droughts were the cause of losses and economic instability in the agricultural sector (Ramirez 1992). At approximately the same time, the Laboratory for Oceanography was established at the National University in Heredia (Costa Rica), a center that would eventually provide needed researchers and information for national climate analyses.

As one of the areas first and most directly affected by tropical Pacific Ocean warming, Costa Rica is a site of research activities into the historical evolution of the El Niño phenomenon (e.g., tree ring research). The role of El Niño in global climatic variability and its impact on global climate change have become key questions for understanding current and future global climate conditions.

El Niño has now become a topic of public discourse, which is reflected in the publications of Costa Rica's national institutions. The Bulletin of the National Meteorological Institute IMN (Spanish acronym), published as a vehicle for communicating technical meteorological information to the public, shows a concern with the ENSO phenomenon. At least three bulletins in 1991 and 1992 explicitly describe El Niño or associated phenomena (IMN 1991a,b; 1992). A more recent bulletin discusses the decadal oscillation in the Pacific (IMN 2000) (the PDO).

Costa Rican climate patterns

Costa Rica is characterized by two typically tropical climate patterns, on its Caribbean and Pacific coasts. The coasts are separated by a volcanic cordillera, which divides the types of weather patterns. The central plateau and intermountain valleys at an elevation of 1,200 meters is home to the major cities and a large part of the Costa Rican population. The populated central plateau is significantly cooler than the coastal regions, but generally follows the weather pattern of the Pacific coast.

The most widely recognized climate pattern is the rainy climate of the eastern Caribbean watershed, which is responsible for Costa Rica's well known humid tropical rainforest vegetation. In contrast, the northern Pacific watershed has a distinct monsoonal pattern, with intense rains followed by months of drought. This area is characterized by dry tropical forest.

Costa Rican climate patterns, and their variations, are a product of its inter-oceanic and inter-hemispheric location. As a narrow land bridge dividing the Caribbean/Atlantic and the Pacific, Central America in general, and Costa Rica in particular, are directly affected by ocean/atmosphere interactions. The east-west Walker Circulation which covers the breadth of the Pacific tends to cause subsidence of dry air on the western coast of the isthmus; the volcanic mountain range which divides the isthmus tends to create a rain shadow, so that even when pressure gradients favor the introduction of moist Caribbean air, most precipitation remains in the Caribbean watershed.

The other major influence on the Costa Rican climate is the Inter-Tropical Convergence Zone (ITCZ), which marks the dividing line between the north-south and south-north cycling Hadley cells, within which warm air rises at or near the equator, and subsides some 30 degrees north and south of the equator. The ITCZ migrates south in the northern winter months, and north in the northern summer months, crossing Costa Rica; the convective currents of the ITCZ are an important source of moisture for both the Pacific and Caribbean watersheds.

Obviously, Costa Rica's climate is extremely sensitive to subtle changes in the relationships between the Pacific and Caribbean air masses, and the northern and southern air masses. Disruptions caused by El Niño have a direct impact on day-to-day and season-to-season climate. However, since the impacts depend on the precise location of the ITCZ and the relative pressures of the ocean air masses, the climate forecast is easily mistaken.

The identification and announcement of the 1997–98 event

By the time the 1997–98 El Niño event was first detected early in 1997, the phenomenon had been linked in the public's mind to earlier events of the 1980s and 1990s. The linkage was so strong that the Director of the Costa Rican Meteorological Institute felt a need for extreme caution in the possibly premature identification and official announcement of an "El Niño Event," as it would have sown seeds of panic among some sectors of the population. Even with this caution exercised, cases arose where actions were taken which went beyond reasonable and prudent precaution to unnecessary caution to the detriment of the Costa Rican population.

Ironically, the initial announcement of the El Niño event in official circles was made by regional organizations, rather than by national institutions. In March of 1997, the head of the Regional Commission for Hydraulic Resources (CRRH)[1] communicated the possibility of an El Niño event beginning later that year. This note was sent first to another regional institution, CORECA (Regional Council for Agricultural Cooperation), and from there it was communicated to the ministers of relevant institutions in the different countries of the isthmus. In view of the apathetic response to the announcement from most of the Central American countries, the regional institutions may have been justified in their somewhat speculative initial announcement, which relied on the one and only climate model which predicted the onset of El Niño (more than a dozen climate models are commonly used, and none of the others at the time predicted the event).

The actual wording of the CRRH/CORECA announcement was quite reserved, indicating the possibility of an El Niño event; it did not predict with certainty, and it did not suggest the possibility of a *strong* event. Nevertheless, it was a more forceful indication than the National Meterological Institute considered appropriate; the IMN only issued its first advisory when there was a much more positive forecast in May and June.

Preparation for the 1997–98 event

Of all the countries of Central America, Costa Rica's prompt and active response to the announcement was unique. The initial speculative announcement prompted the formation of El Niño commissions within national institutions, and the creation of an inter-institutional coordinating committee.

At the Ministry of Agriculture, the El Niño commission began reviewing contingency plans for drought. In some cases, preparation simply consisted in activating existing plans which had been developed even before Costa Rica's periodic droughts had been associated with El Niño. The expected impact of El Niño was an early onset of the dry season in November of 1997, and its extension into August or September of 1998; the normal monsoonal dry season lasts from November until May.

The preparation effort was mostly directed toward consciousness-raising among the agricultural population during the latter part of 1997, in preparation for drought in mid-1998. Public informational meetings were convened, and conducted by ministry officials. In some cases the meetings were attended by high officials in the IMN, the Oceanographic Laboratory of the National University of the CRRH.

The consciousness-raising was hindered by the then-current weather conditions; a heavy rainy season beginning in June of 1997 made producers skeptical. In some cases, the drought warning was issued in the middle of torrential downpours and floods, which seemed to limit the credibility of the prediction. To make matters worse, the first predicted impact of the El Niño was an early cessation of rains at the end of 1997, which did not occur. This warning had been issued at public meetings, and caused great embarrassment for the meteorologists, as it made their entire message suspect.

The most active and intrusive preparation for the El Niño event was the recommendation to reduce the cattle herd in the Pacific monsoonal climate zones of Guanacaste and the Central Pacific coast, as it was expected that the extended drought would push producers past the limits of their customary water and food supplies. As a result, there was a massive sell-off of the western herd, pushing down prices in the market, and redistributing animals to areas where the impact of the drought was expected to be less severe.

In the water sector, the major preparation was the acceleration of existing irrigation and well-boring projects to help ensure water supplies in potentially affected zones.

The national insurance agency, INS, cut off credit to farmers on the west coast, apparently in response to a similar action by the national agency in Panama. Protests by farmers led to a careful meteorological review of specific regions, and the re-establishment of credit in zones where there was a minimal possibility of drought.

Impacts of the 1997–98 El Niño

At the outset, it must be stated that it is extremely difficult to differentiate El Niño impacts from normal climate variability in Central America. Given the torrential nature of the rains and the limited capacity of watersheds, floods are common throughout the region on an annual basis. Further, drought is a normal feature of the Central American climate. Traditional methods have been developed to respond to the annual drought, but a crisis may ensue with the extension of the 'normal' dry season by a few weeks.

The official report of the Economic Commission for Latin America identified approximately US$100 million in damage, combining impacts in agriculture, fisheries, and forestry. Drought, irregular rains and water shortage lead to losses principally in the drier zones of the country. The regional ocean warming typical of the El Niño event leads to a decrease in the fish catch in national waters – an exact parallel to the well-known impacts on fish populations in Peru.

Losses in forestry are of special note. An extended dry season leads to an accumulation of combustible material in dry tropical forest areas, which makes the control of fire extremely difficult. Fortunately, in Costa Rica the use of fire for agricultural clearing has been largely eliminated, and while the occurrence of forest fires did increase, the frequency was nowhere near the crisis levels achieved in other Central American countries.

Surprisingly, one of the major impacts of the El Niño was in animal production, not in the most drought-prone areas but in the less prone areas where animals had been moved in preparation for the extended drought. Costa Rica's Northern Plain is an anomolous climate area; following the traditional division of climate zones along the continental divide, the Northern Plain falls in the Caribbean zone. However, in parts it is much closer to the Pacific coast than to the Caribbean, and the continental divide is so low as to be non-existent. While it generally follows the Caribbean pattern of having virtually no dry season, its driest period is drier than that of other areas in the Caribbean climate area.

For the 1997–98 El Niño event, the climate of the northwest portion of the Northern Plain was much more like the Pacific than the Caribbean. Ironically, the relatively benign traditional climate had not required that ranchers of that area develop contingency plans to prepare for drought. In fact, Ministry of Agriculture officials reported that the ranchers responded inadequately to the impending drought because they could not believe it would come to pass as predicted. They continued to expect that the rains would begin 'next week', and took inadequate action to protect their cattle. To make matters worse, the climate prediction for El Niño did not include drought for the northern zone, so ranchers felt confident on the basis of historical patterns and official predictions that the drought would not be overly extended.

Another ironic impact of the El Niño "drought" was the increased water damage to crops and flooding. Long-time meteorological researcher and former head of the National Meteorological Institute Patricia Ramirez found that total precipitation during El Niño years does not vary significantly from long-term averages. The apparent drought is caused by a change in rainfall pattern, where rain tends to cluster in very short time periods. Aquifers do not recharge, plants and infrastructure are damaged by heavy showers, and there follows a relatively long period before the next rain.

A bittersweet impact of the 1997–98 event was the restructuring of the mandate of the National Emergency Commission (CNE, in Spanish). Along with the Ministry of Agriculture, the CNE began preparations for El Niño through the allocation of disaster response budget to areas of expected impacts. This initiative was curtailed by a Supreme Court ruling, which confirmed that its disaster-response mandate required that it take no action *until* the disaster had actually occurred, and its planned activities were postponed until El Niño impacts actually manifested themselves. In the wake of El Niño, national legislation was changed to permit the CNE to prepare for predicted disasters.

Conclusions

The principal conclusion of this El Niño event is that there is a willingness and capability to respond to early warnings of climatic events in Costa Rica, even when these are not entirely certain. Government officials and producers were able to take raw information and transform it into meaningful responses based on their previous experience, and the expected nature of the El Niño impacts.

On the negative side, El Niño forecasts were too imprecise to permit specific preparations for impacts. Major errors were made in the forecast that had negative economic impacts for farmers who had taken actions based on the forecasts. Unfortunately, impacts are very localized, and farmers and government officials must make decisions on specific farms, rather than larger regions. While there is no doubt that the heightened alertness of the producers in response to the knowledge about the El Niño event is positive, it is not prudent to make long-term plans on that forecast, since it may be generally correct or incorrect, and in addition, may be specifically correct or incorrect. The proper response to the forecast is to hedge bets and be prepared for a range of contingencies.

Several efforts are currently proposed and underway to improve predictive capabilities of major climatic events such as El Niño. The major recommendation to such efforts is "Don't be satisfied with generalities." While meteorologists may find probabilistic statements satisfying and appropriate in their forecasts, decision makers require more clear-cut (detailed) information, which helps them make correct decisions and avoid foreseeably bad decisions. This lesson may be less to do with forecasting than with the development of improved, detailed descriptions of meteorological processes within a country, and with the development of methods of communicating relevant information to non-professional users of climate-related information.

The potable water sector has determined that important forecast data are air temperatures. During the 1997–98 El Niño the national water service AyA (Aguas y Alcatarillados) found a surprising increase of about 5 percent in water consumption, which they attribute to increased temperatures.

At the same time, there is an important niche for the more generalized seasonal predictions. On an isthmus, hydrological cycling is greatly accelerated. Improved seasonal forecasting can be critical for water-control decisions for flood control, hydroelectric generation, and irrigation. Similarly, these generalized forecasts may be useful to farmers for generalized management decisions (whether to plant corn or sorghum, for example). The eventual integration of seasonal forecasts into production planning requires a certain period for learning and development of communication techniques, as farmers and other users learn how to interpret seasonal forecasts in the context of their own activities.

Lessons learned

- In some sense, the issuing of a warning raises an expectation of responsibility on the part of the warning agency. As an economic disaster, recovery is politically complex since, without loss of life, a "disaster" takes on a different aspect in the public's mind. Some parts of the economic disaster are directly caused by preventive measures; for example, the forced sale of cattle in Costa Rica in the face of an El Niño-related drought drops the price of cattle and impoverishes the farmers. There is an expectation on the part of those warned that the warning agencies will remedy the problems which arise. The justice of this expectation is questionable, since it might be argued that the farmers were saved from greater losses. In effect, the warning allowed them to "cut their losses" in anticipation of a potentially greater misfortune. Unfortunately, this is impossible to demonstrate, and one might always argue that the warning was in some sense misleading, thereby causing an economically disadvantageous decision on the part of the farmer. The lesson learned is that the warning of a possible disaster causes a series of actions, which may be negative over the long run, and there is an expectation of responsibility for the warnings because of these negative impacts.
- The level of detail in an El Niño forecast is so low that in some cases it tends to mislead rather than inform. While the forecast of a drought in

Guanacaste was correct, cattle were moved to an area where no drought was forecast, but an area in which one later occurred, creating an intensified crisis. Since the forecast drought turns out to be functional rather than absolute (i.e., an effective drought as a result of rain at the wrong time rather than too little rain), it may cause counterproductive water conservation measures in water control and hydroelectric facilities. If water is maintained at maximum levels in expectation of drought, short intense storms can cause flooding because of improper preparation. This type of flooding has not actually occurred, but it is a possibility.

- The determination of the economically appropriate response to a potential El Niño event is difficult because of local variability in climate, and uncertainty as to the extent of an expected drought. As a result, the proposed measures may be too extreme and could cause more harm than good. A year after the end of the 1997–98 event, some in Costa Rica questioned whether the recommendation to sell off cattle had in fact been justified, in view of the economic losses that it caused. The alternative of keeping the animals in situ and having the cattle lose weight, and having some die, may have been the more appropriate response.
- The response to the forecast of El Niño must be geared to each national situation. In Costa Rica, a simple announcement resulted in an immediate response on an official level. The National Meteorological Agency exercised extreme caution in its announcements and advisories to avoid an extreme public overreaction. In other Central American countries, the same type of announcement resulted in very little preparation, possibly requiring a more emphatic announcement of the forecast and possible consequences of El Niño than that required for Costa Rica.
- Much of the discussion regarding the forecast of El Niño uses concepts and language which are not entirely meaningful to the general public. More effort is necessary to interpret meteorological information about El Niño and to present it in language that is specific to the different sectors, such as agriculture, hydroelectricity, or potable water services.
- As an occasional event (i.e., irregular but recurring), there is a tendency for a lack of continuity in preparedness for El Niño. Since Costa Rican governments change every four years, and personnel in ministries change as well, the technical awareness of preparation and response methods has a tendency to dissipate.

Note

1. The CRRH is part of the regional economic integration structure collectively known as SICA, the Secretariat for Central American Integration. The governing commission for CRRH is made up of the heads of the meteorological institutes for each country.

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Cuba country case study: Impacts and responses to the 1997–98 El Niño event

Team leader:
Dr. Lino Naranjo-Diaz
Centro Nacional de Clima
Instituto de Meteorología
Aptdo 17032, Havana 17
Cuba

Team members:
Pedro Cárdenas Pérez
Abel Centella Artola
Oscar Solano Ojeda
Yamila Rodriguez Eduarte
Amparo Pérez Benítez (all with Instituto de Meteorología)

Executive summary

The Republic of Cuba is an independent state located in the Caribbean basin. It encompasses an archipelago of 110,860 square kilometers and is administratively divided into 14 provinces, and these are further subdivided into 168 municipalities. The political and administrative capital of Cuba is Havana (with more than 2 million inhabitants) which, in turn, constitutes the smallest province in terms of area in the country. In 1998, the Cuban population was estimated at 11,139,900 inhabitants, which translates into a population density of about 100 inhabitants per square kilometer.

The agricultural area in Cuba is over 6,000,000 hectares (ha), of which more than 2,000,000 ha are devoted to the permanent cultivation of sugar cane. Almost 3,000,000 ha of the Cuban territory are covered by forest. The state owns 53.7 percent of the arable land, while the rest (46.3 percent) belongs to the private sector.

The gross domestic product (GDP) of Cuba has undergone important variations in the last several years. At the beginning of the 1990s, the Cuban economy, which had been linked closely to the economies of the Socialist countries of Eastern Europe, suffered a severe impact caused by the disintegration of the Soviet Union (its main commercial partner) and the collapse of the Communist governments in Eastern Europe. This fact, along with the existence and permanence of an economic blockade imposed by the government of the United States since 1960, caused an important contraction in growth rates, which have remained under 0.5 percent for GDP during these years. Since 1995, important transformations began to take place, including a wider opening to foreign investment and an accelerated development of tourism and related activities. In 1997, increments above 2 percent per year were registered, maintaining a growing trend.

The climate of Cuba can be considered tropical or tropical oceanic, characterized by a well-defined rainy season (occasionally referred to as the "wet season") with warm temperatures, and a "dry season" when the precipitation is sparse and the temperature cooler.

The rainy season extends from May through October and accounts for nearly 70 percent of the annual total rainfall. The dry season runs across the remainder of the year (November through April), when Cuba is affected by weather events in the higher latitudes. These events are mainly responsible for the few rainy episodes in this season.

Climate-related and other natural hazards

Among the severe weather events that affect Cuba, tropical cyclones (TCs) are considered the most important. The number of tropical hurricanes that affect Cuba annually is quite variable, with totals that run from 0–5. The western region of Cuba is the most affected during the hurricane season, with an average of one hurricane every 1.9 years.

Another important natural hazard in Cuba is drought. The frequency of this climate anomaly has increased in the last few decades, bringing very harmful consequences for agricultural production and for soil conservation. Cuban soils are experiencing serious symptoms of salinity and desertification in coastal and semi-arid areas. The frequency of years with moderate and severe droughts has doubled in the last 30 years.

Droughts are usually combined with high evaporation rates, which result in reduced soil moisture and a drop in the groundwater level. Occasionally, when droughts are interrupted by episodes of torrential rains, the interaction between rainfall intensity and soil loss causes intense erosion processes in soils with poor vegetative cover and a high surface drainage capacity.

Heavy precipitation (HP) is also a concern. HP episodes are those that accumulate 100 mm or more of rain in a single location during 24 hours or less. During the 1965–90 period, the occurrence of HP was about 85 days per year, on average, in the country. In El Niño years, there is a notable increase in the number of days with HP – an annual average of 100 days.

In Cuba, a thunderstorm is classified as a severe local storm (SLS) when it is associated with tornadoes, destructive wind gusts of more than 90 km/h, hail, and/or waterspouts. Based on a study of 25 El Niño years, only four had no major SLS events. In particular, the number of devastating tornadoes increases during El Niño years. Therefore, in El Niño years the presence of SLS episodes of extreme force should be expected.

Level of scientific research relating to El Niño and other climate-related hazards

Since 1991, Cuba has maintained an intense research effort on El Niño, attempting to establish impacts and to use El Niño as a climate forecasting tool. In 1995, a five-year project with the study of ENSO as its central objective – its predictability of impacts on the climate of Cuba – was built into the National Scientific Program, "Global Changes and the Evolution of the Cuban Environment." Among other goals, the program aims to develop a deeper knowledge of ENSO's impacts on the climate of Cuba, demonstrating that other climate forcing factors are able to mitigate the impacts of ENSO's extremes.

Starting in 1997, research related to El Niño and Cuba became more focused on its socio-economic impacts. In 1999, a new national five-year project was developed, supported by funds from the National Environment Agency. This project focused on ENSO warning systems and the prediction of ENSO's extremes and their impacts on the nation's climate and society.

For these reasons, it can be affirmed that at the time of the onset of the 1997–98 El Niño event, the level of scientific development reached by Cuba in studies related to these extreme events was high, allowing for efficient monitoring and prediction activities.

With regard to other climate-related hazards, a wide spectrum of studies has been developed in the last 20 years, focused mainly on hurricanes and drought episodes. There have been many studies regarding the climatology, forecasting, and impacts of hurricanes in Cuba. In the last five years, a strong concern has developed related to the role of tropical cyclones in interannual variability of climate and of seasonal forecasts. In fact, Cuba is considered one of the countries in the Americas with the highest scientific development in the study of these dangerous systems.

Meteorological conditions in Cuba that generate serious droughts have been thoroughly analyzed and, recently, Cuba's Climate Center was able to develop a national system of drought monitoring for the country.

The 1997–98 event

Cuban interest in El Niño underwent a sharp step-like change in the 1990s, passing from having been a mysterious and virtually unknown climate-related process to policy makers and the public, to becoming one of the main factors to be considered when speaking about Cuba's climate. In March 1997, information coming from the US National Centers for Environmental Prediction (NCEP) indicated the possibility that an El Niño event was in progress. In April, the prediction method of an ENSO Index developed in Cuba indicated an increase of this index suggesting warm El Niño conditions until August. Consequently, in May 1997, the Cuban Climate Center released an alert on the possible development of an El Niño event for the current year.

In June 1997, it became evident that the evolution of this event pointed toward the development of a strong mature El Niño. Consequently, this was noted in a Special Warning Number 2, released at the beginning of July.

All the information flowed toward three levels. The first level, composed of the Ministry of Science, Technology and Environment, the Advisers Team of the Ministers' Council of Cuba and Civil Defense, possesses the highest level of responsibility for the development of disaster preparedness strategies in the country. In turn, it constitutes the source of information from which other government agencies base their preparation policies. The second level is made up of the media, and a third level includes the different agencies of international assistance.

Much of the international information on the evolution of the event was obtained by means of the Internet. Another key element in monitoring activities was information from the global telecommunication systems. At the national level, the main source of information (predictions and evaluations) was the Institute of Meteorology.

The first reference in the media to El Niño and its effect in Cuba appeared on 21 February 1987, when the newspaper *Granma* published an article entitled, "Does El Niño Return?" In the 1990s, due to the progress in scientific research in this field in addition to the creation of the first system of climatic monitoring in Cuba, interest in El Niño increased. Funds granted to research projects on El Niño increased in addition to a more active dissemination of El Niño information to the public by way of the official media. After the 1994–95 event, news coverage significantly intensified. The first mention immediately prior to El Niño's 1997–98 onset was in January 1997.

The first reports about the 1997–98 El Niño in the media appeared by the middle of 1997 in Cuban radio and TV news programs. In the press, news about El Niño's development appeared in September 1997. Between September 1997 and August 1998, 11 articles on El Niño were published. The bulk of the reports relating to the 1997–98 El Niño was published in 1998. There was a general tendency in the Cuban press to increase reporting about El Niño in the winter. Traditionally, in Cuba this is the time in which El Niño's biggest impacts should be expected.

The Cuban media were not prolific in comparisons of the 1997–98 event with previous events. In several journalistic articles and other reports, some references to the 1982–83 El Niño appeared, but in almost all cases, with the objective of illustrating potential impacts and not by way of a comparison of these events.

Teleconnections

Studies agree on ENSO's influence on winter circulation in the Caribbean. This is similar to what takes place in the United States and is mainly due to frequent intrusions during winter of the extratropical westerlies from the North American continent. In Cuba, the influence of El Niño becomes more significant in the second half of winter. The biggest natural disasters in this season are associated with extratropical cyclone systems that form under El Niño conditions.

In summer, the interrelationship between circulation over the Cuban region and El Niño becomes less evident. In general, no significant relationships have been found in surface circulation. However, changes in upper-air circulation patterns should bring an increase of the vertical wind shear during El Niño years, establishing a connection between ENSO warm events and an observed diminishing of the activity of tropical hurricanes in the Atlantic. This constitutes an important positive impact for the region.

The existence of significant relationships between the anomalies of sea surface temperatures in the tropical Pacific Ocean and tropical cyclone activity in the Atlantic, with a tendency toward a reduction of this activity during El Niño years, was established in 1964. There is also a significant relationship between El Niño years and the duration of the cyclone (hurricane) season.

Climate-related anomalies and impacts in the 1982–83 event

In terms of disasters, the impact of the 1982–83 event was the most severe ever experienced in Cuba. In the winter of 1982–83, a record 26 extratropical cyclones developed in the Gulf of Mexico. Anomalies of unusual intensity and frequency affected Cuban territory. The most well-known event associated with the 1982–83 El Niño was the intense coastal flooding that plagued Havana, a level of flooding not witnessed since the

Great Hurricane of 1926. It occurred on 17 March and flooded extensive urban areas of the city of Havana, producing severe damages to its infrastructure.

Damage throughout the country related to this event was considerable. More than 40,000 acres of tobacco were completely destroyed, 65 percent of tomato production was severely damaged, strong winds demolished more than 1.5 million banana trees with an estimated production capacity of 50,000 metric tons. Damage to potatoes was estimated at more than 120,000 metric tons lost, representing one-fourth of the entire crop for that year. Sugar cane was also heavily damaged with a considerable reduction in yield.

The impacts in other societal sectors were also considerable. Although major disease outbreaks did not occur, due to the intense efforts of the Cuban health system, increases were detected in the incidence of non-transferable illnesses such as bronchial asthma associated with the stress caused by severe weather conditions.

Climate-related physical and social impacts of the 1997–98 El Niño

In the 1997 rainy season, there were high maximum temperatures, especially in September when new records were reached. Rainfall distribution was very irregular. At the beginning of October, most of the country showed monthly accumulations below 50 percent of the historical average. Irregularities in rainfall distribution were linked to a very reduced level of cyclone activity.

In the dry season, anomalies of daily mean and minimum temperatures exhibited a shift toward higher values. Rain in the November–March period in Cuba was very much above average. As a consequence of an increase in the number of extratropical lows, nationwide occurrences of strong winds, intense rains, thunderstorms, and other dangerous meteorological processes were recorded. In addition, starting in April 1998, an intense drought lasted during April, May, and June, causing the most significant rainfall deficit recorded since 1941 for the April–June period. Drought conditions were very severe in almost all parts of Cuba but were most unfavorable in the eastern region. The percentage of the historical rainfall average at the end of June 1998 was only 56 percent for Cuba. This caused serious impacts, disrupting water supplies for human consumption in some major cities. The province of Guantánamo was the most affected. In addition to the precipitation anomalies, temperatures also reflected significant positive anomalies.

In winter, soil moisture was not favorable for the sucrose accumulation in sugar cane plants and, consequently, an important drop in industrial yields was reported. In addition, the 1998 drought produced the total loss of 8,000 ha of "spring cane" (cane which is sown from May to July) in the eastern regions. The loss in sugar cane production was more than 700,000 metric tons.

The anomalous rains in the dry season adversely affected the potato crop. Losses were estimated at more than 18,077 metric tons. High humidity, heavy winds, and hailstorms that were reported in some locations reduced the expected lifetime of plantations. In some areas, there were disease outbreaks that generated additional losses, mainly in Havana Province.

Fields of banana plants were severely affected by strong winds that demolished or damaged over 6,710 ha in the western provinces. Until 31 January 1998, tobacco farmers had reported the loss of 3,350 ha because of wind. In addition, the temperature regime was unfavorable because anomalies higher than 1.5 °C negatively affected the tobacco leaves. Also, weather conditions were favorable for the propagation of pests and plant diseases (in particular Blue Mold).

The summer drought adversely affected milk production. In the eastern provinces alone, losses surpassed 20 million liters during the summer of 1997. Nearly 13,000 animals died from malnutrition in the state sector, and it was necessary to evacuate more than 25,000 cattle to safer places. Feed had to be provided to another 225,000 by different methods.

In lobster fishing, a decreasing population in fishing areas was noted which, together with the days when fishing activities were disrupted by bad weather, caused losses on the order of US$9 million. In other marine fisheries such as shrimp and different varieties of fishes, the main losses resulted from many days without capture because of an increase in bad-weather events during the winter.

Regarding human health, cases of bronchial asthma and acute diarrheic illness declined during the 1997–98 event. In the case of bronchial asthma, this can be explained by the presence of a warmer (with reduced inter-seasonal contrast) winter. The decrease in acute diarrheic illness was due to more a humid winter and the delay in the onset of the rainy season (caused by the onset of the summer drought). The most significant anomalies in acute respiratory illnesses took place in June 1998, coincidentally with the existence of markedly warmer and drier conditions than expected. The increase caused by these anomalies in the city of Havana brought losses of nearly US$6 million, and 23,242 cases more than expected.

The direct impacts of the 1997–98 El Niño on population and housing occurred for the most part during the dry season or winter (November 1997–April 1998). They were associated with the occurrence of severe meteorological events that caused considerable damages and economic losses. These events, although they did not exhibit extreme characteristics like those observed during the 1982–83 winter, caused comparable losses. Nearly 20,000 people suffered some kind of property damage, and more than 12,000 were evacuated.

Reliability of attributions

The current level of research on the ENSO cycle and its impacts in Cuba allows us to believe in many of these attributions with an acceptable margin of confidence. It seems clear that the increase in precipitation in the winter season is a usual characteristic in years under El Niño conditions. However, in the case of the intense summer drought in 1998, considerations about a reliable attribution are more complex.

In an analysis of the last 24 years of attributions, a direct association of drought with El Niño was not found. However, the remarkable and uncommon characteristics of the 1997–98 El Niño leave a wide margin for speculation. It seems reasonable to think that, if the onset of this event began earlier than many other events (including the 1982–83 event) and reached its mature stage in a different period, its effect on the regional and global circulation took place with a different climatic background. Consequently, its impacts on regional climate would have to be different.

The temperature anomalies that occurred, as much in the winter as in the summer, could be considered as a logical result of the deviations observed in the precipitation and in the weather. However, it should be emphasized that temperature in Cuba has shown an important warming trend during the last few decades. In the last 50 years, monthly mean minimum temperatures in Cuba have risen around 1.7 °C, a considerable warming rate.

Responses

At the end of the 1997 summer, the National Headquarters of the Civil Defense sent to groups in the central administration of the state warnings about a developing El Niño, indicating preventive measures to be adopted in order to reduce the expected impacts in each sphere of responsibility. In addition, exceptional measures were taken to keep active the prevention system created during the 1997 hurricane season, for possible future disasters.

From April 1997, the Meteorological Service began to keep farmers and other agricultural entities systematically informed about expected weather and climate anomalies. For its part, the Ministry of Agriculture formulated a set of indicators and measures for all companies and agricultural entities in the country. Because seasonal predictions anticipated an increase in rains during the dry season, the Sugar Ministry anticipated the timing of the sugar harvest for 1997–98. In addition, based on forecasts and on the onset of drought, the Sugar Ministry made the decision to postpone a massive seeding of sugar cane, which had been programmed for the spring season in those regions where the prediction of water reserves indicated the possibility of unfavorable conditions.

Due to the onset of the agriculture drought in the summer, and the prediction of its possible intensification, the Ministry of Agriculture decided to protect cattle and main crops and to avoid forest fires. However, such measures were not applied effectively. In a general sense, Cuban agriculture does not yet have an appropriate "culture" about El Niño, nor does it have a good understanding of how to use climatic predictions more efficiently.

Cuba has developed a national plan for the handling of a wide range of possible disasters. It constitutes a plan for emergencies that allows the authorities in each region to execute, in an organized way, measures to protect the population and economic resources before the occurrence of any disasters.

El Niño events are not explicitly considered in Cuba's national disaster plans as a disaster. The fundamental cause of this is the nature of the Cuban system of civil defense, which is essentially built for facing emergencies caused by specific meteorological events, such as intense rains, droughts, coastal floods, strong winds, etc., regardless of their origin or the atmospheric systems with which they are associated. Perhaps the only exceptions to this rule are tropical cyclones, historically considered Cuba's most dangerous natural hazard and the only meteorological system explicitly considered to be a disaster in Cuba's disaster preparedness plans.

It seems clear that in El Niño years, a higher number of severe meteorological events becomes more probable and some increase in frequency occurs. For these reasons and the experience of the 1997–98 event suggest that, regardless of the levels of current scientific uncertainties, clear distinctions could be identified between El Niño and non-El Niño years. These distinctions should not be ignored in our national plans against disasters.

It is a real possibility that as the knowledge about El Niño and its impacts in Cuba continues to improve, and as the national monitoring service establishes more reliable climatic forecasts, the associated severe events will reach an important place in disaster prevention plans, similar, perhaps, to what currently happens with the impacts related to tropical cyclones.

The main factor behind the Cuban response to the impacts of climatic anomalies is the existence of a centralized structure with wide participation at all levels of society. The fact that the National System of Civil Defense is attached to the general plans for the military defense of the country assures that there will be a high level of response and availability of resources. If a single aspect has to be noted to best describe the main virtue of the Cuban disaster response system, it would be the fact that its main priority is preserving human life, even at the cost of major resources.

Another outstanding positive aspect is the close connection between decision makers and the centers in charge of the country's monitoring services. This is executed through a flow of information that guarantees exchanges among the different decision levels. That the state assigned to a unique institute the task of "climate monitoring" is also one of the strengths of the Cuban system. This guarantees equality of approach and a concentration of scientific effort toward the main concerns. The role that the media played in developing a clearer popular perception about El Niño also constitutes a positive aspect to be highlighted.

However, the system also exhibited some weaknesses. The popular and institutional perception of what El Niño is remains incomplete and occasionally erroneous. In spite of efforts carried out by the Cuban government, an education system structured to teach the public about the phenomenon and its impacts does not yet exist. In general, most professional education courses do not include subjects related to the climate system. This means that future decision makers in different economic sectors will not possess a solid understanding on climate-society issues in the scientific field. Although major research has been developed about ENSO's impacts on the climate of Cuba, this knowledge still has a wide margin of uncertainty. Each El Niño (and La Niña) event is different from one to another, which makes it difficult to improve the efficiency of the prevention system, which is run according to previously established guidelines. In addition, it negatively influences the state of preparation of society, affecting the credibility in predictions and the level of general knowledge. Because of this, some socio-economic sectors occasionally show some resistance to taking measures in response to an El Niño forecast. Consequently, this diminishes the general effectiveness of society's responses.

Another point to be considered is about the capacity of certain levels of the society and the economy to show better responses when forecasts have varying lead times or responses. Although strategic measures can in theory be taken many months in advance, it is not realistic to think that smaller communities subjected to the daily tensions of an economy of subsistence would be able to deal with preventive measures even a few weeks in advance with a high level of effectiveness.

Users still do not use climate forecasts effectively. The language of an early warning forecast about El Niño does not always cover the expectations or needs of decision makers who are more interested in obtaining information about the cost of the possible impacts on specific socio-economic activities than in knowing more detail about climatic variables.

Finally, it should be emphasized that the 1997–98 El Niño influenced, in an important way, Cuban society's preparedness for and responses to the 1998–2000 La Niña. Both events existed very close together in time, causing the long-lasting 1997–98 drought to spread into the 1998–99 winter. This brought severe consequences to the already stressed Cuban economy. Nevertheless, this coincidence (a decaying El Niño and an emerging La Niña) contributed considerably to a more effective response to La Niña's impacts; Cuban experience with El Niño had made possible better preparedness.

Lessons learned

- The existence of a very strong signal for El Niño's impacts in Cuba was certainly demonstrated in the case of the 1997–98 event. Although this El Niño had unique features, which differed from other strong events, many of the expected influences over Cuba's climate did take place. However, unexpected effects, such as an intense summer drought, severely stressed the Cuban economy.
- One difference with other underdeveloped countries is that Cuba has a high level of scientific research on the ENSO cycle and with other climate-related hazards research. It also has a well-defined structure for monitoring weather and climate. These factors were crucial in successfully dealing with the impacts of the 1997–98 El Niño.
- The 1997–98 event proved that the response mechanisms of the Cuban government were capable of coping effectively with the major impacts of El Niño, including the government's request for international assistance. In fact, many of the expected negative impacts were avoided because of timely measures taken in many economic and social sectors.
- Many scientific uncertainties still remain, however, regarding the impacts of El Niño (and La Niña) in various parts of Cuba. The level of knowledge of the general public and of policy makers about the ENSO cycle is incomplete and sometimes erroneous. A comprehensive education program targeting all levels of society would change this.
- Cuban society tends to respond to early warnings of ENSO's extremes by applying predetermined behavioral responses based on individual experience or on some "average" condition. As yet, current predictions are unable to establish how far from average the intensity of the predicted event will be or what the real impacts might be. Consequently, earlier warning about the onset of ENSO's extremes would be more useful only if it gives more answers to users than do the current forecast methods and content.

Ecuador country case study: Impacts and responses to the 1997–98 El Niño event

Team leader:
Dr. Pilar Cornejo-Grunauer
ESPOL (Escuela Superior Politécnica del Litoral)
Campus Prosperina
PO Box 09-01-5863
Guayaquil, Ecuador

Team members:
Armando Gutiérrez-Espinoza (health specialist)
Alberto Compódonico (health specialist)
Mario Gómez (health specialist)
Maria de los Angeles-Gutiérrez (assistant)
Arturo Puchaichela (specialist on water and environment)
Indira Nolivos (oceanography and environmental science)
Juan C. Blum (environmental economist)
Patricia Urdiales (assistant)
Maria Cecilia Villalba (assistant)
Monica Barco (secretary)

Executive summary

At the end of March 1997, anomalous conditions were present in both the tropical Pacific Ocean and the atmosphere. During May 1997, these anomalies and their patterns confirmed the development (onset) of an El Niño-Southern Oscillation (ENSO) event that lasted until June 1998. Its evolution (phases of development) was similar to other events, but its timing was different.

Information on the evolution of the 1997–98 El Niño and its probable impacts was disseminated as early as July 1997, based on the known impacts of the 1982–83 event. However, Ecuador's political instability – four presidents between 1996 and 1998 – took its toll when El Niño came in 1997, and Ecuadorians, in general, were not able to cope with its impacts.

When an El Niño occurrence of unknown magnitude and duration was announced by the Escuela Superior Politécnica del Litoral (ESPOL) on 31 May 1997, the private and governmental sectors became alarmed. The governmental response was quick but not effective. On 2 July 1997, a national emergency was declared by the president, under the National Security Law, giving the National Civil Defense the power to coordinate any action to cope with El Niño. A contingency plan was approved in July of 1997. However, instead of following the law, a permanent committee for coordination of actions to cope with the El Niño phenomenon was formed and named Comité Para Enfrentar del Fenómeno de El Niño (COPEFEN). At the beginning, it was put under the office of the president but later, due to widespread information about the misuse of international funds, this was changed to the vice-president's office.

Several campaigns were launched to disseminate information about the potential impacts of El Niño on the areas of direct impact (the coastal plains west of the Andes), based on the impacts during the 1982–83 El Niño event. Some prevention campaigns, started as early as June 1997 and supported by private and governmental sectors, were oriented toward impact mitigation as well as prevention.

The impact scenarios were provided by several organizations working on El Niño and its impacts. ESPOL provided impact scenarios for the socio-economic sectors. The Instituto Oceanográfico de la Armada (INOCAR, the Naval Oceanographic Institute) provided scenarios for the coastal areas and beaches. And the Instituto Nacional de la Pesca (INP, the National Institute of Fisheries) provided scenarios for the fisheries. These organizations, along with the University of Guayaquil, the Centro Nacional de Investigaciones Marinas (CENAIM), the Catholic University of Guayaquil and others, are part of the Estudio Regional de Fenómeno El Niño (ERFEN, or the Regional Study of the El Niño Phenomenon.)[1] After August 1997, each organization started providing biweekly reports to the government and the general public.

These impact scenarios could be developed because Ecuador is in the proverbial direct line of fire of El Niño. El Niño's impacts are felt directly when the Kelvin waves hit the western, equatorial coast of South America. Its physical effects from the 1982–83 El Niño, used as a forecasting analogue, are summarized below:

- *Increase in oceanic temperatures:* Local fisheries of small pelagic species declined and fishmeal prices increased. Other warm-water species replaced these species. Some birds and mammals that fed from this fishery, on the continental shelf and around the Galapagos Islands, starved to death. Coral reef bleaching was another adverse impact.
- *Increase in rainfall along the coastal provinces during periods longer than the rainy season:* Rainfall produced flooding, mudslides, infra-

structure destruction, collapsed bridges, agricultural devastation and poor sanitary conditions which became health problems. Secondary impacts on the economy of these coastal provinces were also evident.

- *Increase in sea level (due to Kelvin waves) which increased in activity and height due to storms in the northern Pacific:* The higher sea level caused coastal erosion at the shoreline, destroying any structures near the beaches. It also caused problems for the artisanal fishing boats, a loss in tourism at the beaches, and an influx of debris to the beaches, such as dead animals and trees.

Socio-economic impacts

According to the Instituto Nacional de Estudística y Censos (INEC, the National Institute for Census and Statistics), El Niño events had a strong impact on the coastal and island populations of Ecuador, which make up 50 percent of the country's inhabitants. It is also important to notice the relative youth of this affected population: during 1997–98, approximately 34 percent of those affected were younger than 15 years. The most important impacts of the 1997–98 event (in millions of dollars) are summarized in Table 1.

Most of the flooded cities had problems with water supply, sewage, and damage to their infrastructures. Even though the affected urban population was larger, the rural populace suffered the most. The rural population remained isolated; the flooding destroyed their highways, bridges,

Table 1 **Impact of El Niño (millions of US$)**

Sector and subsector	Direct damages	Indirect damages	External effects	Total damages
Social (a)	63.1	129.1	29.2	192.2
Infrastructure (b)	123.3	707.0	80.2	830.3
Economic (c)	582.9	709.0	545.4	1291.9
Expenses on mitigation, prevention and emergency		333.1		333.1
Total	769.3	1878.2	654.8	2647.5

Source: Comisión Económica para América Latina y el Caribe (CEPAL) (1998), *Evaluación de los efectos socio-económicos del fenómeno de El Niño en 1997–1998*, 37–41. Ecuador.

(a) Social sector includes housing, health, and education.

(b) Infrastructure sector includes water and sewage, energy and electricity, transportation and telecommunications, urban infrastructure.

(c) Economic sector includes agriculture, livestock and fisheries, industry, commerce, and tourism.

and roads, their lifelines to the cities. Much of their harvests and agricultural products were lost, raising market prices. Also, most of the rural communication and transport activities are done on third-level roads that, under Ecuadorian standards, are available only during the dry season.

Microeconomics

An analysis of price variability based on two indices that reflect the microeconomic impact – the index for producer prices (IPP),[2] for the national level, and the index for the urban consumer (IPCU), for the coastal plain level – shows the following:

(a) An increase in the IPCU due to an increase in the transport costs of goods in January 1998, caused by speculation about the duration of El Niño and whether there would be an increase in precipitation when the 1998 rainy season coincides with El Niño;
(b) Political instability arose due to general elections for the president, vice-president, and congress, while a new constitution was debated, developed, and adopted.

When El Niño declined between June and August 1998, coastal highways remained rudimentary but still connected. The end of El Niño helped to normalize food distribution and to improve the transport of people and cargo between affected areas. The IPP fell in June 1998, while the IPCU had a speculative increase due to the second presidential round. By August 1998, El Niño's effects had almost disappeared from the Ecuadorian coast, while the chosen indices increased as they responded to the new government and its economic regime (NB: President Jamil Mahuad started his four-year term in August 1998, lasting until 21 January 2000).

Fisheries and aquaculture

Sardine (*sardinops sagax*) landings were reduced drastically, while an increase was observed in Pacific anchoveta in *chuhueco (centengraulis mysticetus)*. But before drawing conclusions, the INP experts indicated that the effect of the sardine fleet's fishing closer than usual to the coast, in an area where *chuhueco* is usually predominant, must be taken into consideration. However, stocks of sardine and other pelagic species from Ecuador migrated southward toward the Peruvian-Chilean coast causing a reduction of 57 percent in total landings for 1997 (248,277 metric tons) with respect to 1996 (435,961 metric tons). As observed after previous El Niño events, a positive impact was an expectation for an increase in the recruitment of yellowfin tuna. This expectation was realized two years later, in 1999, resulting in large catches of tuna by the Latin American fleet. In the case of the shrimp industry, El Niño had both negative and positive effects. The most important positive effect was an increase of 40 percent in total exports during 1997 with respect to 1996.

Agriculture

These strong events negatively affected nearly all agricultural sectors and significantly affected those along the coast. Crop loss was due to the following problems:

- *Lack of flowering:* mango, asparagus, and melon;
- *Excess humidity:* only 50 million pounds (5.5 percent) of sugar cane were harvested out of the expected 900 million pounds;
- *Flooding:* rice, soy, banana, beans, vegetables, fruits, sugar cane, coffee and cacao;
- *Transportation problems (collapsed highways and bridges):* shipping bananas, a major export crop.

The total area affected by the phenomenon reached 613,000 ha (15 percent of the total agricultural land of the coastal area). The total amount of direct losses estimated in agriculture was US$524 million, including the crops ready to be harvested but lost in 1997 due to the lack of transportation. The indirect losses due to the impossibility of the first sowing in 1998, was estimated at US$441.2 million. The total damage to the sector reached an estimated US$996 million.

Health

In Ecuador, several diseases have been associated with El Niño periods: *v. cholerae, campylobacter, c. botulinum, e. coli, salmonella, shigella, hepatitis A, malaria, dengue, leptospirosis, leishmaniasis, encephalitis*, among others. There were four epidemic problems during the last El Niño (1997–98): cholera, leptospirosis, dengue and malaria. Each outbreak was enhanced by El Niño. However, the number of cholera cases during the 1991–92 event was 17 times that of 1997–98, indicating that the magnitude of an event is cause for its potential impact upon a disease. One reason for this dramatic decrease could have been the Contingency Plan of the Public Health Ministry for the prevention of epidemiological diseases, like malaria, cholera, dengue and leptospirosis. This plan had three target actions:

- Social preparation and transport;
- Control of vector-borne endemic and epidemic diseases;
- Aid to populations at the affected zones and shelters.

It is important to note that human health problems are also caused by secondary impacts. One problem of attribution comes from the fact that populations at poverty levels will always be affected, independent of the magnitude of an El Niño event, because of its higher vulnerability.

El Niño attributions

Not all the damage reported by CEPAL (1998) and other institutions can be completely attributed to El Niño. Other underlying societal causes of the impacts include poverty, lack of education, bad and corrupt politicians, a weak economic situation, among other factors, all of which need to be studied. If we did an analysis by sector, we could simplify and understand the reliability of these attributions.

Agriculture

Excess rainfall, as a result of El Niño, did affect the size of the planted areas of different crops: bananas, sugar cane, rice, and soy. Also, air temperatures and cloudiness negatively affected some fruit plants, like mango, by preventing them from flowering. Flooding occurred in the same area, causing additional destruction.

Health

In this sector, the problems were originally derived from poverty but were enhanced by El Niño. Lack of potable water, sewage treatment and drainage problems in small cities and rural communities make them good candidates for water-borne and vector-borne diseases, even during so-called normal conditions. When an El Niño event hits the country, these conditions are worsened, triggering an increase in disease. Prevention measurements depend on economic and human resources available from the Ministry of Health.

Fisheries

El Niño directly affects this sector. The decrease in sardine fisheries and other small pelagic fish populations is due to an increase in ocean temperatures which caused them to migrate southward looking for cooler conditions. The rate of recovery of these fisheries is not fast. Some fisheries are positively affected, e.g., the shrimp and dolphin (magi magi) fisheries. Also, the activities of artisanal fishermen declined because of the higher surface wave activity during El Niño.

Infrastructure

The maintenance of public infrastructure, such as highways, secondary roads, and bridges, was not done properly during 1996. This was due to the presidential campaign and, in the earlier part of 1997, due to the country's political situation. Also, there are a lot of problems related to road construction, such as noncompliance with the regulations required for heavy rainfall episodes during a normal rainy season. Roads in Ecuador are not built to last. Therefore, the damage to public infrastructure is mainly due to poor construction and maintenance, and should not be attributed solely to El Niño. In relation to private infrastructure, especially housing, the problems are due to a lack of any "territorial order" (i.e., zoning regulation and/or enforcement). People living in rural zones, or urban margins, do not take into account whether they are on a river's flood plain, an unstable hillside, a dry river bed in a flooding area, etc., when they build their houses. Also, they do not use good materials for their construction. Therefore, most of the damage to the infrastructure should not be attributed to El Niño.

Responses to information

Responses varied; those from the public sector (e.g., government) were markedly different than those from the private sector. The government established a unit under presidential control (COPEFEN) to coordinate all actions needed to mitigate the expected impacts of the event. However, this was largely ineffective because this organization did not take into account the organizational structure of the country in the case of a disaster. National Civil Defense should have been the agency in charge.

The response of the private sector was fast, and largely more effective, because it is better organized under national and provincial chambers by sector, and especially because they were aware of the potential impacts of El Niño on each sector. However, we can identify several strengths and weaknesses in the responses of both sectors to the El Niño impact scenarios that were provided.

Strengths

- *Timeliness in request for aid:* good timing and the ability to request international funds for coping with disasters;
- *Higher education level and organization level in the economic sector:* allowing the economic sector to better assimilate climate information and information about impacts on its activities;
- *Prior knowledge of some of the expected impacts:* this would have helped in the allocation of aid.

Weaknesses

- *Difficulty in forecasting the duration and magnitude of the event:* only maps of regional and of some local impacts could be provided, using the 1982–83 event as a plausible worst-case scenario;

- *Lack of credibility:* this may be because of the lack of a ‘‘forecasting culture’’ within the country and misinformation;
- *Lack of organization:* within the weakest socio-economic sectors, a lack of organization made them unable to react as a group;
- *Lack of funds:* lack of access to even small amounts of money deterred the implementation of mitigation plans;
- *Information unavailable to all:* information received about the El Niño event was not always in a suitable and understandable form from the perspective of potential users of such information. There were some exceptions, such as efforts directed by local and regional organizations, which went area by area to explain the potential impacts.
- *Political problems:* political instability was at a high level.

Lessons learned

If a perfect forecast had been available as early as October 1996, knowing what is known now about the actual impact that did take place in Ecuador, the responses could have been different, especially in the private sector and in the education sector. For example, the school year in the coastal provinces runs from April–May to December–January. Given a perfect forecast, there would have been enough time for developing an educational campaign at the high school level that could have had a positive impact, mainly on the urban population.

Government responses might also have been different because there was, at the time, a president from the Ecuadorian coast who was running the country. In general, however, the political and socio-economic situations of the country are the ones that most influence any possible response to an El Niño event. There are some lessons to be learned from an analysis of the socio-economic and political settings during the 1997–98 El Niño, of its impacts and the country’s responses. These lessons must be taken into account before the impacts of the next event plague the country.

The lessons summarized below are not in order of importance. Several of these lessons, drawn from the project’s Brief Executive Summary Report prepared for the Millennium UN General Assembly, were considered applicable to the Ecuadorian country case study.

- The condition of the country’s infrastructure at the time of the El Niño event has a lot to do with the severity of impacts on the infrastructure of that event.
- Political and socio-economic conditions such as poverty and conflicts during an El Niño will have a major effect on how adverse the impacts will be.
- Existing political and socio-economic (and military, as on the occasion

of Ecuador's border war with Peru during the 1997–98 event) problems will have to be dealt with by the government at the same time that it is forced to cope with a forecast of El Niño's onset or of its impacts.
- The globalization of news releases (e.g., media coverage about El Niño's impacts elsewhere on the globe) heightens the concern of the public about possible impacts in their own country.
- In times of El Niño-related disasters in Ecuador, it is imperative that rivaling government agencies and ministries work together. They should be expected to follow the pre-established chain of command – the National Civil Defense in the case of Ecuador – which is better prepared to cope with disasters than any other government agency acting alone.
- There are positive as well as negative impacts of El Niño within Ecuador (e.g., the shrimp industry), but the positive effects are often either overlooked or downplayed as to their importance.
- The flow of information about El Niño (not just forecasts) to rural areas must be improved in order to make El Niño forecasts and research usable by the public living in these at-risk areas.
- Radio is an important channel of communication about El Niño (e.g., early warning and development) and its related impacts to the poorer segments of the population.
- Governments must be educated about the importance of weather and climate information, not only for effective disaster response but for economic and sustainable development purposes as well. In other words, there is a need to overcome the lack of a "weather/climate information culture."
- To include an explicit consideration of El Niño in a national disaster plan for Ecuador would be only part of the solution. Another part is to provide sufficient funding to implement the El Niño-related aspects of the plan. Yet another part is to create awareness of the phenomenon.
- There is a need to identify a reliable source (or sources) of El Niño information, including forecasts, in order to avoid confusion in the government about conflicting forecasts of a possible El Niño event.
- The impacts of previous El Niño events must be reviewed in order to gain a better perspective on the range of potential impacts on society and of possible societal response strategies. Prior knowledge of El Niño impacts in Ecuador can help to better target some of the at-risk groups.
- International funds need to be available in a timely way, so that governments at various levels can take proactive measures in anticipation of the impacts of an El Niño event.
- There is a need for a forecast with more reliable information about the magnitude and the duration of an El Niño. This requires international financial support for research on other aspects of the ENSO cycle, and for research on the onset of El Niño alone.

Notes

1. ERFEN studies the physics of El Niño and its impacts on fisheries and other biological resources of the region. This program is part of the *Comisión Permanente del Pacífico Sur* (CPPS), or the Permanent Commission for the South Pacific, which was created in 1975. CPPS is a regional program with Peru, Chile, Colombia, and Ecuador as members.
2. There is no IPP for 1997 or for the regional level available, so the IPP at the national level for 1998 is used.

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Ethiopia country case study: Impacts and responses to the 1997–98 El Niño event

Team leader:
Tsegay Wolde-Georgis
Embassy of Ethiopia
3506 International Drive NW
Washington, DC 20008 USA

Team:
Demlew Aweke (National Meteorological Services Agency)
Yibrah Hagos (Disaster Prevention and Preparedness Commission)

Executive summary

Ethiopia is a developing country that has been vulnerable to climate-related disasters during the last three decades. More than 88 percent of Ethiopia's 60 million people are engaged in agricultural and pastoral activities for their livelihood. With little access to irrigation, these predominantly smallholding farmers depend on rainfall to cultivate their crops. Poverty, lack of access to technology, subsistence agriculture, deforestation, soil erosion, and over-population are some of the problems that increase the vulnerability of the people to climate-related disasters. Constant wars and political instability also contributed to the severity of the impact of disasters.

Ethiopia is located in the tropics. Its climate, however, is modified by altitude, which has led to the existence of diverse microclimates. Ethiopia has four climatic zones, which are classified according to the patterns of rainfall. These climate zones are those (1) with a distinct wet and a distinct dry season, (2) with two wet and two dry seasons, (3) with two wet seasons and one dry season in between, and (4) with an undefined rainy season. Altitude leads to the creation of microclimates such as the *quola*, *weinadega* and *dega*, which are hot, temperate and cool, respectively. One of the major causes of rainfall variation in Ethiopia is the north-south movement of the Inter-Tropical Convergence Zone (ITCZ), following the seasons. The three-season pattern known as *kiremt* (big rains from June–September), *bega* (dry from October–January) and the *belg* (small rains from February–May) characterize the crop-producing areas of the country.

Drought is the dominant climate-related disaster in Ethiopia. Droughts in Ethiopia have killed many people and animals in 1957–58, 1964–65, 1972–73 and 1983–84. Though not as pronounced as drought in their impact and publicity, floods and fires have increasingly caused disasters. In response to these disasters, Ethiopian governments decided to create the Relief and Rehabilitation Commission (RRC) in 1976 (which was renamed in 1995 the Disaster Prevention and Preparedness Commission (DPPC)).

In the 1990s, the government of Ethiopia had created four important documents to guide its early warning system and food security. These are (1) National Food Security Policy; (2) The National Policy for Disaster Prevention and Preparedness Management (NDPPM); (3) General Guidelines for the Implementation of the National Policies on Disaster Prevention and Preparedness Management; and (4) The Five-Year Disaster Prevention Plan 1998–2002 (DPPC).

The National Disaster Prevention and Preparedness Committee (NDPPC) is chaired by the Prime Minister. The Regional Disaster Prevention and Preparedness Committees are presided over by the regional presidents. Its important members are the National Meteorological Services Agency (NMSA) and the Ministry of Agriculture and the DPPC, which is the secretary. It also has other important ministries as its members. The objective of the NDPPC is to implement the National Disaster Prevention and Preparedness Policy. There are early warning committees at all levels of the government down to the lowest level, the *wereda*. The committees gather the information, evaluate their work and report to the higher-level committees. They are composed of various government agencies.

There were major developments in the area of preparedness for climate-related hazards in Ethiopia in the 1990s. To this end, rural communities were involved in water and soil conservation activities such as terracing the hills and the construction of micro-dams. Ethiopia established the National Disaster Prevention and Preparedness Fund (NDPPF), seed reserves, and strengthened the Emergency Food Security Reserve Administration (EFSRA) by raising its stock from 33,000 metric tons (MT) to 307,000 MT. These activities were conducted to strengthen Ethiopia's disaster prevention and preparedness capacity.

Ethiopia began to use El Niño information to forecast drought after the 1983–84 drought, which was believed to have been influenced by El

Niño. According to the manager of the NMSA, interest and preliminary research on El Niño was motivated by the desire to make long-range forecasts for the country (Kassahun 2000). Because of the severity of the drought in 1983–84, the NMSA was compelled to prepare and issue a seasonal forecast of the *belg* and *kiremt* rains for 1987, well in advance.

The NMSA uses statistical and analogy methods in constructing its El Niño impact forecast. For example, the 1997–98 El Niño's analogue event was the 1972 El Niño. The NMSA scientists identify the current El Niño and compare it with known El Niños of the past with similar characteristics. Then, the forecast would follow the pattern of the past El Niño. The NMSA scientists also realized that the sea surface temperatures (SSTs) in the Indian and Atlantic Oceans also affect Ethiopian weather. El Niño is a relatively new concept in Ethiopia with no known scientific research on it outside the NMSA.

The 1997–98 event

The NMSA was the first Ethiopian agency to hear about the 1997–98 El Niño in March 1997. Other agencies learned about it during the presentation of the weather assessment outlook by the NMSA when presenting its seasonal forecast. The El Niño information had been received from the Climate Prediction Center of NOAA through its *Climate Diagnostics Bulletin*. The NMSA did not have an e-mail connection at that time. When NMSA heard in May 1997 that the 1997 El Niño would be strong, it issued the El Niño-related seasonal forecast on May 29.

The first media report on El Niño appeared on 5 August 1997, when experts from the NMSA gave an interview on Ethiopian TV to explain the role of the El Niño phenomenon in Ethiopian droughts. There was no report in the Ethiopian media about the evolution of the 1997 El Niño.[1] The media reported the NMSA forecast issued by NMSA at the end of May, but there was no follow-up report on the issue.

Media interest in El Niño began to pick up when the impact was felt at the end of August, and when the Prime Minister's office instructed federal and regional authorities to monitor the situation of El Niño and its impact on Ethiopia. The Ethiopian News Agency, the *Ethiopian Herald* and *Addis Zemen* wrote that El Niño causes drought in Ethiopia. The media also wrote about the impacts of the drought and floods of 1997 for which they blamed El Niño. One of the shortcomings of the Ethiopian media was their inability to clearly inform the public without confusion. There was no expert analysis or editorial specifically focused on El Niño and its climate-related impact in Ethiopia, which might have contributed to an understanding of the phenomenon by Ethiopians.

Teleconnections

According to Kassahun (1999), research at NMSA concluded that El Niño affects the weather in Ethiopia. In 1987, El Niño effects on the Ethiopian seasonal forecast were first considered by the NMSA (Haile 1987). El Niño years are characterized by below normal rainfall in Ethiopia. Neville Nicholls believes that the 1888 Great Ethiopian Drought was caused by El Niño. Empirical observations also show a connection between El Niño and droughts in Ethiopia. For example, the major droughts in 1957–58, 1965, 1973, 1983–84, 1987, 1993–94 occurred following El Niño events. The teleconnection between El Niño and Ethiopian seasons has been established by NMSA. El Niño decreases and disrupts the *kiremt* rainfall (main season) in Ethiopia and boosts the *belg* rainfall (small rainfall season). However, it should be noted that weather in some areas might not be correlated with El Niño events because of the country's diverse microclimates.

Total rainfall in Ethiopia between June and September 1997 at 20 weather stations was 20 percent less than 1996. According to the NMSA, almost all parts of Ethiopia had dry spells in the *kiremt* months of July and August 1997. Out of the 33 zones in Ethiopia, 18 zones received late rainfall, affecting land preparation and sowing. The 15 zones that had a good start in rainfall were affected by dry spells in August and September 1997, which adversely affected the maturation stage of the crops.

The unseasonable rainfall in October and November 1997 led to fungal attack, slowed the rate of desiccation of the seeds, and led to the germination of the seeds before the harvest.[2] Erratic rainfall affected the size of cultivable land by 9 percent from that of 1996, caused by oxen with low energy levels due to less access to fodder. Poor farmers could not rent or borrow oxen at the right time because the owner gave priority to his own plot. The replanting of the land several times following the coming and retreating of rainfall depleted the seed reserves of farmers. Yields were low because of reduced land preparation, and poor and early cessation of rainfall. Heavy rainfall that flooded farms along with pest infestation also reduced output. Lack of fodder reduced the price of cattle and some animals died, especially in the Raya region of northern Ethiopia. Coffee, the main cash crop of the country, was reduced in production because "coffee berries ready to be picked from the trees have been falling on the ground due to heavy rains."[3] Food production declined after two years of good harvest in 1995–96 and 1996–97. Total output in the *meher* season in 1997–98 was reduced by 24 percent from the 1996–97 output. Prices of agricultural commodities also increased by 13–53 percent from those of 1996.

It was reported that there was an abnormal number of rainfall-related deaths: more than 237 persons and 16,887 animals. Many houses were washed away because of floods and thousands of people were displaced. Some commercial plantations in the Awash Valley were flooded, which was a loss of millions of birr.[4] Water shortfalls in hydroelectric dams led to the rationing of electric power.

The abnormal weather was the cause of these disasters. The only other factor that might have decreased 1997–98 food output was the reduction in the subsidy of fertilizer prices. However, farmers interviewed did not cite that as a cause of decline in food production. There was access to credit from the government and NGOs to buy fertilizers, but farmers were not sure of the reliability of rainfall. Besides, the use of fertilizer is effective with the use of selected seeds and adequate rainfall. In 1997–98, the use of fertilizer would not have increased output because farmers were replanting their land with fast-maturing and drought-resistant crops.

Responses

The first response of the Ethiopian government to the El Niño was to issue a forecast on 29 May 1997. It warned that the *kiremt* rainfall would be erratic and begin late. The DPPC wrote its early warning report about the possible impacts of the abnormal weather. Immediately, the NDPPC came up with a response plan to avert the disaster. The two-pronged response was designed in the area of agricultural policies and mobilization of resources. Meetings were organized in the regions, zones and *weredas* to brief every Disaster Prevention and Preparedness Committee member on responses specific to the area. They decided to study the strengths and weaknesses of the most vulnerable *weredas*.

At the national level, the NDPPC asked the Ministry of Agriculture, which is a member of the committee, to come up with possible responses. The ministry estimated that food production would be down by 40 percent, based on the weather forecast issued by the NMSA for the *kiremt* season. It recommended the planting of drought-resistant crops, such as chickpea, and the replanting of failed crops with fast-maturing ones, such as teff and lentils. It also recommended the provision of seeds to farmers until the end of August and the protection of crops through the free distribution of pesticides. In addition, it advised the use of all newly constructed micro-dams and ponds by farmers, as well as the building of irrigation canals. Farmers were also advised to plant potatoes and convert lost crops to feed the animals. The mass media was to be used to educate the people on the response actions.

A major response came from the office of the Prime Minister when the issue of El Niño was raised during a meeting of the Prime Minister with high-level national officials and the regional presidents on 25 August 1997. They addressed their concern about the impact of El Niño and all responsible officials and departments were given instructions to respond to the crisis. The regions also issued evaluation reports on the impact of the erratic rainy season on agriculture. The DPPC issued a special report in October about the impact of El Niño on Ethiopian weather.

As the season progressed, the Ministry of Agriculture advised farmers to replant their crops, especially when the rains returned to some areas in August. The zone officers provided the seeds on credit in order to take advantage of the rains. The October–November 1997 floods disrupted the normal harvest of crops, and local governments organized popular campaigns to help farmers gather their crops. One of the most important roles of the NMSA during the 1997 abnormal weather was to update the unpredictable weather by providing information, such as about the continuation of the rains beyond the normal end of the season. For example, on 12 November 1997, the NMSA urged farmers to "gather their harvest before an untimely rain expected over the various parts of the country." The Ministry of Agriculture also advised farmers to harvest their mature crops before it was too late. Farmers were also advised to construct drainage in areas where crops had not yet matured.

The Ethiopian government was so concerned about the crisis that it asked the UNFAO/WFP crop production and food needs assessment team to arrive earlier than usual. The DPPC was also mobilizing resources internally and from the donors. The DPPC continued to appeal for aid to donors who were initially reluctant in their generosity. On 29 November 1997, Ethiopia appealed for 572,835 MT of food aid to be distributed to over 4 million people. The major component of the 1997–98 appeal was emergency relief. Food supply was critical as early as December 1997 in the central highlands. Resource constraints and the lack of carry-over stock from 1997 contributed to the problem. Donors finally pledged 352,249 MT and eventually delivered 303,987 MT.

The timely response to the crisis by the government avoided the death of people due to famine.[5] The Ministry of Agriculture continued to advise farmers for the 1998 *belg* season. In December 1997 and January 1998 one could see unseasonable crops, such as chickpeas, in the field in many parts of northern Ethiopia.

One of the characteristics of the 1997–98 crisis was the way information was flowing between the various DPP Committees in the center and in the regions. Despite various constraints, the Disaster Prevention and Preparedness Committees at all levels met every two weeks to exchange information and experience and to evaluate the effectiveness of various responses. Local functionaries were also working despite the disadvantage of having unreliable local weather information about their *weredas* or villages. Ethiopia has designed a five-year development plan to deal with future disasters.

As a final note, at the end of the El Niño in the middle of 1998, a war started between Ethiopia and Eritrea. The war began on 12 May, at a time when Ethiopians were coping with the adverse impacts of El Niño. The conflict was an added constraint on the El Niño-related responses by the government and the people. About 450,000 Ethiopians who live in the border areas occupied by Eritrea were displaced and became dependent on food aid. They lost their animals, seeds, and harvests. Other farmers in the border areas could not plant, because of the lack of security and occasional shelling. Thousands of Ethiopian farmers were mobilized to defend against the Eritrean threat, and the farms of those who joined the army were cultivated with the help of those who remained in the villages. In July 1998, Eritrea confiscated 45,000 tons of US grain in an Eritrean port en route to Ethiopia. It is believed that Eritrea confiscated more than US$300 million worth of goods when the conflict erupted. Ethiopia was forced to import food and other items through Djibouti in order to avoid the Eritrean ports because of the conflict.

There has been research interest on the climate-related impacts and responses in Ethiopia. Some of the major works have been done institutionally in the NMSA and the DPPC, on Ethiopian climate and disaster management, respectively: on the chronology of drought, on El Niño, on seasonal forecasting, on the impact of Pacific SSTs on Ethiopian weather, and on global climate change and Ethiopian weather. These are some of the reports that have come out of the NMSA. There is very little research interest outside the NMSA on El Niño impacts in Ethiopia. Most of the research in Ethiopia has been in the area of drought and its impact on society. One of the notable researchers in the field includes Rahmato (1991) on the coping mechanisms of peasants to drought and famine. International research on Ethiopian drought includes the social history of famine in Wollo, and on the Ethiopian early warning system.

Forecasting by analogy

Lack of timely and credible weather forecasting is one of the constraints on the Ethiopian seasonal forecast. Theoretically, if there had been credible and perfect information as early as October 1996, there would have been adequate time to disseminate the information, and the response could have taken the form of a non-emergency. In the case of 1997, for example, the NMSA was informed about the El Niño as early as March 1997, but it had to wait until the end of May to declare a forecast for fear that a weak El Niño might not have a pronounced impact. The NMSA did not want to panic the users by giving out unreliable information. However, a May forecast (as was done on 29 May 1997) coincided with the beginning of planting in Ethiopia and was of little use for those who planned to plant long-maturing crops, such as maize and sorghum, at the end of April and May. There was very little early warning time to prepare any countermeasures against the impact of the event.

Research shows that it took more than five weeks for the digested information and the various alternative recommended responses to reach the lowest *wereda* early warning committee. For example, in the case of the Tigray regional state, the NMSA gave its forecast on 29 May 1997 (*Ginbot* 19 in the Ethiopian calendar) and the Zone Disaster Prevention and Preparedness Committee members met with the regional DPPC at the beginning of July 1997 (*Sene* 28 in the Ethiopian calendar). It was after finishing this meeting in the capital, Mekelle, that they returned to their zones and gathered the *wereda* early warning committee members in the middle of July. It took this amount of time because those involved at the different levels of government had to receive the information, study and discuss it and come up with the relevant responses to their specific problems.

With perfect and earlier information, the emergency nature of the activity could have been changed into a routine development work. Perfect information could have helped in Ethiopia's preparedness for the disaster. Time is a very important factor in disaster response. There would have been enough time to mobilize domestic and international resources to reduce the impact of the El Niño. A perfect forecast with a longer lead-time could also have helped farmers and the government to have the time to budget their resources effectively both at a macro (national) and household level. For example, the Ethiopian government could have managed its import and export of cereals by taking the impacts of drought and flood into consideration. Rural households could have reduced their expenditures for festivities, such as weddings and *teskar*s (memorial feasts for the dead), and saved their food for the impending food shortages.

Lack of trained staff, especially at the regional, zone and *wereda* levels, is one of the major constraints even in the face of perfect information. For example, one of the recommendations might be to construct dams and canals to harvest and distribute all the rainwater, but this would have been a very difficult task to accomplish in the short period of nine months. The amount to be done, even during normal weather conditions, is so huge that it would be difficult to solve all the problems. Weather is only one factor: there are also many existing social problems in the country. In other words, responding to abnormal weather alone is not enough since there is widespread poverty in the country. There is also the perennial problem of the lack of meteorological information at the local level. Many of the diverse microclimates in Ethiopia outside the cities do not have meteorological stations. Thus, El Niño information is relevant at the national level but very difficult to forecast for the local microclimates.

El Niño's impact on Ethiopia is real. Therefore, El Niño considerations should be added explicitly to the country's national disaster plans. These would help the national policy makers and the average person realize the impact of an El Niño and prepare for the event. Such inclusion into the Ethiopian disaster preparation plans would also help in the understanding of the phenomenon by a wider audience in Ethiopia. It should be noted that very few people outside the NMSA and the DPPC understand the impacts of El Niño.

There are strengths and weaknesses in the Ethiopian government's response to El Niño-related climate impacts. The recurrence of drought in Ethiopia has led to the accumulation of experience in disaster response. The need to understand droughts in Ethiopia led the NMSA to discover the role of El Niño in 1986–87. Despite the lack of capacity, such as trained manpower, the NMSA has developed an effective methodology of forecasting by analogy, which is being used up until the present. The response side has also led to the creation of a strong institution such as the DPPC with a department of early warning that works very closely with the Ministry of Agriculture and the NMSA. The DPPC has accumulated experiences to provide early warning and effective response to disasters. The Ethiopian government has created an enabling political environment for disaster response. Finally, one of the strengths of the country's response to El Niño is the existence of goodwill and support by international donors for the activities of the government in response to disaster.

Until recently, Ethiopia's forecast and response to El Niño have been biased toward droughts, which left other disasters such as floods, fires, and fast-onset disasters as secondary. In the last three years floods and fires have become more frequent in many parts of Ethiopia. Another weakness is the low level of research activity on El Niño. No models adequately relate Ethiopian weather to El Niño for use in forecasting. There is a lack of trained personnel and scarcity of resources, particularly in the regions, for an effective response. Solutions to some of these problems could make Ethiopia's use of El Niño as a tool in the forecasting of climate-related disasters more effective than has been the case until now.

Conclusion

Ethiopia is a developing country faced with many socio-economic problems, such as limited access to education, water supply, and food. High population growth, environmental degradation, and climate variability compound the intensity of the problem. Lack of access to irrigation and the dependence of Ethiopian agriculture on rainfall have made food security in Ethiopia vulnerable to the variability of weather and climate.

The recurrence of drought and famine has led to the creation of an excellent early warning and response mechanism in Ethiopia. The DPPC is the central institution of the Ethiopian National Disaster Prevention and Preparedness Committee. The NMSA is a member of the NDPPC that provides weather forecasts to the users. The existence of such an institution has helped the country in the prevention of disaster in the 1990s.

The NMSA used the analogue method to identify characteristics of the 1997 El Niño. It reached the conclusion that the 1997–98 El Niño was analogous to that of 1972 in the amount and distribution of rainfall. The drought of 1973–74 had killed 200,000 people in the northern part of Ethiopia. The 1997–98 rainfall was variable during the *kiremt* season and anomalous excessive rainfall during the *bega* or harvest season. It destroyed the crops during the growing, flowering, and harvesting season. Total production was 25 percent lower than the previous year.

Donors were initially reluctant to meet the demand for food aid. One of the reasons was probably the existence of a record harvest in the previous year and the success of the Emergency Food Security reserves. The widespread news in 1996–97 that Ethiopia had begun exporting food must have hurt the demand for food aid when crops failed in 1997–98.

One of the major problems that hinders long-term effective weather forecasting in Ethiopia is the absence of meteorological information in various parts of the country that have been accumulated over a long period of time. At present, there are only 600 meteorological stations in Ethiopia. Most of those stations are located in the urban areas. If the researchers were expected to forecast accurate El Niño-based forecasts for the diverse climate zones of Ethiopia, they would require meteorological information such as rainfall, temperature, pressure, etc. for those localities. One of the forecast and response constraints in Ethiopia was a lack of trained personnel to interpret the information, especially in the regional states. In addition, those who work in the regions do not have access to resources such as transportation, communication, and office equipment.

At the national level, Ethiopia has to increase the number of its researchers in meteorology in general and in climate forecasting in particular. At present there is no single Department of Meteorology in any of Ethiopia's five universities. Mechanisms have also to be made so those social and physical scientists outside the DPPC and the NMSA could develop an interest in conducting research on the relationship between El Niño and climate-related impacts in Ethiopia. In general, there is a need for the training of meteorologists, especially for the regions. There is a need for the supply of basic office materials, computers, and access to the Internet.

The El Niño of 1997–98 exposed the fragility of food security in developing countries, even with a government that is focused on agricultural development. Ethiopia had excellent food production in 1995–96 and 1996–97, but the optimism was dashed with the onset of the first drought. In spite of the existence of a supportive political environment for those involved in disaster prevention in Ethiopia, the struggle was very difficult. At the end of 1997, the Emergency Food Security Reserve was depleted and there was nervousness in the country that famine might revisit the country. Only the mass intervention of the donors averted a "killer" famine. One of the lessons we learn from this experience is that even though food security reserves are an excellent way of responding to disasters, if they rely on donor generosity for refills, they cannot be dependable. Donors can ignore pleas for food to replenish stocks, as happened in the case of Ethiopia in 1999 and 2000.

Long-lasting preparedness for climate-related impacts is necessary to improve the capacity of the country, especially in water conservation before the onset of drought. Ethiopia is very rich in water resources, but a farmer's access to irrigation is very limited. We should also learn that one of the reasons for the containment of the 1997–98 disaster was the positive economic condition in the country, open-mindedness on the part of the government, and donor support. In the final analysis, however, we should note that complete national preparedness to disaster can come only through socio-economic development in all sectors of the country.

Lessons learned

- The existence of institutions in Ethiopia such as the disaster prevention and preparedness committees at all levels of government is important for the vertical flow of El Niño-related forecasts and impact information. However, the time it takes for the analyses of forecasts of El Niño to go from the highest levels of government to the lowest community ones must be shortened to allow for more lead time to prepare for the proposed impacts.
- Involvement of the Prime Minister's office gave an important impetus to the level of credibility and importance of the El Niño forecasts.
- Even countries such as Ethiopia, with little advance in scientific research, can select appropriate forecast methods, such as the use of historical analogues, and can issue usable forecasts on El Niño impacts.

- The Ethiopian media did not take a keen interest in disseminating information about the 1997–98 El Niño's development until the impacts were being felt. It usually followed the responses of the government instead of becoming a leader and educator of the public on awareness of El Niño's potential impacts. The media must be encouraged to sustain their interest in the phenomenon, so that the population can better understand what it means to its food security and livelihood.
- There is a strong and compelling argument to enhance Ethiopia's meteorological system and research activities at the national level. Such information has practical development application and is not just "curiosity-driven" research. Research interest in El Niño and other climate-related impacts should also be encouraged outside the NMSA (National Meteorological Services Agency).
- Successful responses to climate-related impacts require coordination between the national government and donors, as happened in Ethiopia in 1997–98.
- There is a need for the issuance of forecasts before the onset of the planting season. The late issuance of forecasts to improve the probability of success merges the risks associated with the timing of forecast and the response capability to proposed impacts.
- Governments need timely and credible El Niño forecasts that also include a forecast about its intensity, timing, and spatial distribution of potential impacts.
- El Niño information, including forecasts, is useful for long-range development planning and not just for disaster early warning. Some of the recommended responses to reduce the adverse impacts of El Niño, such as the use of various types of dams, construction of canals, and the selling off of herds, are actions that should continue even after the El Niño event itself has ended.
- There is a tendency to refer to whole countries when referencing El Niño's impacts. But it is seldom that an entire country would be adversely affected in the same way by an El Niño event given the variability in topographic features, e.g., Ethiopia is known for its local, small-scale (micro) climate regimes. Ethiopia can suffer from droughts and floods during the same El Niño event. It is important for governments to identify in advance the regions and sectors that are vulnerable to the regional impacts of ENSO's extremes.
- There should be an improved capacity of the regions in Ethiopia, in terms of skill improvement, access to information and resource capacity, to issue their own regional forecasts. This would make the forecasts more relevant to the local areas and would reduce the time spent in communication with the central government.
- Education and training programs at the local and regional levels re-

lated to El Niño would improve Ethiopia's overall ability to mitigate El Niño's adverse impacts.

- Countries such as Ethiopia that are frequented by climate-related hazards must not rush to export their cereals or deplete their food reserves before having assessed the status of the main harvest season, as happened in 1997–98 in Ethiopia.
- The national-to-local communication systems must be developed and maintained between El Niño events so that they will be available and functioning during El Niño's impacts.

Notes

1. The only exception to this was *Addis Tribune*, which briefly warned of the evolution of El Niño in its 6 March 1997 issue.
2. UN Food and Agriculture Organization, 19 December 1997.
3. Reuters, 9 December 1997.
4. The birr is the currency of Ethiopia.
5. *Addis Tribune*, 13 March 1998: "Prime Minister Meles Presents Six-Month Report to Parliament."

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Fiji country case study: Impacts and responses to the 1997–98 El Niño event

Team leader:
Atu Kaloumaira
South Pacific Applied Geoscience Commission (SOPAC)
Private Mail Bag
General Post Office
Suva, Fiji

Team members:
Sakenasa Varea (SOPAC)
Nazmin Bi (Fiji Meteorological Service)
Jope Davetanivalu (Ministry for Health)
Viliame Uluinayau (Pacific Water District)
Rishi Raj (Pacific Water District)
S. Koroinivalu (Ministry for Education)
J. Terry (USP)
A. Tuifagalele (National Disaster Management Office)
Mataiasi Dinavuso (MAFF)
Kaliopate Tavola (Fiji Sugar Marketing Company)

Executive summary

The Republic of Fiji, located in the southwest Pacific Ocean, consists of more than 300 islands (97 of which are inhabited) with a land area of around 18,000 km^2. The two major islands (Viti Levu and Vanua Levu), contain over 93 percent of the approximately 800,000 population, with the remainder widely dispersed to outer islands. Fiji is subject to many types of hazard with arguably the most frequent and severe being tropical cyclones.

The tropical climate of Fiji has distinct wet and dry seasons, and rainfall is strongly affected by predominant southeasterly trade winds, which generally keep the southeastern portions of the main islands cool and wet, while the western regions are normally much drier.

Since independence, the economy of Fiji has traditionally been based

on the export of sugar, with additional income from tourism, other forms of agriculture, and mining. Diversification of the economy now means that tourism and light industry (including garment manufacture) are making up significant portions of the gross domestic product (GDP). Despite this, however, the sugar industry and subsistence agriculture support the majority of the Fijian population. The sugar industry is concentrated in the driest western portions of the islands.

Research on ENSO's impacts in Fiji

The primary agency for meteorological monitoring, forecasting, and research in Fiji is the Fiji Meteorological Service (FMS). This organization has strong professional linkages with equivalent groups in New Zealand (NZ), Australia, and the Pacific ENSO Application Center in Hawaii. Despite having a strong competency in forecasting and monitoring, the FMS does not have the capacity for sophisticated research into the ENSO phenomenon or its extremes in the country. Some statistical comparative studies are made with cyclone occurrences in relation to ENSO events, but no other detailed studies have been carried out.

Due to the disastrous impacts of the 1997–98 El Niño event in Fiji, the government requested the UN Disaster Assessment and Coordination (UNDAC) Team to assess the effects of the drought and advise on mitigation measures. Following from this UNDP and NZ Overseas Development Assistance sponsored a study on the socio-economic impacts of the 1997–98 El Niño in Fiji and Tonga. In addition to these two studies, a national and a regional workshop were held in Fiji to disseminate study findings and to bring together the various diverse agencies involved in managing El Niño's impacts, particularly droughts.

National planning for disaster response

A National Disaster Management structure within Fiji has been established over the last seven years with the assistance of the South Pacific Disaster Reduction Program (a UNDP initiative in response to the International Decade for Natural Disaster Reduction). This structure involves both government and NGO groups, with aims of coordinating and improving all aspects of risk management in the country.

Forecasting capacity

The Fiji Meteorological Service has the equipment, skills, and contacts to enable forecasting of El Niño conditions up to 12 months before their onset. Forecasting is made using (1) general monthly rainfall pattern analysis, (2) analysis of past ENSO warm and cold events, (3) rain forecast models (both locally and foreign-developed), and (4) regional prediction models from foreign agencies.

ENSO effects in the Fiji region

Fiji is a country normally affected by frequent tropical cyclones. El Niño events tend to push normal areas of cyclone generation eastward. Hence, during El Niño years, many cyclones tracked to the east of Fiji. The most serious effect of strong El Niño events in the Fiji region is that of reduction in rainfall and eventual drought. However, since Fiji lies within the transition zone of the Southern Oscillation, the effects of El Niño events are not always distinct or predictable. Often there is a significant (4–6 month) delay between El Niño indicators and the onset of damaging drought in Fiji (e.g., in 1982 and 1997), although impacts of El Niño events that begin in the dry season may show up earlier in reduced rainfall (e.g. 1987). Once begun in the western parts of the main islands, El Niño droughts spread first along the northern coasts and eventually to the islands in the southeast of the Fiji group over a period of 6–12 months. Recent El Niño-related drought conditions have lasted for between 12 and 18 months. The El Niño events of 1986–87 and 1997–98 have been associated with the worst droughts recorded in the country.

The 1997–98 El Niño event

Physical impacts

Two months after the Southern Oscillation Index (SOI) dropped below zero, rainfall in Fiji began to decrease from normal levels (May 1997); the decrease in rainfall lasted for 18 months. Islands in the western part of Fiji were first affected by drought conditions in September 1997. The drought then proceeded eastwards. Total rainfalls in northern, central, and western areas of Fiji were 22–42 percent of normal values between February and October 1998. Many sites recorded monthly rainfall of less than 10 percent of normal values during the middle of 1998. Interior areas of the main Fijian island began to show drought impacts toward the end of 1998, before the drought ended in October.

Socio-economic impacts

A string of six preceding natural disasters since 1992 in Fiji had, through a cumulative effect, stretched the natural coping mechanisms of the Fijian informal sector (extended family and village support systems), and checked the growth of the overall economy. The 1997–98 drought is now known to be the most damaging ever in Fiji, and one of the worst disasters ever to have hit the nation.

Primary industries

Sugar industry

Sugarcane areas, concentrated in the western and northern parts of the main islands of Fiji, roughly correspond to the most drought-prone areas of the nation. The labor-intensive industry is well organized and regulated through a series of districts and sectors, managed by the Fiji Sugar Corporation (FSC). Within the sectors are 17,500 growers on various scales, mostly family-based small units, many of which have other families that depend on the grower for employment and income. The entire industry supports about 25 percent of Fiji's population, around 200,000 people.

The 1997–98 drought caused a 5 percent drop in the planted area of sugar cane, but more importantly, of the crop that was left, 25 percent was wiped out. National production loss was around 50 percent (c. F$104 million), far greater than had ever occurred in any of the previous six natural disasters (droughts and cyclones). The worst production losses were in the marginal lands, closest to the sea and on steep slopes.

Impacts on 1998 grower income were buffered by pricing protection at three times the market price on sugar exports (under the Lomé Convention). However, 77 percent of the farmers still received less income, or even none (33 percent), during the drought. Average farm-dependent family incomes dropped from F$3,500 to F$1,500 and below. Food gardens, normally supplementary to the lives of these families, were also destroyed in the drought.

Responses in sugarcane areas included supplementary rations, supplied through the government, Red Cross, and community organizations. These were targeted either to worst-affected areas or to specific worst-affected farms. NGOs targeted special-needs groups that had been overlooked, including children and lactating mothers. Additional responses included a major government-funded crop rehabilitation program, through which most resources went into replanting sugarcane stocks. Little benefit from this program reached smallholders and farm laborers.

The needs identified in the sugarcane areas included the following:

- Review relief food criteria and policy;
- Discontinue sugarcane planting on marginal land and, instead, encourage the planting of other tree crops;
- Introduce irrigation to intensify production in some suitable areas;
- Provide grants for drainage maintenance;
- Supply vegetable seeds and rations on a food-for-labor basis;
- Provide access to credit and micro-financing.

Long-term impacts on the sugar industry were avoided because the government provided a large capital boost with the crop rehabilitation program. This enabled a rapid return to production and improved plant stock and fertilization that was already well overdue in many areas.

Other agriculture and forestry

Rural subsistence, although estimated at only 3.8 percent of GDP, plays a role in the support of 80 percent of Fiji's population. To increase the economic robustness of communities, in 1995 the government instigated a program to commercially develop selected (but existing) high-value crops. Despite these programs, impacts on subsistence food supply were severe.

Agricultural drought development followed that of the hydrometeorological drought, from northwest to southeast through the main islands and Fiji Group. At all times production was relatively unaffected in the central and southern windward coastal belt of Viti Levu. Only minor areas of irrigated agriculture exist in the drought-affected zones.

Food security issues that emerged as a result of the drought were monitored from March 1998, although the absence of drought-rating classifications and indices monitoring systems made it difficult to substantiate the large losses thought to exist. In the sugarcane belt, food crops were completely devastated. Export vegetables and root crops were reduced to 50 percent, and in the peak production months of June and July no plantings were possible and planting materials were often wiped out. The secondary hazard of wildfires, particularly in the north of Fiji, damaged up to 40 percent of cultivated crops and up to 10 percent of the native forest – removing an additional source of supplementary food.

Livestock fatalities in the nation's 28,000 cattle and 190,000 small ruminants had begun by the end of the drought. Around 55 percent of these animals are kept on smallholdings in the drought-affected areas. Pastures were destroyed and supplementary feed for livestock was unavailable. During the drought, the instances and extent of forest fires were greater than normal and forest crops in several areas with thin topsoil were severely damaged. In addition, the fisheries sector noted an increase in lower-value species in catch composition during the El Niño event, although this recovered following its end.

Responses in this sector included a rehabilitation program begun in May 1998, targeting food security. This involved establishing "stock" farms of planting material in strategic areas both within and outside of drought-prone locations. The UNFAO provided seed material and project funds following its own assessment and the Foundation of the Peoples of the South Pacific (FSP Fiji) targeted boarding-school plantations with its assistance.

The needs identified in this sector included the following:

- Meet food and planting material shortages through low-technology means;

- Address the long-term food supply issues of malnutrition and anemia;
- Redevelop education and awareness programs targeted at food security;
- Establish a drought-rating classification and identify reliable indicators;
- Establish databases and disaster management plans for this sector.

Medium- to long-term impacts have been slight, and long-term impacts were mostly confined to the tree-crop sector (pine, cocoa, and coconuts). Despite these impacts, some aspects of the drought proved to be of positive benefit to the production in the forest industry, enabling improved access to logging areas. Other medium-term impacts included improved grazing pastures in many areas that were in need of re-establishment.

Water supply and hygiene

Metered water in Fiji is derived entirely from surface sources and supplied to urban areas, covering up to 70 percent of the population. Rural supplies are derived from surface sources, in addition to local wells and roof-rainfall-catchment systems. There tends to be very little storage capacity in rural systems, because rainfall is generally high and well distributed throughout the year.

Water-supply shortages affected both urban and rural systems in drought areas, and schools were particularly badly affected. This resulted from both inadequacies in rural storage systems and the poor maintenance and networking of metered systems. Groundwater was more extensively utilized in some areas where operational boreholes were located.

Over 33 percent of all drinking water samples collected during the drought by UNDAC were biologically unsafe for consumption, and there was little follow-up with remedial action based on these results. Hygiene standards dropped further where flush-toilet systems could not be operated and greater use was made of pit-latrines and communal facilities because of the new El Niño-related drought situation. In addition, due to a greater consumption of packaged food, a sharp increase in litter was noted.

One response to water shortages was government-funded water deliveries (by truck or boat) to all affected areas, beginning in some areas in October 1997. This cost up to F$190,000 per month. The Ministry of Health initiated the construction of pit latrines in schools, along with other measures promoted during an awareness and education campaign.

Needs identified in the water sector included the following:

- A nationwide education and awareness program targeted at improving and maintaining roof-fed water supply and storage systems;
- Provision of assistance to sustainably develop further groundwater resources;

- Rapid implementation of urban water-supply master plans;
- Development and enforcement of guidelines for biological water monitoring and remediation;
- Development of alternative sources of water for some areas, e.g. solar-distillation plants.

There were no significant long-term impacts to this sector from the drought, although it was considered that the government supply of water to the needy during drought exacerbates dependency in the community, and encourages indifference to the improvement and maintenance of local water supply systems.

Health and nutrition

The Ministry of Health identified the onset of a potentially dangerous situation toward the end of the drought, indicating sporadic increases in health and social problems. Remote and poorer rural areas experienced the greatest adverse health impacts. Malnutrition increased in the poorer rural areas, due to the failure of domestic gardens; the drought exacerbated existing chronic malnutrition and micronutrient deficiencies. These included a high rate of anemia observed in lactating mothers. Sanitary standards decreased because of the lack of water, forcing the relocation of some households and increasing social discomfort in most others (i.e., a misery factor).

The sugarcane belt encompassed the worst affected areas, with babies, lactating mothers, and the elderly being most affected by infantile diarrhea, malnutrition, and dietary deficiency. Major contributing factors were the poor quality of delivered drinking water, loss of domestic gardens, and insufficient income to purchase alternative food.

Drought response included government emergency food and water provisions to affected families, supplemented by donor NGO and international agency contributions of food, planting materials, and cash. Around 250,000 people were provided with various rations, although in many cases, the rations were nutritionally deficient (particularly in iron), having been designed for the short period of relief required following cyclones. There were no health strategies on a national scale. Health interventions are normally made on a case-by-case basis through doctor consultations. Hence, many cases probably went undiagnosed and therefore untreated.

Short-term needs identified in the health and nutrition sector included the following:

- A national awareness program to target micronutrient deficiencies, particularly for women of childbearing age;
- Multisectoral support to the Fiji Plan of Action for Nutrition, targeted to improve food security;

- Strengthening of aspects of food security and feeding practices in agriculture and health extension programs, respectively;
- Consideration and development of standards for nutritional requirements with respect to future drought rations.

There were no apparent long-term impacts on infectious disease or low birth weight, although it is considered that these would have shown up if the drought had lasted much longer.

Education

Most schools suffered water supply problems, which resulted in unsanitary conditions where flush-toilet systems failed. In addition, many boarding schools suffered from loss of food gardens, and some were closed due to poor preparation for the likely drought impacts. School absenteeism increased because parents could not provide bus fares or food for lunch. Response in this sector was spearheaded by a number of NGOs, supplying food, bus fares and other forms of assistance.

The main needs identified in the education sector were as follows:

- Develop adequate water supply and storage systems;
- Develop strategies to maintain school gardens under drought conditions.

Long-term impacts were difficult to quantify, including whether absenteeism would affect future performance and whether antisocial habits were developed during periods of absenteeism.

National economy

The 1997–98 drought was classified as the most catastrophic natural disaster to hit Fiji in the twentieth century. Negative impacts on the sugar sector were not made up for by growth in other sectors during this time. The economy was driven into recession, reducing GDP in 1997 by 3 percent, and in 1998 by a further 5 percent (against a background of 3 percent average annual growth over the previous five years). The rapid recovery of the sugar industry helped to minimize the drought's long-term impacts, which should be insignificant in 3–4 years.

Prices remained stable throughout the drought. The lack of disposable income and the availability of government food rations in affected sectors subdued demand. Interest rates were also not affected, with a major devaluation masking any drought impacts. There were short-term impacts on wages and employment, but this quickly returned to normal following a bumper crop in 1999.

Income was worst affected in around 17,000 households, directly reliant on sugar, with a further 93,000 households that were able to supplement income from other sources. Subsistence agriculture was also affected, mostly impacting the poorest sectors of the community.

Response to the 1997–98 El Niño

Statements

Before the actual impacts of the 1997–98 El Niño, the FMS suggested a possible emerging El Niño condition in its April 1997 monthly weather summary, acting on advice from the Bureau of Meteorology of Australia. By June 1997, the FMS indicated the possibility of a significant drought. No further response from key agencies was made to these warnings because of a general state of unpreparedness and a lack of understanding of meteorological terminology.

During and after impact, several drought-specific reports were released by the FMS to key government agencies. The government declared a state of emergency and dispatched senior administrators to assess and coordinate response needs. Assistance in assessment was requested from UNDP when damages exceeded the capacity of the nation to cope.

Major activities

- Coordination of relevant scientific organizations in Fiji to provide more information to the public and the government;
- Declaration of a state of emergency;
- Provision of emergency food and water rations by the government, with additional assistance from donors, international organizations and NGOs. Food was supplied to about 250,000 people at a cost of F$3.3 million/month, and water supplied to >50 percent of the population, costing a further F$0.5 million;
- NGOs and community-based organizations were active in food and cash assistance to school children as well as setting up public appeals;
- The Public Works Department established additional groundwater supplies.

Conclusions

- Disaster impacts of the 1997–98 El Niño-related drought were on the verge of snowballing before its end, but the sugarcane Crop Rehabilitation Program was highly effective in aiding a rapid economic recovery.
- The drought highlighted the need for active cooperation among disaster managers, water users, and meteorologists to develop effective and timely forecasting and early warning systems. At least a 6–12 month lead time is required by communities to prepare. Good linkages with media organizations are required to achieve this.

- Key agencies need to develop drought-response strategies in the form of timely alleviation plans.
- Information supply needs to be increased with the establishment of drought indices and key monitoring strategies to assess El Niño-related drought impacts on all sectors. Health information was particularly difficult to interpret in the context of the 1997–98 El Niño.
- Awareness and education programs are required to assist communities in drought preparedness and response.
- For water management there needs to be (1) an improvement in household self-reliance, (2) better management of reticulated systems, (3) identification and sustainable exploitation of groundwater resources, (4) more active management of catchment systems, including changes induced by production (commercial) forestry, and (5) assessment of the vulnerability of water sources.
- To protect income and production there needs to be (1) an improved understanding of drought-tolerant crops and how to manage them, and (2) procedures for either moving affected stock from affected areas or providing supplementary feed.

Policy implications

Understanding ENSO's extremes

There is a general lack of understanding of the effects and indicators of ENSO and other climate anomalies on community vulnerability. The appropriateness of rainfall data to indicate drought was particularly unsuited to Fiji. A more appropriate method would be to define classes of drought, such as the following:

- Meteorological drought – based on rainfall parameters, but not useful in itself to water users;
- Hydrological drought – based on river levels; in the Fiji ENSO-hydrology study this provides a better indicator of available water resources;
- Agricultural drought – based on crop yield and production, provides a direct indicator of meteorological drought on agricultural production;
- Socio-environmental impacts of drought – includes parameters such as an increase in social crimes, deterioration in health and living standards, etc.

For these measures to be useful, there needs to be more background research into their utility during past El Niño-related droughts.

Individual sector level implications

Commonalities in policy needs for all sectors include the following:

- Public education and awareness programs;

- Organizational plans for drought situations;
- Review of legislation;
- Strengthening of information management systems.

Water resources and the environment

- A concerted effort is needed to develop a national water-resource plan including sources and sinks to link with drought management plans and irrigation schemes;
- Remote sensing tools need to be applied to produce vulnerability maps and to monitor use and conservation of water resources;
- Rainfall data need to be converted into other indicators of drought that are more meaningful to key agencies and the public, i.e., more "user friendly;"
- The policy of supplying emergency water on demand needs to be reviewed to avoid developing a "culture of dependence."

Food and nutrition

- Background levels of malnutrition and micronutrient deficiencies exist in many parts of the country. These issues need to be addressed if drought impacts on human health are to be alleviated;
- Policies to alleviate these issues need to be based at the community level and need to coordinate partnerships among agencies such as agriculture, community health and nutrition, district-level development, and other community-based organizations;
- Government-supplied rations should be changed to more effectively alleviate malnutrition and micronutrient deficiencies, particularly when long-term supplements are planned;
- Given that forecasts are available, promotion of traditional food-preservation practices should be carried out, and possibly supplemented by income-generation promotion from these activities;
- A long-term measure would be to investigate the micronutrient supplementing of food resources, as is already being carried out with iron in flour.

Agriculture

- Strategic and tactical planning for drought can alleviate some of a drought's impacts on agriculture, using existing policies;
- Since the largest impact of the El Niño-related drought was on the sugar industry, and this in turn caused the greatest human suffering, acceleration of the crop diversification program for Fiji is required;

- Land-zoning policies should also be developed and enforced to encourage suitable uses of land considered marginal for sugar production;
- Infrastructure and policies need to be developed to support small livestock holdings with supplementary feed supplies, perhaps involving molasses from local sugar mills.

Meteorology, planning, and other services

- To improve the value of forecasting more dialogue is needed with El Niño forecasters and end users in order to review terminology in use;
- The Fiji Meteorological Service should be proactive in improving the understanding and predictability of ENSO events and their impacts;
- Drought vulnerability and risk maps should be prepared as planning tools;
- Nationwide education of the ENSO cycle and its effects needs to be strengthened;
- Policies on school placement, transport, water and food supplies in times of El Niño-related water shortages need to be reviewed;
- Minimum housing standards require review, focusing on self-sufficiency and integrity of water supplies;
- Provision of micro-finance in rural areas needs to be investigated.

National policy considerations

- Drought monitoring indicators need to be established and researched, particularly in areas of health, education, and social issues. These indicators need to better quantify drought's long-term impacts;
- Economic mitigation and prevention strategies for droughts should be put in place rapidly, considering the major negative impacts that the 1997–98 events had on the country's economy;
- Working definitions of drought need to be established, to define medium and long-term impacts and the cost and benefits of mitigation strategies.

Lessons learned

The following are some additional key lessons learned from how Fiji responded to the 1997–98 El Niño-related drought.

Applied research

The 1997–98 drought was a wake-up call to disaster managers and water users in the country to work more closely with meteorologists and to develop drought forecasting just as it has been done for cyclones. Our study revealed that Fiji was in some sense fortunate in that the drought broke early as disaster impacts were just on the verge of rapidly worsening. As it happened, the measures taken by the whole nation were sufficient to help contain the economic and social distress caused by the drought. The Sugarcane Crop Rehabilitation Program was most effective in returning economic recovery of the nation.

Damages can be minimized if drought victims and disaster managers have reliable and accurate drought-forecast information to guide preparedness and relief responses. The Fiji Meteorological Service provided a drought forecast in May 1997. However, the information users hardly responded, most probably because of the difficulties to utilize information that was provided in meteorological terms. Nevertheless, the present level of forecasting skill in Fiji is quite high.

Information management

The paucity of socio-economic data has been a major problem in assessing the impacts of past El Niño disasters. Such data are needed to assist researchers in making cost-benefit (economic) analyses of long-term prevention, mitigation, or adaptation measures. A good example of this situation is with health statistics, which showed increases in skin and nutrition-related diseases during the drought. However, it was hard to segregate this information according to contributions of individual hazards that had hit Fiji during the last six years of the 1990s.

The UNDP study (running concurrently with this study) tried to develop a methodology for assessing drought impacts.

In summary, some of the *key* lessons to be learned from the 1997–98 El Niño-related drought are the following:

(a) Planning

- Effective drought-response strategy;
- Better dissemination of forecasts;
- Education of communities about appropriate responses to drought;
- Appropriate and timely drought-impact alleviation plans.

(b) Water and environment

- Improved household self-reliance for drinking water;
- Better management of the reticulated water system;
- Identification and mapping of groundwater resources;
- Clearer understanding of the impacts of pine plantations on stream flow;
- More active management of various watersheds.

(c) Income and production

- Improved understanding of drought-tolerant crops;
- Better understanding of where and when to plant;
- Procedures for moving livestock out of the expected drought-affected areas.

(d) Forecasting and early warning systems

- Simple housekeeping chores are still the best response actions and basic first-mitigation responses;
- Strengthen the working relations among meteorologists, water managers, and disaster managers;
- Undertake assessments of the vulnerability to drought of water sources such as wells, streams, and roof catchments;
- Users require at least 6–12 months lead time to purchase materials;
- Establish good linkages and understanding with the media.

The most effective mitigation strategy is to prepare, issue, and publicize timely El Niño- and drought-related forecasts. If properly warned, most people will take action to minimize the impacts of a potential disaster as best they can with available resources.

Indonesia country case study: Impacts and responses to the 1997–98 El Niño event

Team leader:
Dr. Kamal Kishore
Information Manager
Asian Disaster Preparedness Center (ADPC)
Asian Institute of Technology
PO Box 4, Klongluang
Pathumthani 12120, Thailand

Team members:
Dr. Adang Setiana (BAKORNAS PB) (National Disaster Management Coordinating Board)
A. R. Subbiah, Technical Advisor, ADPC
Tien Sribimawati, BPPT (Agency for Assessment and Application of Technology)
Ir. Sri Diharto, BMG (Badan Meteorologi Dan Geofisika)
Sutarto Alimoeso, Department of Agriculture
Peter Rogers, Technical Advisor, ADPC

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Executive summary

The 1997–98 El Niño had significant social and economic implications for Indonesia. A large part of the country suffered from severe drought, resulting in a huge shortfall in rice production that necessitated the import of over 5 million metric tons of rice to ensure food availability to the economically weaker sections of the society. In the forestry sector, the effects of large-scale forest fires during 1997–98 were unprecedented, damaging more than 9.7 million ha of forest area (ADB and BAPPENAS

1999). The smoke and transboundary haze from these fires affected not only Indonesia but also other Southeast Asian countries, in particular Brunei Darussalam, Malaysia, and Singapore. In addition to impacts on the agriculture and forestry sectors, the 1997–98 drought and fires also significantly affected other sectors such as transportation, tourism, and public health.

Given that the linkage between El Niño events and drought in Indonesia has been well established scientifically, it is important to analyze why this scientific understanding did not translate into effective countermeasures essential to mitigate the worst effects of El Niño 1997–98. This report presents an analysis of the impacts of the 1997–98 El Niño event on Indonesia and identifies lessons learned that will be helpful in dealing with future extreme climate events.

Setting

Indonesia is the largest archipelago in the world, inhabited by nearly 210 million people. Over the past three decades, the country's economy has moved from being an agriculture-based to an industrialized economy. Agriculture's share of the country's GDP gradually decreased from 47 percent in 1969 to 33 percent in 1978, 21 percent in 1988, and was around 16 percent in 1998. However, with half of the country's workforce directly dependent upon agriculture for their livelihoods, it remains an important sector of the economy. Forests and estate crops and related activities also constitute an important sector, both in terms of the percentage share of the GDP as well as in providing employment. By 1996, some 445 logging concessions were operating on 54 million ha of forestland, of which close to 1 million ha were reported to be logged annually. In 1994, wood and wood products produced about US$5.5 billion in export revenue for Indonesia, representing about 15 percent of total foreign earnings and employing 700,000 people (Sunderlin and Resosudarmo 1996). Both the agriculture and forestry sectors seem to be highly susceptible to the adverse impacts of climate variability.

Indonesian climate and its sensitivity to ENSO

The climate of Indonesia is generally characterized by two seasons: dry (April to September) and wet (October to March). Based on the number of dry and wet months, the country is divided into 14 agroclimatic zones, of which 11 are considered as sensitive to extreme climate variability since rain fluctuations can upset established cropping patterns.

From 1877 to 1997, 93 percent of the drought years have been linked to

El Niño events. Several studies show a clear positive correlation between normalized Indonesian rainfall anomalies and the Southern Oscillation Index (SOI). While in El Niño years the onset of the monsoon is later than normal, during La Niña years the onset is earlier in most areas. Therefore, an El Niño event causes delayed planting and consequently a delayed and reduced harvest. A La Niña year offers the possibility of advancing the planting season with an early increased harvest, as well as the possibility of planting an additional crop.

Although ENSO influences the climate of the entire Indonesian archipelago, it is important to note that there are discernible regional and seasonal differences. Being in the monsoonal areas, the south and southeast regions of Indonesia (comprising South Sumatra, South Kalimantan, Java, Bali, and Nusa Tenggara) are relatively more sensitive to ENSO's extremes. In these regions, the dry season and transition to wet season are highly influenced by the ENSO cycle. It will be important to take these regional and seasonal sensitivities into account when developing focused plans to deal with ENSO-associated consequences.

The 1997–98 El Niño event

Rainfall anomalies

The extent of the drought in Indonesia in 1997–98 is shown by the 1997–98 annual (March–February) rainfall percentiles calculated from 33 stations.[1] Most parts of the country suffered from reduced rainfall, with 13 of the 33 stations having the lowest rainfall on record (on the 0 percentile). The only areas approaching the 50th percentile (near normal) were North Sumatra and Biak. El Niño delayed the onset of rainfall and resulted in frequent dry spells during the 1997 wet season. Both these factors caused delayed planting of wet season paddy, as enough accumulated rainfall was available only in December 1997. In Semarang, Central Java, which is one of the representative stations in the Java rice growing belt, the onset of wet season rains did not occur until 15 November (nearly a month later than normal), and the season was marked by several dry spells.

The March–May 1997 rainfall was close to or even above normal across much of the country, but dry conditions prevailing across southern and eastern parts suggested an early retreat of the monsoon. By June–August 1997, the areas with substantial rainfall deficits had spread to western regions except for North Sumatra. The drought reached its peak in September–November 1997, with all parts of the country except Sumatra having extremely low rainfall, and deficits of 400–500 mm being common. By the December 1997–February 1998 quarter, rainfall was generally close to normal except for pockets in East Kalimantan and Sulawesi, precisely the areas where large-scale forest fires occurred in early 1998.

Impacts on agriculture and food security

Rice production in Indonesia is heavily influenced by the monsoon rain patterns, which have an important bearing on agricultural performance during the main (wet) and secondary (dry) seasons. The wet season normally extends from October to March and produces 60 percent of the country's annual rice crop and half of its maize, soybean, and groundnuts. The dry season covers April to September, during which the remaining annual crops are produced.

The rainfall anomalies during the 1997–98 wet season caused a decrease in area under rice cultivation by 380,000 ha (3.4 percent below the previous wet season). Farmers planted maize as a compensatory crop in areas where paddy could not be planted. The switching over to maize was to the extent of 266,000 ha more than the area normally cropped with maize (an 8 percent increase from the previous wet season). The reduced rice production, coinciding with the economic crisis which began in 1997, led to a 300 percent increase in the price of rice. The government of Indonesia imported over 5 million metric tons of rice in order to maintain price levels and to ensure the availability of food to the economically weaker sections of the population.

In addition to the reduction in the main-season rice crop, secondary-season production was affected by the following factors:

- The delayed harvesting of the main wet-season crop during 1997–98, due to the delayed onset of rains, caused a subsequent delay in the planting of the 1998 dry-season crop by one to two months, with significant production loss;
- Grasshopper infestation, which normally affects tree crops, seriously damaged 1998 dry-season field crops, particularly in Lampung province, probably because of the destruction of natural grasshopper habitats by serious forest fires in Kalimantan and Sumatra. The problems of pest attack were exacerbated by ineffective control measures, as most farmers could not afford the substantially higher cost of imported chemical pesticides, the price of which was estimated to have increased five-fold over that of 1997;
- In addition to ineffective pest control during the dry season, it is estimated that fertilizer application rates were considerably lower and unbalanced, which not only reduced the physiological ability of plants to resist pest attacks but also affected grain formation. Research studies indicate that the potential yield loss due to this factor could be as high as 30 percent.

Impacts on the forestry sector

Probably the most disastrous event during the 1997–98 El Niño, one that caught international attention, was the widespread occurrence of forest fires with associated smoke and transboundary haze. The fires were among the most severe in the previous two decades and had a significant socio-economic impact. A study commissioned by the Asian Development Bank (ADB) and BAPPENAS (1999) estimated the economic cost of the 1997–98 fires and drought to be in excess of US$9 billion. The 1997–98 fires and the resulting smoke and transboundary haze became a matter of international concern. Besides Indonesia, a number of Southeast Asian countries, in particular Brunei Darussalam, Malaysia, and Singapore, were badly affected. The Philippines and Thailand also suffered, though to a lesser degree. The severity and extent of the smoke haze pollution was unprecedented, affecting the health of millions of people across the region. International support had to be mobilized to suppress the fires. The experience underscored the enormity of the problem, leading the Association of Southeast Asian Nations (ASEAN) Environment Ministers to adopt a Regional Haze Action Plan (RHAP) setting out cooperative measures to combat the perils brought by forest and land fires. The scope of the pollution resulting from the fires, especially those from peat soils and cleared conversion forest, shows that the impact was an environmental problem of global dimensions. In 1997–98, the forest and land fires in Indonesia contributed 22 percent of the world's carbon dioxide production. Over 700 million metric tons of carbon dioxide were released into the atmosphere, elevating Indonesia to being one of the largest carbon polluters in the world in that year.

Responses to the 1997–98 El Niño event

Forecasts indicating the possible onset of an El Niño event were available to the Indonesian Bureau of Meteorology and Geophysics (BMG) as early as late 1996. BMG incorporated this information into a dry-season seasonal climate forecast for the entire country, which was issued to all relevant user departments at national and provincial levels in March 1997. The forecast information was communicated through the existing information network which is utilized for routine administrative functions. No urgency was attached to the timely flow of information from national to provincial to district to subdistrict levels of various user departments.

In the agriculture sector, no major interventions were undertaken to manage water resources, plan appropriate agricultural inputs, or minimize crop losses. In the forestry sector, following the warning of possible El Niño-induced drought, the Ministers of Environment and Forestry, and a number of provincial governors, called on everyone to be alert and to take action to prevent forest and land fires. However, these warnings were not followed up and fires began to occur in early 1997. There was little evidence of a substantial institutional fire prevention and preparedness program in place. The institutional structure to respond to early warnings and provide information and guidance to field operators about fire forecasts was highly inadequate. There were almost no procedures in place to eliminate or minimize the use of fire during dangerous periods.

Lessons learned

The following lessons can be learned from the experience of the 1997–98 El Niño in Indonesia:

Downscaling climate forecasts

- Even though the teleconnections between local climate and El Niño events are considered strong and reliable for Indonesia, a global ENSO forecast is not directly usable on the ground. The global climate parameters need to be translated into relevant local weather variables (e.g., for rice cultivation, the onset and duration of rainfall in wet season, and the number of dry spells in wet season) and related outlooks for various sectors, geographic locations, and seasons.
- The country's past meteorological data need to be retrieved and its observational network strengthened to support a national climate research agenda to fully understand the implications of the ENSO phenomenon for the local climate in different locations of the country.

Making climate forecasts actionable

- An interdisciplinary, multi-institutional climate forecast applications research agenda needs to be developed. BMG and other climate research centers need to establish closer working relationships with a range of intermediaries (such as agricultural, forestry, and irrigation research centers), and existing and potential user organizations.
- Under the climate forecast applications research agenda, there is a need for national researchers to review the impacts of and responses to previous El Niño events in order to identify those impacts that can be attributed to an El Niño event. Based on such studies, El Niño risk maps should be developed for various sectors, regions, and seasons.
- Based on applications research, forecast products should be tailored to meet the needs of specific user groups. For example, for rice cultivation

in a given area, instead of the usual terciles, appropriate forecast parameters may include the onset of wet season rains, the probability of accumulated (threshold) rainfall of 75 to 100 mm over a period of three weeks, the number of dry spells, and the termination of wet-season rains. Thorough research may indicate that the SOI has high correlation with these parameters in some areas and relatively low correlation in others. Such interdisciplinary research is imperative for developing robust decision-making tools at national and local levels.

- Although most critical resource sectors deal with different kinds of risk (with probabilities implicit in them) in their normal-time operations, climate forecasts stated in probabilistic terms are difficult to understand. Greater dialogue among climate forecasters, intermediaries, and users will help translate probabilities into concepts more familiar to different sectors. On the one hand, this will help in making forecasts more actionable, and on the other, it will assist in making the expectations of users and intermediaries from the climate science community more realistic.
- There is a need to create a higher level of awareness of the ENSO phenomenon and its impacts among the public and policy makers. ENSO extremes are here to stay and must be viewed by planners not only as important, but also as important as the natural flow of the seasons.
- It is also important, when it comes to potential disasters, that various departments and agencies share information about potential impacts as well as potential preventive, mitigative, and adaptive strategies and tactics.

Setting up response systems

- Based on past experiences and climate forecast applications research, it is necessary to outline specific prevention, preparedness and response strategies that clearly identify institutional responsibilities and implementation interrelationships.
- Communication should be strengthened between different agencies at each level (horizontal), and within each agency from national to local levels (vertical). In times of El Niño-related crises, emphasis should be placed on the speedy flow of information between and within different agencies.
- The 1997–98 fires exposed inadequacies in the forest fire management system in Indonesia. Since then, a number of national, regional, and international initiatives have been underway to review and strengthen the Indonesian forest fire management structure. Wide-ranging improvements have been recommended and implemented in regulatory

and legislative frameworks as well. The next El Niño event will test the implementation effectiveness of these measures.

- Given scarce resources, it may be prudent for regional governments to undertake benefit-cost assessments in order to determine the most cost-effective responses to El Niño impacts on the environment and societies.
- Although in the long run, effective management of the consequences of an El Niño event would require more effective management systems in critical resource sectors even in normal times, in the short term, special institutional arrangements may be required to deal with El Niño events. Such measures may include the establishment of high-level task forces assisted by professional working groups at national and provincial levels.
- There is a need for an explicit commitment of resources to support El Niño management programs.

Note

1. Personal communication with D. Kirono, Ph.D. candidate at Monash University, Australia, conducting research on Indonesian rainfall variability.

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Kenya country case study: Impacts and responses to the 1997–98 El Niño event

Team leader:
Fredrick Karanja
Department of Meteorology
University of Nairobi
Nairobi, Kenya

Team members:
Laban J. Ogallo (Dept. of Meteorology, University of Nairobi)
Francis M. Mutua (Dept. of Meteorology, University of Nairobi)
Christopher Oludhe (Dept. of Meteorology, University of Nairobi)
Seth Kisia (Dept. of Veterinary Anatomy, University of Nairobi)

Executive summary

This project was carried out for Kenya, which lies between latitudes 5° north and 5° south and between longitudes 34° and 42° east on the eastern side of the African continent. Kenya has a land area of about 569,137 km^2. It has a great diversity of landforms ranging from glaciated mountain peaks with permanent snow cover, through a flight of plateaus to the coastal plain. The country is split by the Great Rift Valley into the western part which slopes down into Lake Victoria from the Mau ranges and Mt. Elgon (4,300 m) and the eastern part which is dominated by Mt. Kenya and the Aberdare mountain ranges that rise to altitudes of 5,200 m and 4,000 m, respectively.

The socio-economic problems experienced by Kenyans are varied, including those arising from inequitable patterns of land ownership, a high population growth rate, rural-urban migration of the population, poorly planned urbanization, deforestation, a low level of literacy, and high levels of unemployment. Kenya's population growth rate is still one of the highest in the world at 2.6 percent. This implies that the economy of the country has to support a large and growing number of young people. This has also created rural-urban migration that overstretches the resources in the urban areas leading to a decrease in the standards of land management, infrastructure, water, sanitation, and municipal services. The result has been a steady decline of health and environmental standards as well as an increased vulnerability to human-made and natural disasters. Due to the population growth, there has been a noticeable rural-rural migration to the arid and semi-arid land areas, affecting the ecosystems of these regions and rendering them more vulnerable to disasters such as drought and environmental degradation.

The above problems are coupled with high levels of poverty prevalent in all sections of the Kenyan society. According to a 1994 welfare monitoring survey, 48 percent of the rural population are food-poor, while 47 percent of the rural population and 29 percent of the urban population were identified as absolutely poor. A large number of the poor are living by either subsistence agriculture or employment in the urban informal sector. The recent El Niño (1997–98) and the heavy rains of 1999 showed that those most affected by these natural occurrences are the poorer sectors of the population living in slums and squatting along flood and landslide areas. Poverty also seriously affects their resilience to disasters, given the constant challenges for survival, which many face.

Kenya is characterized by its limited natural resources, especially water, minerals, and agricultural land. This condition, coupled with the fragility of its ecosystems and vulnerability to increased pressure by human activities, raises critical environmental issues related to biodiversity, deforestation, desertification, drought, floods, and water and air pollution. Forest resources and soil cover are being depleted due to the rapid increase in population and the demand for human settlements and agricultural land, grazing, sources of construction materials, food, fuel wood, essential oils, and herbal medicines.

These factors make Kenyans highly vulnerable to any major disruptive activities, for example, damages caused by natural hazards such as floods and droughts. The number of deaths and injuries to both human beings and animals, damages to infrastructure, disruption of public services, and economic losses from man-made and natural hazards are on the increase and present a threat to the socio-economic development of the country.

In order to reduce the impacts of these hazards, it is necessary to put in place measures to manage the hazards before and as they occur. To do this, an early warning system must be in place to create awareness of the impending disasters and, hence, enhance preparedness. A system should also be in place to deal with the effects of an ongoing hazard. This requires the setting up of disaster mitigation and emergency response facilities. The main objective of this assessment is to review forecasts and impacts of the 1997–98 El Niño, as well as the climate-related early warning and natural disaster preparedness systems in Kenya, in order to improve its ENSO coping mechanisms. Based on this assessment, the project identified research and policy needs and forms a basis for developing preliminary guidelines for future regional and national natural disaster preparedness plans for ENSO warm and cold events and their impacts. Specifically, the project is aimed at forming the basis for:

- Identifying policy needs which can then be developed or incorporated into appropriate operational disaster management and research programs. This would include, but would not be limited to, those relating to the potential yet-to-be-identified linkages between ENSO and climate change.
- Developing a preliminary set of guidelines for national and regional preparedness for ENSO's extremes.
- Designing a capacity-building program for fellowship and the training of mid-level resource and sector managers, post-graduate education, and outreach to the international academic and scientific communities.

Through an improved understanding of early warning, the project ultimately contributes to the safety and welfare of people and the environment by enhancing preparedness for the impacts of future ENSO warm and cold events.

In achieving the main objective, the project considered the impacts of the 1997–98 El Niño phenomenon on various sectors of Kenya. The responses of Kenyans to the phenomenon were also studied. In particular, the project studied the water resources, agricultural, transport, human health, and the socio-economic sectors.

The short rains, which occur during the months of October to December, were extremely magnified during the 1997–98 El Niño episode. The rains, which started as normal rains in October in most parts of the country, picked up to flooding levels during the beginning of November and continued at high levels into January of the following year. They subsided slowly and ended by mid-February 1998 in most parts of the country.

It was determined during the project that the Kenya Meteorological Department (KMD) had issued a forecast for the 1997–98 El Niño event as early as July 1997. According to the KMD, this forecast was sent to the Office of the President, Ministry of Agriculture, and the Ministry of Information, Transport and Communications, which are usually on their mailing list. The information was also sent to the Kenya Power and

Lighting Company, which normally uses the monthly and seasonal rainfall forecasts for planning. This forecast was subsequently widely published through the electronic and print media. However, it was received with skepticism due to alleged earlier "wrong" forecasts from KMD. It was therefore not taken seriously, and hence no mitigation and/or emergency response procedures were put in place. In general, a sizeable percentage of the Kenyan population was aware of the impending heavy rainfall in advance, but did very little to safeguard against its effects.

As the heavy rains hit the country and continued into December 1997, almost everybody realized that the warnings from KMD were real, and immediately thereafter, almost anything that happened to the water resources in the country was attributed to the El Niño. The interest in and awareness of El Niño was enhanced when its devastating impacts were seen throughout the country. The various articles and presentations in the print and electronic media created more interest and awareness on the subject. Due to its uniqueness, intensity, and destructive power, the 1997–98 El Niño event was an intriguing phenomenon to many in the country, even to those involved in ENSO research. It was, therefore, not surprising that the 1997–98 El Niño was blamed for almost all the problems that individuals, groups, and the Kenyan population as a whole were facing, be they the worsening national economy, social ills and diseases, retarded national development, or even domestic hardships. The resultant floods had wide-ranging positive and negative impacts on various sectors of the national economy. The sectors identified that were seriously affected were agriculture, water resources, transport, communications, and health.

Water resources sector

The water resources sector was both negatively and positively affected by the 1997–98 El Niño event. The negative impacts included widespread flooding that led to the destruction of property in several sections of the country, increased soil erosion in areas with poor land use and management practices, and increased frequency of mud and landslides, especially in the hilly areas. Other negative impacts included surface and groundwater pollution, destruction of small storage earth dams, and the increased sedimentation and siltation in the rivers and streams that led to the sedimentation and siltation of the major water storage reservoirs. The general cost of these negative impacts amounted to about US$9 million. However, this sector also benefited from the excess rainfall during this period. Pollution loads were reduced through the washout effect of the rainfall, soil moisture for agricultural production was enhanced, and the water reservoirs were adequately recharged boosting the output levels of the hydroelectric dams.

Agriculture sector

The agricultural sector was also negatively and positively affected by the phenomenon. The abundance of rainfall resulted in increased plant and animal diseases that affected the livestock and crop production in several regions in the country. The flooding also affected the farms through waterlogging, leading to further reduction in yields and destruction of livestock water facilities. Several cases of deaths of animals through drowning were also reported. The estimated combined loss suffered by this sector reached US$236 million.

However, in the arid and semiarid areas the rains were a welcome relief from the perennial dry situation leading to development of good pasture and the resultant improved livestock performance. Agricultural production in some areas increased due to the enhanced availability of moisture for the crops. The rains enhanced and prolonged the time of moisture availability for the biological soil and water conservation structures to take up. Tree planting and survival rates were generally increased to nearly 100 percent.

Transport and communications sector

The El Niño rains devastated the transportation sector. The accompanying floods and landslides wreaked havoc on the roads and transportation infrastructure throughout the country. Several bridges and an estimated 100,000 km of both rural and urban roads were destroyed leading to a general paralysis of the transportation system in most parts of the country. The estimated cost of these damages was about US$670 million. The aviation and shipping industries were also disrupted through the flooding of the facilities. Scheduled and chartered flights were disrupted due to poor visibility and the submergence of the navigational equipment and runways by floodwaters. The docking facilities at the shipping ports were also submerged in floodwaters making it impossible to off load merchandise from the ships. Telecommunications were severely affected by falling trees that destroyed the communication lines. The underground cable channels were also flooded, causing a disruption in services. Interruptions of electric energy supply were experienced as some equipment was destroyed by floodwaters, falling trees, and collapsing buildings. However, a positive effect of the event was experienced by the energy sector with the complete recharging of the hydroelectric dams and, hence, the enhancement of the production of electricity.

Health sector

The 1997–98 El Niño event greatly affected the health sector. Over 300,000 families were adversely affected by the phenomenon. The country's health resources were stretched beyond manageable levels. Several health facilities were physically destroyed, water sources were contaminated, and there were increases in the number of stagnant water ponds, overgrowth around homesteads and market centers, blockage and overflow of sewers and open drains, and an increase in fly breeding as a result of decomposition of refuse. These factors led to an upsurge of disease epidemics and an increase in the morbidity and mortality rates.

All of the above impacts directly or indirectly affected the socio-economic well-being of the Kenyan society. The education sector was also affected, with schools being inaccessible because of flooding which led to closures or to low attendance rates. The end-of-year examinations were disrupted. Businesses were seriously affected through the aforementioned transportation and energy disruptions. The political general elections, scheduled for the end of 1997, were affected, also by the problems in the transport sector, and subsequently rescheduled. The heavy rains that were experienced interfered with social functions, such as weddings, funerals, and church services, during this period.

Considering the impacts of the 1997–98 El Niño event on various sectors of Kenya, it is evident that Kenyans were not adequately prepared and had no facilities in place to cushion the adverse impacts. Although the forecast was available in July 1997, no mitigation or emergency procedures were put in place. Due to the low frequency of widespread flooding problems in the country, the Kenya government had neither a flood disaster management policy nor an institutional framework to monitor and manage flood disasters prior to the 1997–98 El Niño floods. The only disaster management institution that was in operation during the early periods of the 1997–98 El Niño floods was the National Famine Relief Program, whose mandate is almost exclusively related to the monitoring and management of the negative impacts of droughts. This program was not well equipped to manage the impacts of heavy rains. Further, an attempt by the government to mitigate the effects of the negative impacts of the 1997–98 El Niño floods was hampered by the diversity of the impacts which could not, therefore, be handled by any one government ministry in isolation.

However, after the effects of the rains began, the government acted by setting up the National Disaster Operation Center to oversee and coordinate all efforts put toward addressing the serious impacts. It also embarked on a public awareness campaign through the electronic and print media and declared the floods a national disaster. Despite the limitations of the existing economic and financial constraints, the government spent large amounts of money to purchase and transport emergency food, water treatment chemicals, and medical supplies to the worst-affected communities. It also approached donor countries and agencies to help defray the costs of rehabilitation and emergency operations.

The media played an important role during the 1997–98 El Niño event by publishing, on a daily basis, stories related to the effects of the event. It raised the awareness of the public as well as that of the policy makers. The private companies responded to the emergencies by pooling their resources and participating in the rehabilitation of the infrastructure around them. They resorted to the use of diesel-generated power in cases where there were power interruptions and hence were able to maintain some production levels.

Lessons learned

From the devastating impacts of the 1997–98 El Niño event, several lessons were learned. The scientific community, which is involved with research on the ENSO phenomenon and rainfall characteristics in the region, has learned that the warming (or cooling) of the Indian Ocean as well as the Pacific Ocean adversely affects the rainfall patterns in Kenya considerably. However, research has not as yet revealed clearly the quantitative association between ENSO's extremes in the tropical Pacific Ocean and the variations in rainfall in this region. A lot of effort is, therefore, being made to understand the frequency and occurrence of extreme rainfall events, and how these are related to El Niño. Several research papers have been produced on this topic, furthering our knowledge about it and El Niño's teleconnections to Kenya. The relationship between the El Niño and the rainfall over Kenya is now relatively better understood leading to better rainfall forecasts.

The 1997–98 El Niño event hit the country at a time when the government had no plans or policies in place to deal with the associated flood and resulting health hazards. The country had neither a national plan nor a policy for responding to flood disasters that could impact negatively on national economic sectors such as agriculture, health, and infrastructure. The government has learned that such a plan or policy should be developed or added to either the National Disaster Plans or to the National Water Policy, with clear flood early warning and management mechanisms.

In addition, there are many uncoordinated efforts among different early warning units in various departments and ministries such as the Kenya Meteorological Department (KMD), the Central Bureau of Statistics (CBS), the Department of Resource Survey and Remote Sensing (DRSRS), and the Arid Lands Resource Management Project (Office of the President), among others. It has, therefore, been proposed that coordination among the noted departments and ministries be strengthened and an early warning unit be established and be well equipped to enable it to monitor the situation on the ground and collect reliable data, which would enable the ministries to respond appropriately and effectively to disasters in their economic or social sectors.

Some of the other lessons learned include the following:

- The forecast should, if possible, be for periods longer than three months, so that effective control measures can be put in place.
- The storm drainage systems in urban areas should be maintained and serviced regularly.
- The government should educate the public well in advance through proactive awareness campaigns about possible El Niño-related disasters.
- The Kenya Meteorological Department's forecasts should be as accurate as possible.
- The settlement of potential disaster areas, especially those in the flood plains, should be discouraged through a clear government policy.
- In the future, planners should always incorporate climate and weather information in their planning activities.
- The government should institute a policy or plan that supports flood prevention through integrated watershed development programs in eroded mountainous regions.
- The government should also support the design and management of strategic food security reserves.
- There is a need to find a viable response to future disasters through intervention by, for example, capacity building for early warning and disaster preparedness.

Mozambique country case study: Impacts and responses to the 1997–98 El Niño event

Co-team leaders:
Dr João Borges-Coelho
Department of History
Eduardo Mondlane University
C.P. No. 2511
Maputo, Mozambique

Gary M. Littlejohn
7 Dean Close
Rhodesway, Bradford
West Yorkshire BD8 0DD
United Kingdom

Team:
Mussa Mustafa (Instituto Nacional de Meteorologia)
Marcelino Luca (Ministry of Health)
Jorge Amade (Instituto Nacional de Investigacão Agronomica)
Ana Loforte (Eduardo Mondlane University)

Executive summary

Mozambique, located in southeast Africa, has three main landscapes: the southern coastal plains rising to 200 meters above sea level and covering about 44 percent of the country; the central and northern plateau, between 200 and 1,000 meters above sea level covering about 43 percent of the territory; and the interior large plateau and mountain ranges over 1,000 meters and covering about 13 percent of the territory. Most agricultural production takes place in the center and north of the country, where most of the population is also located (apart from the major cities), mainly because the low-lying southern coastal plans are prone to drought and floods. The latter come mainly from rivers rising in neighboring countries. Rains in the center and north tend to be produced by westerly winds generated by the Inter-Tropical Convergence Zone (ITCZ), bringing depressions and occasional tropical cyclones.

The population has grown considerably since 1950, despite a series of wars, from 6.5 million to 16.9 million in 1998, at the time of the last El Niño event. The infrastructure and agricultural profile of the country remain profoundly influenced by its colonial heritage, even though much of the infrastructure has been destroyed in the wars. The other effect of its colonial past, apart from a low level of literacy at independence in 1975, was the widespread use of monoculture crops, particularly cotton. This reduced food security in Mozambique, and encouraged labor migration both within the country and to neighboring countries. The most important labor migration was from the south of the country into South Africa. The combination of monoculture and labor migration rendered the country (especially the south which has long been prone to drought and flood) highly vulnerable to the impact of natural disasters. The lack of investment has meant that there are comparatively few resources to mitigate the effects of such events.

Mozambican independence more or less coincided with the change that took place in 1976 in the frequency and timing of ENSO extreme warm and cold events. Emergency coping institutions were developed rapidly to deal with the effects of serious floods in 1978. These soon developed into a more permanent arrangement in 1980, but the nature of disaster management changed with the intensification of South African-backed destabilization and the developing conflict that became much more intense from 1982 until the Peace Accord of 1992. This conflation of war and the effects of the El Niño events of 1982–83, 1987–88, 1991–92 and (after the war) 1994–95 meant that Mozambican disaster management did not distinguish very clearly between natural and war-related disasters. The 1991–92 drought lasted into 1993 in the center of the country, and this meant that the immediate post-war period leading up to the 1994 elections created a huge field for emergency activities, which included massive efforts by the UN peacekeeping mission, the UN Operation in Mozambique (ONUMOZ), and its humanitarian office, the UN Office for Humanitarian Assistance Coordination (UNOHAC).

In 1995, the institutional setting changed with the departure of ONUMOZ and the emphasis shifted to the idea of a coordinating rather than an implementing body, as the DPCNC (Department for the Prevention and Combat of Natural Calamities) had been. This discussion developed further during the 1997–98 El Niño event, as the Mozambican government developed its Multisectoral Action Plan in consultation with SADC (Southern African Development Community) regional agencies or activities such as SARCOF (Southern Africa Regional Climate Outlook Forum), with meteorologists from the US, with the UN and the major international donors. The result was the creation in June 1999 of

INGC (Instituto Nacional de Gestão de Calamidades), the body that was soon to be tested by the floods of early 2000.

Within this developing institutional framework, the SNAPSA (Sistema Nacional de Aviso Previo de Segurança Alimentar) early warning system has had the lead role among Mozambican government agencies for advising on impending extreme weather events. This is composed of staff from INAM (Instituto Nacional de Meteorologia) and INIA (Instituto Nacional de Investigacão Agronomica) with input from the UN Food and Agriculture Organization (UNFAO), and with a technical commission including key personnel from other ministries.

Climate-related and other natural hazards in Mozambique

Apart from drought and floods, the other climate-related hazards are tropical cyclones, malaria, cholera, pest infestations (particularly red locust), and famine. The impact of pest infestations has been controlled with considerable success since the mid-1990s, but the use of adequate sanitation facilities to reduce the impact of disease remains a high-priority issue.

Scientific research on El Niño in Mozambique

The main center for research on recent and contemporary ENSO events is INAM, together with INIA. However, there is also research work being conducted at Eduardo Mondlane University (UEM), where there is an undergraduate degree in Meteorology and Physics, and at the Universidade Pedagogica. In addition, there is ongoing work on past ENSO events in the Institute of Geology, and by staff now at the Department of Archaeology and Anthropology at UEM. International contacts include the University of Zululand, the SARCOF network, which notably includes the Drought Monitoring Center at Harare and the South African Weather Bureau, the University of Oklahoma, and NOAA (National Oceanographic and Atmospheric Administration). It is not clear whether links have been maintained with the International Research Institute (IRI) for climate prediction located at Columbia University, but such links were certainly there during the 1997–98 El Niño event.

Historical interest in El Niño before the 1997–98 event

There was some research before the onset of the 1997–98 El Niño, most notably in 1996, but there seems to have been little on current ENSO phenomena before then. The press coverage, indicating public awareness and interest, shows little mention of it before 1992.

The 1997–98 event

Information on the 1997–98 El Niño

The 1997–98 El Niño was noted in a special SNAPSA bulletin in March 1997, but the first serious Mozambican report on it took place in July 1997, and was the result of papers sent from the Drought Monitoring Center and the FAO Regional Headquarters in Harare, Zimbabwe. This led to a series of meetings, most notably a SARCOF meeting in Kodoma on 8 September, a MICOA/INAM/IRI meeting on 15 and 16 September and a full national planning meeting from 1–5 October. This presented the first draft of a Multisectoral Action Plan to deal with El Niño, the first such initiative undertaken by the Mozambican government.

The UN agencies, especially the FAO and the World Food Program (WFP), were involved in the development of this plan, and the major donors USAID and the EU were also active from August 1997. The revised Multisectoral Action Plan was considered by a wider group of donors early in December 1997, and changes were required before they would support an international appeal for aid by the government of Mozambique. This was a little unfortunate since some of the aspects that were objected to were, in fact, quite sensible, although other criticisms were perfectly valid. *The criticism that was most misplaced was of the plan to clear the irrigation and drainage canals of the Limpopo irrigation complex near Chokwe. This had already been suggested by FAO in 1993 and enthusiastically supported by the leadership of ONUMOZ, but had not been taken up. This is a measure that is equally sensible for drought or flood, and its implementation would undoubtedly have saved lives in the Limpopo floods of 2000.*

The response to the 1997–98 El Niño was in general a very positive experience as the MICOA/INAM follow-up meeting concluded in February 1998. However, the rains continued at normal or above normal levels, even including some flooding. This had an unfortunate impact in terms of credibility of seasonal forecasting and the integration of such information into the national decision-making process. This negative effect was partly overcome by the subsequent forecast on the effects of La Niña, but it meant that it was only really in late 1999/early 2000 that the government reacted seriously to flood warnings. INAM continues to suffer from lack of equipment that would enable it to give forecasts in sufficient detail to warn the government of incoming extreme weather events.

El Niño in the media

There was excellent coverage during the 1997–98 event, although the media tended to be blamed for simplifying the message. This may have been true for radio and TV, whose archives were too poorly organized to be worth accessing, but in general it was not true of the press. Despite this, there was some vitriolic editorial comment when the "drought forecast" did not turn out as expected. There was very little coverage of El Niño before the 1997–98 event, the first mention being in 1992.

Teleconnections

Scientific views on the existence and strength of El Niño teleconnections

The most notable work on this has been conducted in INAM and INIA. The 1996 paper by Lucio and Amade (1996), and the subsequent more detailed study by Lucio, are the most detailed analyses on El Niño in Mozambique. Relying as they do on both Mozambican historical and satellite data, they are probably the most authoritative. The SNAPSA paper of December 1997 is another important piece of work on teleconnections, indicating that since 1950 some two-thirds of El Niño events have been associated with drought in Mozambique, and not simply in the south as conventional wisdom had it. The most extensive and intense drought of this period, and possibly of the twentieth century, was that of 1991–92, clearly related to the El Niño of that time. While not based on scientific data, historical records of drought in southern Mozambique also suggest that about two-thirds of El Niño events are correlated with drought, especially for the period 1850–1912.

The issue then is the nature of the processes in the Indian Ocean and possibly even the Atlantic Ocean, which mediate the probable teleconnections between Pacific Ocean sea surface temperature changes and the climate in northeast Africa. This is clearly a priority for future research, and the extension of the Tropical Atmosphere Ocean (TAO) array into the Indian Ocean is strongly recommended, as is the upgrading of facilities at INAM, and the fostering of still wider links with southern African and Lusophone climate and climate-related researchers.

Climate-related anomalies and impacts of the 1982–83 event

The 1982–83 event clearly produced a very serious drought, possibly the most serious one of the century until then. (The drought of 1912 was also very serious, and its full extent may not be recorded.) Because the drought began before the El Niño, and was prolonged and intensified by it, and then continued after it, famine was widespread in the south of Mozambique. The war meant that food aid could not be delivered to the affected populations. *The official estimate of 100,000 deaths from starvation, while not contested by international agencies, does not seem to have found its way into estimates of the deaths caused by the 1982–83 El Niño, which are put at around 1,500 worldwide.*

Climate-related impacts of the 1997–98 El Niño

There were only minor floods in the south of the country, and the damage was more than offset by the increased agricultural production elsewhere. Overall agricultural production grew by around 5 percent, contributing to a pattern of growth of around 10 percent per annum for the calendar years 1996, 1997, and 1998. Growth in 1999 was around 14 percent, partly because of the stable climate conditions for that whole four-year period.

Reliability of attribution

The attribution of drought to El Niño was high, based on a southern African international consensus, which broadly matched that of the WMO. The main issue for attribution now is the improvement of the understanding of western Indian Ocean processes, which clearly outweighed the El Niño impacts in this case (i.e., 1997–98), largely because the Indian Ocean was so anomalously warm. The possibility of Rossby waves generated from the Gulf of Guinea in the Atlantic has not been ruled out, and should be a priority for the TAO array currently being installed in the Atlantic.

Responses

Government reports and statements issued before the impacts of the 1997–98 El Niño became apparent

The main reports were the July 1997 SNAPSA forecast, derived at least partly from the earlier SARCOF statements, the report on the MICOA/INAM/IRI meeting of mid-September 1997, the Multisectoral Action Plan produced in first draft by early October, and the December update produced in relation to the mid-December SARCOF update meeting.

Reports issued after the impacts appeared

After it became clear that rains had been sufficient to avoid serious drought, the main government report was the follow-up meeting of MICOA/INAM in February 1998. In addition, the WFP produced a much longer bound report covering the impact of the event on the whole of southern Africa.

The major responses to the event

These were the preparations that took place in the period July–December 1997, which have been described above.

Mozambican research on El Niño

If one ignores geological and archaeological research on past El Niño events, there has been very little research on contemporary El Niño events before 1996, as has been mentioned above.

A government plan to respond to El Niño

There exists no standing plan to respond to El Niño. The government is currently fully occupied in coping with the impacts of the floods of early 2000 and their aftermath, which are still considerable at the time of writing this report in June 2000. However, the 1997 Multisectoral Action Plan, together with the lessons from the floods of 2000, should help in the formulation of such a plan, and should raise awareness as to its necessity.

El Niño as a disaster

El Niño may not be seen as a disaster because the connection was not widely perceived until 1997 and the expected probable teleconnection did not take place. However, the current floods have been related to La Niña, and this may raise awareness of the importance of ENSO events in general for policy making in Mozambique.

International research on El Niño in Mozambique

While there is ongoing historical research conducted by S. J. Young in Oregon, USA, meteorological and climatological research is concentrated in the USA and South Africa. In the USA, the main centers for research on Mozambique are NOAA, the University of Oklahoma, and Purdue University. In South Africa, the most notable links are with the University of Natal. However, important research is also being conducted at the University of Cape Town. The latter is about to establish links with INAM as a result of this project on the 1997–98 El Niño.

Forecasting by analogy

What could have been done differently?

Very little, in the current state of knowledge, could have been done differently. While plans could always be improved, the main issue was the seasonal forecast itself. This has rightly been identified as a major challenge to climatologists and seasonal forecasters, and can only come about by a combination of improved monitoring and forecasting within Mozambique itself, and international research on the processes in and over the Indian and Atlantic Oceans, preferably through an extended TAO array and the development of better regional climate models.

The information flow, in terms of regular monitoring of meteorological, water, health, and agricultural developments, could be improved, as could public education on the interpretation of such forecasts. In addition, long-term investment in Mozambican infrastructure, especially roads, food security warehouses, and health clinics, would make the country better able to withstand the impacts of climate variability and extreme weather events.

Realistic obstacles to perfect forecasting followed by perfect action

The current limitations on INAM, both in terms of staff development and equipment, are the main obstacles to better forecasting, which can never be perfect in a situation of climate change. This is followed by the need to strengthen the capacity of INGC to coordinate government and international agencies and NGOs in a disaster management scenario. Some of this could be achieved by the integration of GIS and other information into a common format for use by the whole range of agencies likely to be involved in disaster response activities.

El Niño considerations in Mozambique's national disaster plans

It is perhaps now the main element in disaster planning, especially if one includes the impact of cold ENSO extreme events, such as the one associated with the floods of early 2000.

Strengths and weaknesses in the national response to the forecast

The weaknesses consist of the still-fragile national meteorological service, and in the flow of information across agencies, which affects coordination between them. Response would also be strengthened if the processes mediating the teleconnections from the Pacific to East Africa were better understood.

Influence of the 1997–98 El Niño on the response to the following La Niña

There seems to have been no contingency plan for the following La Niña, and the "failure" of the earlier forecast of drought undoubtedly played a major role in this.

Lessons learned

The main lessons are for the Mozambican government regarding longer-term policy formation. There are also lessons for the international donor community, regarding both dialogue with the recipient government over aid priorities and long-term measures to enhance the resilience of the Mozambican economy in the face of a climate variability that will never disappear. The more specific lessons concern the functioning of the INAM (National Institute for Meteorology) and of the INGC (National Disaster Management Institute). The highest-priority lessons are as follows:

- *Prevention! Prevention! Prevention!* Recent floods in Mozambique in early 2000 (a La Niña year) showed that small preventive measures could have spared a great number of lives. These have to be done in connection with local communities making use of local solutions.
- *Education! Education! Education!* This is the only way, in the short and long run, to raise societal knowledge and sensitivity toward this issue. El Niño-related educational activities would include schools at all levels and the media.
- *Forecast! Forecast! Forecast!* Last, but not least, Third-World states tend to neglect investments in forecasts. It is expensive (even if not very expensive, there are always other priorities) and results do not seem evident. It is important to change this mentality. It is necessary to strengthen, on the one hand, the international and regional forecasting networks and, on the other, to include (again) local participation. Forecasting cannot be considered an aseptic technologically based activity (or something which belongs only to the rich Western countries). Human, cultural, and local factors have to be taken into account.

Mozambican government policy formation

There is a grave danger that Mozambican government decision making will continue to show the same old attributes of ad hoc gathering together of people with relevant expertise as a response to events, rather than a sustained process of policy development, with investment in the long-term development of expertise. It is symptomatic of the country's political culture that the agricultural season is still described as a "campaign."

The reasons for this have long been clear:

- Policy formation has long suffered from being in a "response mode" rather than proactive. Some attempts at longer-term policy development, such as the Indicative Perspective Plan of the early 1980s, were not seriously debated, and depended on intellectual inputs from donor countries with their own unrealistic agenda. The 1997–98 El Niño Action Plan was a notable exception to this tendency. However, it suffered from the sometimes poor process of dialogue with the aid donors.

- There has been a constant process of a loss of expertise to international agencies and NGOs or abroad. A country that began in 1975 with 95 percent illiteracy and a very small group of people with higher education has long found that a policy of training staff suffered from high rates of "brain drain."
- The dependence on donor aid, induced by drought and war, has given some donors a *de facto* institutional interest in weakening Mozambican government structures, to minimize debate over their preferred policy prescriptions. Other aid agencies have tried to strengthen decision-making processes with technical assistance programs, but these have usually depended on a few key personnel who have often been enticed away by better career opportunities elsewhere.
- Policy formation without the resources for implementation is inherently problematic. The difficulties in raising taxes in an economy that was in decline from 1981 to 1994 have seriously depleted the capacity of the Mozambican government to act on its own account. The main exception to this has been the delivery of food and other emergency aid. Yet, this has been financed by international donors who understandably wanted a say in its distribution, as well as transparency in decision making. The result has been a silent struggle over aid distribution, which is typical of the politics of emergency aid, especially in situations that were perceived as linked to the Cold War.

The issue now is how to foster a change in the political culture in favor of a longer-term view of economic development and management that is not hidebound (constricted) by issues of debt repayment. The South African-backed Maputo Corridor has contributed to the long-term development of Mozambique, but it is not clear whether this success can be repeated in the cases of the Beira and Nacala Corridors. The question of investment to increase resilience to drought and flood in the south and center is now on the political agenda, with the "award" of US$500 million to Mozambique at the recent Rome donors' conference. However, the link between emergency rehabilitation aid and long-term development is apparently not yet being made, either within the Mozambican government or within the donor community.

The other main lesson is that monitoring meteorological conditions within Mozambique needs to be improved. This is not only a matter of increasing the number of weather stations, but of improved communication with provincial governments and NGOs, to increase coverage of the whole country with its different subclimates.

International donor community

Emergency aid versus development aid

The donor community has, for budgetary accounting reasons, set up an artificial distinction between emergency aid and development aid. It then poses the question of how the transfer from one to another can be made. Part of the answer lies in the simple fact that a little judicious foresight can mean that emergency aid can have long-term benefits, and that some long-term aid can increase capacity to deal with quick-onset disasters. Thus, for example, design and construction of decent flood-resistant roads in southern and central Mozambique could be implemented as a disaster recovery project, but would have long-term economic benefits. A recent search of current UK patents shows that appropriate technology exists to build flood-resistant roads that would be much less likely to be washed away. One wonders if this has been taken into account in planning the reconstruction on EN1, the main road north from Maputo to Xai-Xai and Inhambane.

Similarly, reed-bed construction would reduce vulnerability to malaria and cholera, but is unlikely to be financed as part of a disaster recovery strategy. It could, however, conceivably be funded, for example, by a developed nation under the Kyoto carbon credit measures. The point is that the budgetary distinction between emergency and development aid, which seems to make sense, can at times get in the way. There is little sign of the international donor community interweaving aid in an intelligent way to reduce future vulnerability to climate-related disasters, which remains a serious long-term threat in Mozambique.

Dialogue between donors and recipients

More important than this “eternal dilemma” (between spending on emergency and on development aid) is the need to enhance dialogue both within the donor community and between it and the Mozambican government. There is no doubt that events such as the recent Rome donors’ conference do enhance donor coordination. However, in the period before El Niño, despite the good job done by various UN agencies, and by USAID and the EU Delegation in Maputo, there was still a problem of dialogue in response to the Mozambican government's plan to mitigate the effects of the predicted drought. The EU's private response document was a mixture of perfectly reasonable and quite mistaken points. Rather than dialogue on this to clarify the issues, there was an attempt at imposition of *all* the EU points as a condition of making an international appeal for aid. Such a paternalistic attitude, which, *inter alia*, undermined the advice being given by UN Technical Assistance personnel, was not conducive to good coordination in what was expected to be a serious emergency.

A similar attitude was evident in the UK government's approach before the recent Rome conference. The Minister for International Development, Clare Short, publicly criticized the Mozambican government's capacity to respond to the Cyclone Eline disaster, implying that there was little point in devoting too many resources to disaster recovery in these circumstances. This comment had considerable validity, but took no account of the major restructuring that INGC had been undertaking as a response to a consultancy report from a UK University. As such, a short-term ministerial view was in danger of undermining the long-term perspective of work that was probably instigated by UK-funded aid!

In any case, the UK Department for International Development had had a serious disagreement over emergency aid with the UK Ministry of Defence. The latter was publicly criticized by the House of Commons for its stance, which delayed the delivery of helicopters to Mozambique after Cyclone Eline. The US government was also slow in its response. While these are not El Niño events, they do illustrate the point that it is not just the governments of developing countries that have problems with policy coordination and implementation.

While transparency, speed, and effectiveness are very important for disaster preparedness, and while dialogue cannot eschew criticism of the recipient government's performance, the objective should surely be to enhance the future performance of the aid-receiving government in terms of disaster prevention, mitigation, and recovery.

Long-term investment

Donor governments and agencies need to get away from the so-called "sick children syndrome," where TV pictures of starving children or other stricken people are used to evoke the political response required to justify the emergency aid. To reduce the vulnerability to drought and flood that can be expected with ENSO's extreme events, investment in vulnerable areas is necessary. A simple way to illustrate this is to compare the 1997–98 warm event with that of 1877–78. In the earlier event, tens of millions of people died in India and China. In the latter, stronger event comparatively few died. This difference is largely a result of the stronger condition of both economies 120 years later, despite their far greater populations.

Hence, the issue is how to identify the vulnerable areas. In the case of Mozambique, this is comparatively easy. NDVI (Normalized Difference Vegetation Index) and CCD (charge-coupled device) images linked to weather station and udometric data with the results feeding into GIS (geographic information systems) make it comparatively simple to identify the drought-prone areas on the basis of historical evidence. This could be modified by the use of dynamic climate models of the southern African region, of the type being developed by Professor Bruce Hewitson of Environmental Sciences, University of Cape Town. The reason for the need for such models is that global warming of the atmosphere means that the past is now less useful as a guide to the future and, therefore, forecasting long-term changes or impacts by analogy will likely become less reliable.

Such climatic data could then be linked to soil type data (again, readily available in Mozambique in GIS format) and to population data such as the recent census. Even voting data could be used to give an up-to-date picture of how the still-mobile population is distributed. Mozambique has had a recent comprehensive survey of poverty, which facilitates the identification of economically vulnerable groups. The levels of poverty are even greater than previously thought, which probably means that Mozambique should again be considered one of the poorest, if not the poorest, country on the globe. Such evidence should inform disaster planning. Hence, the role of INGC could be enhanced to facilitate the integration of such data into dialogue with the international donor community.

Improved forecasting

However expensive it is, it is still a rational use of resources from the viewpoint of a country as poor as Mozambique to complete the TAO array of buoys by adding the Indian Ocean to the global network, now that the Atlantic network is under construction. This would enhance the dynamic climate models, and improve short-term prediction, thereby enhancing the credibility of ENSO-related disaster planning. The improved understanding of Indian Ocean dynamics would benefit the whole of eastern Africa, as well as the more densely populated Pakistan, India, and Bangladesh.

INAM

INAM, the National Institute for Meteorology, has lost key personnel to Portugal in the last few years. This has doubtless been because of the lack of up-to-date equipment and prospects for serious research in INAM, and has adversely affected its prospects for serious international research collaboration. To some degree, this has been overcome by contacts that have been established by the current director, Filipe Lucio, to conduct international collaborative research and sustain the research program of INAM. However, prior to Cyclone Eline, it was evident that INAM did not really register as an important part of Mozambican government policy making.

As an illustration of this point, it is worth mentioning that the former director of INAM returned from Portugal with some colleagues, one whom was also a former INAM staff member, just after Cyclone Eline, on a longstanding engagement to lecture on the latest developments in meteorology and climate monitoring. While this was an imaginative and stimulating evening of lectures, and much of it was new material to most of the staff of INAM, in reality there was little that would have been new to anyone reading WMO material and surfing the web regularly. (This would include the Director of INAM and a few others present.[1])

While the number of weather and udometric stations remains so low compared to colonial times, and compared to real needs in a topographically and climatically diverse country, INAM will struggle to take its proper place in the international research community, as this evening of lectures indirectly indicated. The fact that it was taking place showed that the current director is doing everything that he can to maintain international links and to upgrade the qualifications of his staff (there is a program to send staff abroad for further training). It also showed how much remains to be done, in that what should have been material that could be accessed from within Mozambique was being introduced as news from the developed world. It was gratifying that the new minister was present, and one hopes that this was an indication that Cyclone Eline had prompted the senior levels of the Mozambican government to take meteorology and climatology seriously as an integral part of its decision-making process.

Nevertheless, it is worth stating that INAM did well in terms of issuing good weather forecasts, both during the 1997–98 El Niño and later during the floods. The performance could have been improved with Doppler radar and more weather stations, however. Thus, just prior to Cyclone Eline, there had been more rain in three days than during the previous major cyclone, Domoina, in 1984. Although rain had been forecast, the intensity had not, and thus the floods of mid-February 2000 prior to Eline were not expected to be so severe. Hence, it is not special pleading to say that the deterioration of the weather station network needs to be reversed, and that equipment needs to be updated, if not to the levels evident in Macau, at least to give the basic minimum of modern equipment, including the ability to receive data from the new ESA (European Space Agency) satellite.

INGC

This, the National Disaster Management Institute, is a fairly recent creation in its present form, having started its coordinating role in mid-1999. The national action plan for responding to the 1997–98 El Niño was drawn up by its predecessor (DPCNC) in conjunction with other relevant Mozambican ministries. It was unfortunate that this plan was not better received, either by the donors in late 1997 or by the media in 1998 when the El Niño-related drought forecast was thought to have been "wrong." It forms a reasonable basis on which to build a standing contingency plan for disasters, since many of the measures would be the same for flood or drought. It would also help if it were translated into English.

Its role of coordinating ministries means that it has to have the political backing to be heard when necessary, an issue which seems also to have affected the new ISDR (International Strategy for Disaster Reduction) in the UN. Further work is necessary on improving the coherence and financial aspects of the planning process, but the experience of the recent floods should facilitate this improvement. The issue of resources to implement any plan remains a critical one, as the floods showed, and this means that investment in infrastructure to mitigate the effects of droughts should be an ongoing process. It has to be built into donor priorities, until such time as the Mozambican government is able to raise sufficient taxes to finance its own activities. Thus, skill at the politics of international aid will be a continuing prerequisite for the leadership of INGC and for ministries.

Note

1. This lecture was part of a program of establishing a Lusophone network of meteorological services, and coincided with the Portuguese Presidency of the European Union in the first six months of 2000. There had been a meeting of all Lusophone meteorology services, except Macau (where flight difficulties had prevented the new director there from attending) in São Tome a few weeks earlier.

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Panama Canal case study: Impacts and responses to the 1997–98 El Niño event

Team leader:
Maria Donoso
Director
CATHALAC (Water Center of the Humid Tropics for Latin America and the Caribbean)
Panama City, Panama

Team members:
Carlos Vargas
Chief, Meteorology and Hydrology Branch, Panama Canal Authority
Marquel Castillero
CATHALAC Technical Staff
David Martinez
CATHALAC Technical Staff
Kevin Leaman
Meteorology and Physical Oceanography, University of Miami
Mikiyasu Nakayama
Professor, University of Agriculture and Technology, Tokyo

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Executive summary

The administration and operation of the Panama Canal has been carried out jointly by a complex US civilian and military apparatus. To guarantee the security of the canal, the United States received the concession of a strip of land 8 km long on each side of the canal and of the small portion of the Chagres watershed delimiting Madden Lake. This strip of land became known as the Panama Canal Zone.

As time passed and Panama began to grow as a nation following its separation from Colombia in 1903, a new sense of nationalism developed.

The Panamanians felt the need to renegotiate the American presence in the Canal Zone and, in 1977, the Torrijos-Carter Treaty was signed. Under this treaty, the United States was committed to the return of complete control of the canal to the government of the Republic of Panama on 31 December 1999.

At present, the Panama Canal is administered by the Panamanians, and it is incumbent on the Authority of the Panama Canal (in Spanish, Autoridad del Canal de Panamá, ACP) to effectively continue to comply with the tasks for which it was built.

The canal watershed is defined as the geographic area, the surface, and the underground waters which flow toward the canal and are spilled into it or its tributary lakes. The borders of the watershed are defined by an imaginary line that joins the highest points of the mountains surrounding the hydrologic system of the canal. Until 1999, the watershed was said to cover 1,289 square miles. With the passage of Law 44 of 31 August 1999, the legal territory of the hydrographic watershed was extended to include three other river basins: Rio Indio, Caño Sucio, and Coclé del Norte. All three are located to the west of Gatún Lake in the Atlantic region.

Because the canal is not at sea level (Lake Gatún is 85 feet above sea level), the ships are elevated by a system of three sets of locks. Going from the Atlantic Ocean to the Pacific, a ship passes through the locks of Gatún, Pedro Miguel, and Miraflores. The locks are fed by water displaced only by the effects of gravity; water is not pumped into the locks. The water elevates or lowers the ships in the locks. During each transit, approximately 52 million gallons of water are used. The total water storage capacity of the canal is approximately 1,660 billion gallons. However, the net capacity is approximately 365 billion gallons. Gatún Lake provides 203 billion gallons, and Madden Lake 162 billion gallons.

According to Article 84 of the Law of 1 July 1998, "the administration, use, maintenance, and conservation of the water resources of the hydrographic watershed of the Panama Canal will be the responsibility of the Panama Canal Authority, in coordination with the National Authority for the Environment (ANAM), and having as a basis the strategies, policies, and programs related to the sustainable management of the natural resources in these river basins."

The Panama Canal allows the passage of ships from one ocean to the other. However, the watershed that feeds this engineering marvel allowing ships to pass from one ocean to another does not escape from El Niño's effects. Studies about the effects of the El Niño-Southern Oscillation (ENSO) cycle in Panama show that there is a clear tendency during El Niño (the warm extreme) toward a reduction in precipitation below the normal long-term average values, mainly in the Pacific region or the southern part of Panama. Panama's climate has two distinct seasons:

a rainy season (mid-April to mid-December) and a dry season (mid-December to mid-April).

Early studies (Estoque et al. 1985) indicated that El Niño is associated with below-normal precipitation values. The annual mean deviation of the anomaly of precipitation during El Niño years is 8 percent below normal in the region of the canal's watershed. In 11 of the 12 El Niño years used in the study, the precipitation anomaly is negative. There is a reduction in the net river discharge that flows into Gatún Lake during El Niño years, which causes a decrease in the lake's water level. Historical records document a considerable reduction in precipitation in the watershed during El Niño. Consequently, there is a decrease in the levels of the lakes that feed the canal system during El Niño. These events jeopardize the normal operation of the canal. The canal's operating conditions have been especially critical during the last two strong ENSO warm events of 1982–83 and 1997–98.

During extreme water shortages, the authorities responsible for the management of the canal have been forced to implement a set of navigational draft restrictions for transiting vessels. These constraints have had adverse economic effects on some customers and users of the canal. In addition, the fact that some of them have opted for alternate routes to transport their cargo during El Niño years has translated into a decrease in the number of ships crossing the canal, which in turn yielded less general income from transits.

The Panama Canal Authority uses the water of the canal according to the following distribution: 58 percent is used for the operation of the locks; 36 percent for generation of hydroelectric power, and 6 percent for municipal consumption.

El Niño is responsible for causing major problems to the economy of the region and, consequently, to the economy of Panama. Several socioeconomic sectors in the country are affected by El Niño (and La Niña). These sectors include, but are not limited to, the following:

- Water resources and energy
- Natural resources
- Farming
- Fisheries
- Human health

According to data released by government agencies and private companies, Panama's productive sectors experienced losses of over $50 million during the 1997–98 warm event.

The energy generated in Panama is mainly dependent on the availability of water resources. Thus, energy production depends on precipitation, which means it will be affected by El Niño. In years of extreme drought, the country has been subjected to electric power blackouts for periods of more than five hours a day for several weeks at a time. During the 1997–98 El Niño, various cities in Panama experienced daily blackouts ranging from two to four hours. In addition to the irregularities in the delivery of electric power, the population also suffered from shortages in water supply for human consumption, mainly in urban areas. And, as noted earlier, the transit of ships through the Panama Canal has been affected by El Niño events.

The most critical operating conditions that could be blamed on severe drought, observed since the canal's construction, were registered during the El Niño events of 1982–83 and 1997–98. In fact, during the 1997–98 El Niño, the lakes of the canal's watershed reached their lowest levels ever recorded in its history. The Panama Canal Commission, the organization in charge of canal operations at the time, was forced to apply draft restrictions to ships in transit. During the 1997–98 event, several fires were reported in the canal watershed. These were extinguished rapidly, mostly by the US military, and never progressed into major forest fires.

On 10 May 1998, under a photograph of a desert-like countryside landscape, *El Panama America*, a daily newspaper, wrote that "the El Niño phenomenon has harmed farmers and Indian communities that live off the products of the land, and they have not been able to harvest a thing since last year." About 3,861 hectares insured under Instituto de Seguro Agropecuario (ISA) were affected by El Niño.

Droughts also reduce the quality and quantity of pasture available for cattle and, therefore, affect meat and milk production. In addition, a considerable number of cattle died due to illnesses generated by water shortages. The losses were in the tens of millions of dollars. The ISA itself paid US$1.47 million in compensation to 596 farmers and cattle raisers.

Not all crops suffered during the 1997–98 El Niño. For example, in the provinces of Chirique and Bocas del Toro, coffee growers reported an increase in production of 10,000 sacks in comparison to the previous year's yield.

In aquaculture, a decrease in shrimp production was detected, because of low survival rates and poor growth. Shrimp farming is very sensitive to changes in precipitation and air temperature. The effects of El Niño on the fisheries sector are not yet well understood. However, some observations showed a tendency toward a decrease in the number of fish landings during warm events. The cause of this trend is attributed to the anomalous increase in sea surface temperatures.

The impacts of ENSO warm events on the country's economy are most significantly experienced by the poorest sectors of the population, mainly farmers and indigenous groups. Drinking water in rural areas becomes scarce, which brings, as a consequence, an increase in the incidence of water-related and vector-borne diseases such as malaria and dengue. In many cases, the deterioration of the quality of subsurface waters, caused by infiltration from domestic and industrial sources, also aggravates health conditions. Studies carried out by researchers within the framework of the Trade Convergence Climate Complex (TC3) research initiative[1] also showed that during the 1997–98 El Niño, there were increases in the number of people affected by respiratory and dermatological diseases, in addition to vector-transmitted and water-borne diseases.

The Department of Meteorology and Hydrography of the Panama Canal Authority is mainly responsible for the management of water resources in the canal watershed. This institution has an operational mandate and has not carried out specifically scientific investigations on El Niño. Nevertheless, making use of the records of physical data recorded since 1903, it has produced time series that, after being processed and analyzed, can be used to infer the effects of El Niño in the Panama Canal watershed.

The Department of Hydrometeorology of the Institute of Hydraulic Resources and Electrification (IRHE) (recently privatized under the name Electric Transmission Company, or ETESA) was responsible for monitoring the behavior of meteorological parameters in time and space. Until the early 1990s, this was the only government institution to carry out occasional studies of El Niño. These studies centered primarily on the variations of precipitation in Panama during El Niño. Beginning in 1995, studies were carried out to establish the effects of El Niño in Panama and its impact on electricity generation.

The interest in Panama about the El Niño phenomenon began to gradually increase after the warm event of 1982–83, with the few works of investigation already noted. It was not until the middle of the 1990s when the global scientific interest in this phenomenon spread throughout the continent that Panama began to involve itself extensively in ENSO-oriented research. An important role was played by the TC3 Network in the promotion of research on El Niño in Panama. This group of researchers from the physical and social sciences began to organize different activities aimed at evaluating the impacts of El Niño on key socioeconomic sectors. These activities continue to bring together scientists and decision makers.

In the mid-1990s, Panama began to take important steps to combine the efforts of different national institutions and regional organizations to exchange experience and knowledge and, thus, to increase its understanding of El Niño and its effects and consequences in Panama. One of the first initiatives was the organization of the TC3 Network under the coordination of the Water Center for the Humid Tropics of Latin America and the Caribbean (in Spanish, CATHALAC) of the first National

Forum on "The El Niño Phenomenon and Its Impacts on Panama." This took place in November 1995.

The 1982–83 El Niño and beyond

Dependent on a system of locks and a navigable lake, water is a vital element for the Canal's operations. The El Niño event of 1982–83 caused the first important impact of an El Niño on the waterway.

The first indication of El Niño's influence appeared in November 1982, when Gatún Lake did not increase to the level of 26.75 meters (87.75 feet) as normally occurs during that month. It was only at the beginning of February 1982, when this critical level was finally reached, that the implementation of the first restriction was put in place. It is important to remember that this El Niño was not forecast, and even as the event was developing it was not recognized as the onset of El Niño.

With the experience acquired during the 1982–83 event, the Canal Commission decided to deepen by 3 feet the navigable channel of the canal waterway. They thought that by doing so, if another El Niño event of this magnitude were to occur again, it would not be necessary to set navigational draft restrictions, or at least they would not be as significant as those applied in 1983. Recall that the 1982–83 El Niño, at that time and until the 1997–98 event occurred, was labeled "The El Niño of the Century." Of course, canal operators (as well as El Niño researchers everywhere) did not expect an event of the intensity of the 1997–98 El Niño. This event has replaced the 1982–83 event as "The El Niño of the Century." The 1997–98 El Niño restrictions were estimated to have cost US$12 million to the Panama Canal coffers.

Unlike the 1982–83 El Niño, the 1997–98 event was forecast some months ahead of its impacts on Panama. This allowed the Panama Canal Commission to take some preventive measures aimed at mitigating any adverse effects that this event could cause to the waterway. The initial prognosis indicated that this El Niño would be of considerable intensity.

The information about the possible onset of an El Niño was received by the personnel of the Office of Meteorology and Hydrology of the Panama Canal Commission (PCC) in April 1997 through the Internet. Around the middle of that year, PCC officials consulted websites and obtained information indicating that it would be a strong event. The main source for these consultations was the NOAA website postings. The information was presented in numerical, graphical, and tabular form and as text and images. The Division of Public Affairs of the PCC also received information on the development of this event through different media (e.g., TV reports, e-mail messages).

The first news disclosed by the print media on the matter of a warm event occurred on 1 June 1997 through an international news posting from Tegucigalpa, Honduras, entitled "El Niño Returns With Its Pranks," published in the newspaper *La Prensa*. The first news on the possible effects of the event in Panama was published in the newspaper *El Panama America* on 10 June 1997, with the headline, "El Niño Phenomenon Will Cause Losses." Nine days later, a group of experts in the region, participants of the TC3 Network, met in Panama City. They included in their agenda an analysis of the state of the event's development. The conclusions they formulated with respect to El Niño were disseminated by way of the local mass media.

The first news that suggested possible effects of the 1997–98 El Niño event on the canal watershed was published 17 August 1997 in *La Prensa* under the title, "El Niño Could Affect the Canal."

PCC employees from several departments organized a working group that met regularly to coordinate efforts before the imminent impact of El Niño. Participants in these meetings included representatives of the Division of Engineering of the Meteorology and Hydrology branch, the Department of Marine Operations, the Department of Engineering Services, and the Division of Public Relations of the PCC. A series of recommendations from these meetings were provided about the actions to be implemented by the different departments of the PCC. The outcomes of these meetings were reported to the corresponding authorities, who then approved the execution of the recommended actions.

The Department of Marine Operations continuously sent warnings to the ships (users and customers of the canal) to inform them of the situation with regard to canal operations. Special emphasis was given to inform them clearly about the status of draft restrictions. Twenty-two warnings of navigational restrictions in relation to the ENSO event were sent out during 1998. As a result of the imposed draft restrictions, the number of ships passing through the canal decreased by 4 percent during the second trimester of 1998 in relation to the previous year.

From May to December 1997, which happen to be the months of expected intense rains in the watershed, recorded precipitation was significantly below average. That year, the canal watershed experienced its worst recorded drought in Panama Canal history. The existing climatic conditions caused a reduction of 25 percent in the runoff toward the tributary lakes of the canal. In spite of a decrease of 58 percent of the water flow toward Gatún Lake, by the end of September and into the month of October, the authorities of the canal officially announced that the operations in the canal would *not* be affected for the remainder of 1997.

The forecasts by PCC experts in the first months of 1998 were not very encouraging. Based on the experience of the 1983 event, draft restrictions were forecast to begin in February 1998, in light of the possibility that the lake levels would be unable to recover because of the fact that the dry season was already approaching. Measures were taken to mitigate the effects of this event, and to avoid the negative impacts that would affect the customers and users of the canal, as well as the public in general. The measures taken were as follows:

- Saving water by stopping the generation of hydroelectric power at the Gatún plant, and replacing the lost electric power by the more expensive thermoelectric generation. (The Gatún plant is used only when there is an excess of water in the lake, because it would otherwise spill its water directly into the sea.)
- Saving water by using smaller chambers of suitable size.
- Saving water by means of ship transit in tandem through the locks (more than one ship per lock).
- Saving water by means of crossed water transference between adjacent chambers.
- Maintenance of a safe depth in the navigable channel of the canal through the implementation of nearly continuous dredging.

The implementation of these measures cost US$10 million to the canal authorities, but at the same time they brought about water savings of about 10 to 15 percent. Another adopted action was to make a complete sounding of the bottom of the canal section known as Corte Culebra, which would serve to guide the dredging of this section. This helped to eliminate all accumulated sediment and reduced the degree of draft restrictions.

The various measures that were adopted, together with the continuous monitoring of important hydrometeorological parameters for the canal watershed, allowed for a delay in the setting of draft restrictions. Originally, it was believed that draft restrictions would need to be set by the end of February 1998. But it was not until 12 March 1998 that the canal authorities issued the first of their 22 warnings announcing El Niño-related draft restrictions. These warnings were issued to the users with an average of three weeks in advance of their implementation.

On 12 March 1998, months after the implementation of the measures for water conservation, the first draft restriction was applied. This fact was beneficial to the customers who traversed the canal from the end of February to 11 March, enabling them to transport more cargo than would be the case after 12 March. The maximum allowed draft in the Panama Canal was decreased to 39 feet, half a foot less than the maximum allowed draft under normal conditions. Obviously, some customers were affected by these restrictions. A reduction in draft of half a foot, depending on the type of ship, could represent a loss of lift capacity of up to several hundred tons of cargo.

The maximum allowed draft was reduced by a half-foot every time a restriction was set, until it reached a minimum value of 35.5 feet on 19 April 1998. This draft restriction stayed in place until 28 April, when the maximum allowed draft was increased with the coming of the rains that began to fall primarily in the Atlantic sector of the watershed. Progressively, as rain accumulated over the canal watershed, the draft was increased until it returned to its normal value of 39.5 feet on 29 July 1998.

Fortunately, some of the earlier forecasts related to draft restrictions were not correct, such as the one that predicted that the maximum allowed draft would be reduced to 33.5 feet in May 1998. If this had occurred, it would have further affected the customers and users of the canal. On 25 August 1998, the PCC reported the canal lake levels had returned to normal.

During the period of draft restriction, some customers of the Panama Canal had the chance to decide on alternative routes like the North American coast-to-coast railroad or the Suez Canal. Some canal economists were afraid that the programmed increase in tolls by the PCC for January 1998 would have a negative impact on the international marine community and would affect the volume of traffic through the Panama Canal. This increase was programmed before awareness of the appearance of the El Niño for the purpose of gathering funds to finance extension works in Corte Culebra.

The interruption of the generation of hydroelectric energy at the Gatún hydroelectric plant in order to save water had an adverse effect on the Panama Canal. The PCC was deprived of between US$5 million and US$8 million, which would have been generated by the sale of this energy.

In spite of the negative effects of the 1997–98 El Niño, such as the drought in the Panama Canal watershed caused by a reduction in precipitation of almost 35 percent, and the investment of about US$12 million that the PCC had to make to mitigate these effects, the income obtained by the PCC not only fulfilled the projected expectations for that fiscal year (October 1997 to September 1998), but surpassed them. The income (US$743 million) was an increase of 10.6 percent over the previous year's income (US$663.9 million). This success, according to declarations of the PCC authorities, was possibly due to several factors. One of these, and possibly the most important, was the capacity of the personnel to plan and implement actions to counteract the critical climatic conditions in the region that were created by the 1997–98 El Niño. Other factors included the adoption of new tariffs for tolls in 1997 and 1998, the increase in traffic of ships of greater width in the canal, and other services that the canal offered.

Although the Panama Canal could, through successful management, face one of the hardest contingencies ever experienced, the 1997–98 El Niño is still considered the most intense event of the last 150 years. Various customers and users were affected during the four-and-a-half months of draft restrictions. The ships that were affected were mainly those carrying bulky loads, tankers, and other container carriers. Between 12 March and 20 May 1998, 2,612 transits occurred, and of these, 289 ships (11 percent) had to reduce their drafts to be able to go across the canal. This was a low percentage, according to the canal authorities. Some of those ships, having to reduce their draft, experienced a loss of lifting capacity of up to a thousand metric tons for each half-foot of draft restricted. These restrictions obviously affected their economic gain. For example, from 12 March to 16 April, 1,375 ships passed through the canal, and of these 138 were affected by the draft restrictions and were forced to reduce their cargo by approximately 500,000 metric tons. This caused the canal authorities to consider deepening the waterway by a few feet more, as had been done in 1984.

With the approval of the new Law 44 of 31 August 1999, the legal area of the hydrographic watershed was extended to include three other river basins, namely Rio Indio, Caño Sucio, and Coclé del Norte, all three of which are located to the west of Gatún Lake in the Atlantic region. The annexation of these three river basins to the canal system, together with the proposed structural modifications of the waterway, will provide new elements to be considered when modelling the potential impacts of future ENSO warm and cold events on the Panama Canal. Research on the impacts of climate variability still needs to be carried out in parallel with the future development of the Panama Canal system.

Conclusion

The canal authorities do not have the resources to forecast El Niño events and, therefore, they depend on the information that they acquire from international institutions that forecast and monitor the ENSO cycle. The different experiences gained during the El Niño events of 1982–83 and 1997–98 highlight the importance of obtaining early warning of these events to guarantee better management of the watershed's resources. It is not difficult to imagine what might have happened to the operations of the Panama Canal during the 1997–98 event if in 1984 the canal authorities had not decided to further deepen the navigable channel of the canal or if the forecast of the 1997–98 event had been delayed.

Newspaper, radio, television, and other forms of media are important channels through which to disseminate information about climatic events. They are also important forces that can either contribute to the mitigation of the impacts of such events by alerting the opinions of the general public, or can cause unnecessary unrest (even hysteria) when the intensity of the event is exaggerated. In the case of the 1997–98 El Niño, the media did not influence the decisions or actions undertaken by the PCC with regard to the waterway. The PCC conducted its business based on its experiences during the 1982–83 El Niño, and its interpretation of information coming from sources such as NOAA. As a matter of fact, the local media generally based its coverage of the situation as it related to the Panama Canal on press releases issued by the PCC's Office of Public Affairs. This was not the case in relation to other sectors, such as agriculture, where speculation from some media agencies sometimes ran wild.

In general, the treatment of the 1997–98 El Niño by the local media was relatively professional. The reason for such moderate reporting on the effects of the 1997–98 El Niño in Panama could be that enough catastrophic footage of impacts was coming in from Peru and Ecuador, and later from Honduras (after the passage of Hurricane Mitch), that there was no need to exaggerate the situation. Thus, the media could have "attractive" headlines.

In summary, as stated by the PCC Administrator, Alberto Alemán Zubieta, the rapid response of the canal's authorities to the 1997–98 El Niño demonstrated their capacity to handle major problems. The action plan implemented in response to this extreme climatic event was based on the interpretation of information coming from adequate sources such as NOAA, enhanced by input provided by local experts, and the expertise gained by the PCC during the 1982–83 event. However, the continuous and accelerated changes in land use that are taking place in the canal watershed calls for a permanent monitoring of the basin and a constant verification of the models that simulate the response of the canal system to climate variability.

Lessons learned

- In preparation for a future major El Niño event, the Panama Canal Authority needs to guarantee good storage and provision of water for the watershed. The best solution seems to be the expansion of the canal watershed system to include other basins along with the possible construction of new dams.
- During extreme water shortages, such as those generated during the 1997–98 El Niño event, a contingency plan needs to be put in place that should include a good efficient management of water resources that takes into account the different water usages. (This is being put together now.)

- To promptly and adequately take the necessary measures to minimize impacts in ship transits and to inform the shipping industry with sufficient advance notice on these measures, the Panama Canal Authority needs to identify a mechanism in order to have available as early as possible forecasts of the onset of a warm event. (This is being undertaken at present.)
- The available studies on the impacts of El Niño on the watershed were good benchmarks for the Canal Authority to put together a strategic plan during the 1997–98 El Niño, but not sufficient, taking into consideration the continuous and accelerated changes in land use that are taking place in the canal's watershed. This calls for a permanent monitoring of the basin and a constant verification of the models that simulate the response of the canal system to climate variability. In other words, we need to do more research.

Note

1. See the website in Spanish: www2.usma.ac.pa/~cathalac/tccc.htm.

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Papua New Guinea country case study: Impacts and responses to the 1997–98 El Niño event

Team leader:
Joe Barr
Pacific Emergency Management Associates Ltd.
1 Lalor St.
Ainslie, ACT 2062, Australia

Team:
Bernard Choulai (National Disaster Committee Working Group)
Sam Maiha (National Weather Office)
Balthasar Wayi (Department of Agriculture and Livestock)
Kaigabu Kamnanaya (National Disaster Management Office)

Executive summary

Papua New Guinea is the largest developing country in the southwest Pacific region. It consists of the eastern part of the large island of New Guinea and about 600 smaller islands ranging in size from the large islands of the Bismarck Archipelago, up to 200 km long, to small islands and atolls only a few hectares in area.

Most of the larger islands are mountainous. The main range that stretches along the length of the island of New Guinea is one of the great mountain ranges of the world with major peaks over 4,000 meters high and many highland areas over 2,000 meters high. The range contains well-populated fertile valleys, inhabited for up to 9,000 years, that support a large section of the population. The terrain is so rugged that some valleys were virtually cut off until this century and even now many can only be accessed by air or on foot. A chain of volcanoes lies along the north coast of New Guinea and through the Bismarck Archipelago and North Solomon Islands, all of which are close to the tectonic plate boundary. Coral reefs fringe many coasts and islands, particularly in the east.

Papua New Guinea has a tropical climate. The monsoonal rainy season from about November to April mainly affects the south of the country and the highlands and small islands normally experience year-round rain. Average temperatures on the coast and in the islands range from 21 to 32 degrees centigrade with high humidity. The highlands are cooler with frost being experienced on a few occasions each year above 2,000 meters.

Papua New Guinea has a population of about 4.5 million people, which is among the most diverse on earth. Some 600 distinct languages are recognized and there are clear ethnic differences between the people of different areas. The population is scattered throughout the country with the biggest concentrations in the fertile valleys of the highlands and in the vicinity of major urban centers of Port Moresby, Lae, Madang, and Rabaul. The practical density of the population on usable land is about 62 persons per square kilometer. Most of the rural population lives a semi-subsistence lifestyle with an estimated 75 percent of rural households selling at least part of their produce for cash.

Staple crops vary according to climate but the root crops of taro, cassava and yams are most common. Sago is the staple in northwestern coastal areas. All these crops have long growing periods that are further extended in the low temperature areas of the highlands.

The social indicators for Papua New Guinea are low. Life expectancy at birth is 56.8 years with an infant mortality rate of 61 per 1,000 live births. 87 percent of school age boys and 67 percent of school age girls enter primary school, but numbers drop drastically later with only 16 percent of boys and 11 percent of girls entering secondary education and about 2 percent entering tertiary education. Health indicators are particularly poor. There are 1.8 doctors for every 10,000 people and only 40 percent of children are immunized against measles. About 22 percent of the population has access to sanitation while 28 percent has access to safe, clean water.

Independent since 1974, Papua New Guinea is a parliamentary democracy governed by a single parliamentary house in Port Moresby. There is considerable volatility in the Parliament where changing alliances between small groups can quickly alter the balance of power. The provinces have assemblies made up of the elected national members of Parliament from the province, elected heads of local governments within the province, and certain appointed members.

The country has many natural resources. Mining has recently become the largest source of export income and forestry; oil and gas are increasingly important although agriculture remains important. The country is relatively poor, as exploitation and poor administration have meant that the resources have not brought the growth and development that might legitimately have been expected.

The geography of the country severely limits movement, particularly on the mainland. Port Moresby has no road links to any of the provincial capitals. The key roads are the Highlands Highway, which links the second city of Lae to the highlands, and a second national highway that links Lae with the north coast at Madang and continues west along the coast until it becomes indistinct between Aitape and the Sandaun Provincial capital, Vanimo. Air and sea transport are important and there are still people who are familiar with aircraft but have never seen a motor vehicle.

Hazards

Papua New Guinea is at risk from a wide range of natural hazards all of which can have a significant impact on the daily life of the population and on the economy. The rural population accepts the impact of the hazards as part of daily life in a culture in which the struggle for existence is often difficult. The major meteorological hazards are severe storms and floods (which may also cause landslides), drought, tropical cyclones, and frost. The country is also prone to geological hazards, including earthquakes, tsunamis, and volcanoes, of which 14 are currently considered active. The common developing country disease and transport hazards also exist, as do industrial and mining hazards and there are risks to crops from pests and plant diseases.

Disaster management organization

The Disaster Management Act is the basic disaster management document in Papua New Guinea. It describes the basic disaster management structure and responsibilities and requires disaster plans to be prepared. The National Disaster Committee meets regularly, and since 1997 has been paying increased attention to disaster preparedness and mitigation matters. Provincial disaster committees exist in all provinces, although some are only marginally effective.

The National Disaster Management Plan was prepared in 1987, but has not been amended despite many changes to government and administrative arrangements. An updated plan has been drafted and is currently being discussed by the government and other agencies involved.

The National Disaster Management Office has the only full-time disaster management staff in the country. The office performs secretariat and administrative activities on behalf of the National Disaster Management Committee and runs the National Emergency Operations Center. It also coordinates disaster preparedness measures and prepares and distributes the National Disaster Plan.

Papua New Guinea lacks an effective system for collecting, organizing, analyzing and disseminating disaster management information between the government, the public, or external agencies. In 1997 the only hazard warnings were for tropical cyclones; there was no formal system for reporting hazard impacts on any part of the country, and there was irregular contact between the key disaster management agencies and departments. Little baseline information is collected so comparisons with normal times are difficult. Even records of past disasters are poor and hard to trace.

The disaster management system is underdeveloped and under-resourced. This situation is about to change, as a five-year Australian-funded development program is due to begin in 2001.

El Niño and Papua New Guinea

Situated close to the normal warm water pool of the southwest Pacific, Papua New Guinea can be seriously, and quickly, affected by El Niño events. Historically, the most common direct effect of the eastward movement of the warm water pool appears to be reduced cloud cover as a result of decreased convection. This results in lower rainfall over much of the country and this can cause drought in the worst affected areas. Reduced cloud cover also allows faster cooling of the land overnight. In the highlands, this increases the number of frost days above 2,200 meters and allows the frosts to extend to lower altitude areas that rarely experience frost conditions. It may also be surmised that the severity of the frosts at any particular altitude increases but this is impossible to confirm in the absence of temperature records.

The reduced rainfall and higher frost rate can lead to water shortages, crop losses and famine. These increase the vulnerability of the human population to disease and dry the vegetation making it more vulnerable to fire. Surviving vegetation is weakened and, in turn, becomes vulnerable to pest and disease attack. The longer the impact lasts, the longer the recovery period appears to be.

Climate records

Much of the limited historic climate information has to be drawn from available meteorological records (most of which are still on paper), colonial government and mission records, newspaper articles and personal histories. These indicate that major droughts occurred in parts of Papua New Guinea in 1896, 1902, 1914, 1941, 1972, and 1982 with less severe events in other years. All of these years had periods during which the Southern Oscillation Index (SOI) was negative but negative values of 20 or more are only recorded for 1896, 1941, 1982–83, and 1997–98. The droughts of 1902, 1914, and 1972 coincided with much smaller negative SOI values although the first two did occur when the index had been negative for long periods. There are obviously a variety of factors that influence the occurrence of major drought in Papua New Guinea.

El Niño research in Papua New Guinea

In the colonial period there was growing scientific interest in the occurrence of drought in Papua New Guinea, particularly after the 1972 drought. International developments in the identification and study of the El Niño/Southern Oscillation (ENSO) relationship were mentioned in drought research in the 1970s and 1980s, the most comprehensive published records of this research being published in Allen et al. (1989).

With few indigenous scientists, Papua New Guinea has lacked the resources to maintain the momentum of research since independence, and only isolated work has continued – mainly within government agencies. None of the work appears to have been published, but there is increasing experience that is being enhanced by frequent contact with Australian and other researchers.

Since the 1997–98 El Niño-related drought, the National Weather Office has been conducting low-level research on the possibility of predicting serious drought by comparing the accumulated total rainfall in previous wet seasons at Daru, in Western Province, with year-to-date rainfall readings. It is possible that examination of this relationship permits the prediction of dry seasons fairly accurately.

Overseas El Niño research relevant to Papua New Guinea

Australian scientists have continued to study the geography, agriculture, meteorology, and other relevant subjects in Papua New Guinea since independence, often with Australian government funding. A key institution that has fostered this research is the Research School of Pacific Studies at the Australian National University in Canberra.

The Australian Bureau of Meteorology, which has a close relationship with the Papua New Guinea National Weather Office, has also conducted research over many years on weather and climate issues in the region. New Zealand's National Institute of Water and Atmospheric Research has also conducted extensive research into tropical cyclone occurrence in the southwest Pacific, including the influence of the Southern Oscillation and sea surface temperature on cyclones.

The 1997–98 ENSO event

Drought

The National Weather Service of Papua New Guinea, which has limited human and material resources and is significantly underfunded, has only a limited climate monitoring capability. Monthly rainfall figures are recorded at 21 stations around Papua New Guinea but only 12 stations maintain continuous daily records. These are forwarded monthly (sometimes with delays) to the climate section of the National Weather Office for processing when staff is available. Spasmodic reports from the other nine stations provide useful information on trends in their areas.

The weather service, in common with the rest of the government, became aware of a developing drought from media and provincial government reports. Media reports of power reductions caused by reduced water flows in hydroelectric systems, increases in the price of fresh produce in markets, and mine production losses due to low water levels in the Fly River do not seem to have alarmed authorities. There are often drought periods from April to September and there appears to have been no early recognition that this was an exceptional event or that it might be linked to the El Niño. It was not until August 1997 that a National Weather Service staff member returning from studies overseas could be spared to examine El Niño reports from overseas and national rainfall records and prepare a report on El Niño and the reported drought and severe frosts for the government.

The first measurable effect on Papua New Guinea of the 1997–98 El Niño event appears to have been in March 1997 when there was low rainfall at nine of the 12 official weather stations, including all those situated on mainland New Guinea. While most of the country receives high to very high rainfall distributed fairly evenly through the year, periods of up to two months of lower rainfall are not unusual. When below-average rainfall was being recorded at all except one of the stations in April, May, and June, there was only local concern. Above-average rainfall was recorded at a few stations during July (reportedly as a result of short-term events) and in one station in August but this was not enough to relieve the developing drought, which continued for the rest of the year. Notable examples include Tabubil, with one of the highest rainfalls in the country, which received 78.6 mm in August compared to an average of 684.3 mm; and Port Moresby which recorded no rain in August, October, and November and only 7.8 mm in September (compared with an average of about 164 mm for this period). Only near Wewak on the north coast of New Guinea was regular rain recorded, although the rainfall for the period from August 1997 to January 1998 was below average.

Nationwide, needed rain started to fall in January 1998 and by early April most stations were recording significant rainfall. The increase caused flooding in some areas, including the Ramu valley, during March and April.

Frost

As there are no weather-recording stations in the frost-prone zone above 2,100 meters, all reports of frost over this period are anecdotal but it is clear from these reports that there was an increase in the number and severity of frosts with some periods in which frost was experienced over a number of successive nights – a most unusual occurrence. Subsequent research indicates that frosts occurred above 2,200 meters in the western highlands as early as June 1997 and were experienced in every month until at least October. At Tabubil in September 1997, there were eight successive nights of frost in an area that normally experiences only occasional frosts.

Fire

A secondary result of the El Niño drought and frost was the increased incidence of bush fires in mainland New Guinea. The first fires were probably started by landowners burning off vegetation to clear land for new crops when rain returned. Some of these fires got out of control in the unusually dry conditions and spread far beyond the originally planned areas. Later fires are reported to have been lighted by landowners who believed that smoke would bring clouds, which would bring rain. By the time these fires were lit, the vegetation was even drier, so they often spread further and the calm atmospheric conditions left much of the mainland shrouded in smoke and haze.

Alarm

The Papua New Guinea government became alarmed in early August 1997, as it received reports of drought from around the country and of severe frosts in the highlands. The August report from the National Weather Service confirmed that serious drought existed in Milne Bay and Western Provinces but rainfall records from most other provinces were late. The report also states that rainfall in the New Guinea islands was only marginally below normal while the Wewak rainfall figures were taken to indicate that the drought hardly affected the northern provinces.

Initial impact reports

By September 1997, reports from the Departments of Health, Provincial Affairs and Local Government, provincial authorities, churches, and the media covering all 19 provinces revealed food and water shortages, power rationing, school and health clinic closures, and outbreaks of disease linked to the use of brackish or untreated water or to dust and smoke inhalation. Subsistence farmers were already searching for "famine" foods in some areas, and people were traveling long distances to obtain water for drinking and cooking.

The drought assessments

The first assessment

The reports from around the country did not give a clear picture of the national situation nor did they indicate the priority areas for response assistance. In mid-September, the government asked Australia to assist by mounting an urgent national assessment of the situation. A team led by two scientists with long experience in the country was deployed and a rapid first assessment questionnaire covering the impact of the drought and frost on the priority sectors of food and agriculture, water, and health was prepared.

Thirteen assessment teams, made up mainly of staff from the Department of Agriculture and Livestock, carried out the assessment between 25 September and 11 October. The teams visited a representative selection of villages in all provinces and returned a total of 638 questionnaires. Team members were asked to use personal observation as well as discussions with villagers to complete one questionnaire for each village visited. To provide a measure of standardization, teams were asked to complete the questionnaire by making an objective assessment of the situation in each village and by allocating a category on the basis of a five-point scale. The scale was as follows:

(1) Unusually dry, but no major food supply, drinking water or health problems.
(2) Some inconvenience. Staple food is short but other food available; must travel further to collect drinking water but health is okay.
(3) Difficult, with food short and some famine food being eaten, water available at a distance, some babies and old people unwell. No lives at risk.
(4) No food in gardens, famine food only being eaten, water in short supply and possibly polluted, increasing sickness, the lives of small children and old people at risk.
(5) Extreme situation. No food available at all, water very short, many people ill, small children and old people dying.

These summary ratings were quickly entered into a database and the results were mapped on a Geographical Information System. This enabled the most critical areas to be identified easily and priority areas for response agreed upon.

The assessment indicated that about 77,000 people were in a life-threatening situation due to food shortages and a further 100,000 were expected to be in that situation by the end of October 1997. If the rain did not return, a further 250,000 people were expected to enter the critical category in November and another 170,000 in December. The assessment also showed that at least 100,000 people were experiencing critical water shortages, some in places where there were food shortages as well, but many in places where food was still available.

The health situation was harder to assess because the health status of rural people in Papua New Guinea is already poor by international standards and because the health system had been allowed to run down in the previous few years. The teams reported an increase in diarrhea and skin infections but no widespread deterioration in the already poor nutritional status of young children. Although some deaths were reported, these could not be linked directly to the drought.

The reports also confirmed a reported migration from high to lower altitudes. The fertile high valleys were originally settled from lower levels and the people who live in the valleys maintain kinship or "wonto" relationships with others who live at lower levels. Downhill migration during hard seasons is a regular occurrence so some displacement was expected. In 1997 the migration was greater than usual.

The reported water shortages were confirmed by the teams and by a water expert who visited a number of provinces. He found seven islands with no fresh water where people were drinking from coconuts or brackish water from beach springs and wells. The supply of coconuts was diminishing on some islands including one with a population of 1,000 people. He found only three other islands where people had the UN refugee camp standard of 15 liters of water per person per day. Some people were traveling by canoe to the nearest water point to collect water; others were walking as far as several kilometers to obtain water from distant creeks, beach springs and cave pools. Even this water was not always fresh. The expert was particularly concerned that there was insufficient water for hygiene purposes and forecast that this could lead to increasing health problems.

The second assessment

After the first assessment was completed, it was agreed that further assessments would be needed to monitor developments. A second assessment was conducted between 25 November and 12 December 1997. Eighteen teams were deployed and achieved better coverage than the first survey. A shorter questionnaire was used, which required assessment teams to consider a number of factors and provide a written assessment of the situation. Teams were asked to provide separate assessment categories to describe the severity of the food crisis and the water crisis.

This assessment indicated that almost 1.24 million people, 40 percent of the rural population, had little or no food available while about 410,000 people either had very limited supplies of contaminated water or had to collect water of variable quality for long distances. Although some rain had fallen in November and December, it had not made a significant difference to water supplies in badly affected highland provinces and had made no difference to food availability. Some replanting had been carried out but there was a critical shortage of planting material.

The teams reported an apparent increase in severe malaria and in diarrhea among people eating "famine" foods. There were more reports of people dying from unexplained symptoms and of an increase in deaths among young and middle-aged adults but the reports could not be confirmed.

The third assessment

Rain fell in many districts from December 1997 onwards but there were still areas of concern and a third assessment was carried out between 20 and 31 March 1998 by the Papua New Guinea Department of Agriculture and Livestock. It differed from the earlier assessments in covering only those areas identified as critical (Categories 4 and 5 in earlier assessments), and in addressing recovery issues. Fourteen teams were deployed to visit 17 provinces and 244 census divisions.

The questionnaire used on this occasion asked specific questions relating to the amount of rain that had fallen and the needs of the people for both relief and recovery. Teams were again asked to categorize villages both at the time of the assessment and, if possible, in two months' time.

This assessment identified more than 53,000 people still without food and another 336,000 experiencing serious shortages. The food situation was found to have improved considerably since the previous assessment with cultivation of staple crops underway and surplus supplies available in the markets in at least one island province. The number of people in the critical categories was expected to fall by at least 30 percent during the following two months with rapid recovery in most areas in later months. Shortages of seeds and other planting materials were still reported while crop recovery was also being affected by increasing insect pest attacks.

Water availability and quality had improved in most areas with only 75,000 people, many on atolls, now experiencing critical or serious shortages of safe water. As normal rainfall patterns returned, the remaining shortages were expected to ease before the onset of the normal dry season in May.

Once again, diarrhea was the main health problem reported, although the return of the rain had also brought an increase in mosquito numbers and further malaria outbreaks. There were also reports of increased malnutrition in some areas but the lack of baseline data made this difficult to confirm. The Department of Health lacked the resources to carry out a nutritional survey at any stage during or after the drought so reports of this nature remain subjective.

Other impacts

The three assessments carried out between September 1997 and April 1998 concentrated on the impact of the drought and frost on rural communities. Urban communities were not subject to the same food shortages, but the variety of fresh produce available in markets was significantly reduced and prices increased. The prices of domestically sourced goods in trade stores also increased.

In the Papua New Guinea culture, kinship relationships are close and people who migrate to urban centers usually maintain close relationships with their home villages. In an event as serious as the drought, this kinship places obligations on people with resources to help those who are experiencing difficulties. Consequently, urban dwellers were obliged to send food or money to their rural "wontoks" to help them through the drought. This had an economic impact on urban dwellers but reduced the effects of the drought on recipients.

Power restrictions

A major impact on urban populations, particularly in the capital, Port Moresby, was the extent of power restrictions caused by a shortage of water for hydroelectric purposes. Port Moresby relies on a single reservoir for power and water. In April 1997 the reservoir contained more than 250 million cubic meters of water. The level fell steadily, and by November it contained only 80.9 million cubic meters – a reduction of some 66 percent. It was estimated that at current usage rates the dam would be empty by January 1998 if rain did not resume.

To reduce water use, load-shedding measures began in August 1997, but from 17 November the city was divided into two supply areas and each had power cut off for half of each working weekday. A schedule was published in the press and cuts were programmed alternately for the morning or afternoon of each day. This significantly reduced water usage and made it unnecessary to ration domestic water use. Public education campaigns encouraging people to save water were initiated.

Reservoir levels continued to fall and the government decided to reserve the water for domestic use when the reservoir reached a specified level. Before this level was reached, some older generators were repaired and new generators began to be installed so the demands of the hydroelectric system fell. Although significant rain began falling in late December, replenishment of the reservoir took time, and it was not until April 1998 that rationing could be eased. Further easing was implemented in June 1998, and by the end of the year power had returned to normal. A new power station was opened in April 1999 to reduce the need for such drastic measures in the future.

Economic impacts

On 4 March 1998 the Treasury Minister advised Parliament that the country had lost 500 million kina (US$278 million) in foreign exchange reserves as a result of the prolonged drought. This was approximately 62 percent of the previous 800 million kina reserve and left the country with only enough funds to cover the cost of two months of imports. The minister highlighted the impact of the drought-induced closures of mines and stated that the minimal currency inflow from traditional export sources and the downturn in the timber industry had also contributed to the loss.

The long-term impact of the drought on agricultural exports is clear from a number of 1998 reports. Compared with 1997, coffee exports fell by 11.8 percent, cocoa exports by 32.9 percent, copra exports by 35.7 percent and palm oil exports by 22.6 percent. Only copra oil exports increased (by 9.5 percent) and this increase was accounted for by an increase in the delivery of copra to the mills.

The drought had a more direct effect on mineral exports. The most dramatic impact was the fall in the level of the Fly River, which is normally navigable for about 800 km up to the port of Kiunga, the supply port for the huge Ok Tedi mine in Western Province. The level fell so far in August 1997 that only canoes could move on the river. Not only could no ore be carried down to the river mouth for export but also supplies for the mine could not be brought in. Limited movement of barges on the river began in November but ore sales did not recommence until February 1998. Other mining operations in the country were also affected by water shortages.

Social impacts

The social impacts of the El Niño event are difficult to confirm in the absence of any study of the subject. The people worst affected by the drought and frosts were subsistence farmers living a semi-subsistence lifestyle in the highland or island provinces. Their life is difficult and they often experience hardships that would alarm people used to an easier lifestyle even in the developing world. During the drought, many of these families survived on so-called "famine" foods, wild leaves, roots, and animals that are not normally eaten. Searching for these foods is very time-consuming and the life became very hard but the people displayed great resilience, and recovery appears to have been faster than forecast by any of the assessments. The capability of some to survive the drought without any relief is shown by the fact that some villagers in a remote part of Central Province decided not to walk to the aid delivery point (which admittedly was some distance away) to collect supplies of rice and oil. Their condition is reported to have been little worse than that of communities that received relief supplies.

National response

Some provincial and district administrations began to provide relief to specific communities in August 1997. Where a community or group of people were seen to be in serious difficulty and if funds were available, food was bought locally and delivered to the community for distribution. Usually the food was rice, available in bulk from traders in most parts of Papua New Guinea, and tinned fish or meat.

In early September the Papua New Guinea government allocated 4 million kina (US$2.78 million) 1997 to provincial administrations to fund immediate relief to the worst affected areas. On 17 September, the government made a further K20 million (US$13.9 million) available for relief. This sum was to be held in a trust account by the central government and used, as necessary, to fund relief activities. There were delays and the funds did not actually arrive in the account until late November, but once the announcement had been made, there was a public perception that there was plenty of money available and delays in providing relief were widely criticized.

As the results of the first assessment were examined, it was clear that it would be impossible to assist all affected people. The government agreed to give supplementary rations to those in areas assessed as being in Categories 4 and 5, i.e., whose lives were considered to be at risk. The scale of relief agreed upon was 8 kg of rice, 2 kg of wheat flour and 1 liter of oil per person per month to be delivered through provincial authorities to district authorities who would be responsible for distribution through village and community leaders.

In late September the Papua New Guinea and Australian governments agreed that Australia would deliver the relief to parts of the country that could not be accessed by road transport, while Papua New Guinea would make the road deliveries.

Because of the delay in transfer of the allocated funds to the Drought Trust Account, road deliveries did not start until late November 1997. Most of the government supplies were delivered to Lae, a major port and the terminus of the Highlands Highway.

International response

The international response to the developing crisis was substantial. Australia, as the previous colonial power, made the largest contribution and had the highest profile, but a wide range of donors made contributions to the relief operation. Soon after the first assessment report was completed Australia deployed C-130 Hercules and Caribou aircraft and various helicopters as well as naval landing craft to deliver assistance. Deliveries continued from late October 1997 to April 1998. Australia also contributed technical assistance, staff and medical support, consultancy services, non-government organization support and seeds and planting materials for recovery. By June 1998 a total of AU$30 million (US$19.5 million) had been provided.

The only other donor to provide and deliver direct food relief was

France. French military aircraft from New Caledonia visited Papua New Guinea in December 1997 and delivered food over a period of about one week. Japan funded delivery of a large quantity of World Food Program rice to Lae for the Papua New Guinea government's relief operation. Unfortunately, shipping delays meant that most rice arrived at a time when food shortages were easing.

Financial assistance

Donors had provided US$803,000 cash to the Drought Trust Account by December 1997. This was considerably less than the government had sought, although the account was bolstered to some degree by donations from within the community.

Recovery operations

As rain began to fall and vegetation recovered from the effects of El Niño, the priority was to obtain seeds and planting materials (usually tubers and cuttings) to enable people to start planting staple crops as quickly as possible. In drought-affected areas, most or all of the tubers and seeds that would normally have been saved for planting had been eaten or had been destroyed by bush fires, drought, or frost. Some planting materials were located elsewhere in the country and more obtained from overseas. Frost and drought resistant varieties of the major staples that would be acceptable to the local communities were also sought. Particular attention was paid to obtaining tubers of the temperate potato (called the English or Irish potato in Papua New Guinea) for planting at higher altitudes. Seeds of fast-growing vegetable crops were also distributed. By the middle of 1998, when a tsunami struck in Sandaun Province, fresh food supplies from every province were available to be donated for relief assistance.

Post-event reviews

Three "lessons learned" workshops were held in Papua New Guinea during 1998. There was a consensus that although this was the worst and most prolonged drought and frost event to have struck the country in a century, the assessments overstated the seriousness of the situation. While some people were clearly in serious danger of starvation or dehydration, and many others were affected by lack of food or having to use unsafe or brackish water, the number in each of these situations was considered, with hindsight, to have been significantly lower than initially thought. There was agreement that the errors were acceptable in view of the limitations imposed by time, the lack of baseline information, the size of the area to be assessed, the uncertainty about population sizes, and the inexperience of many members of the assessment teams.

The main lessons learned related to organizational matters. There was particular emphasis on the need for an effective disaster management system to be developed throughout Papua New Guinea. It was felt that if such a system could be developed, involving both government and non-government organizations likely to have a role in mitigation, preparedness, response, and recovery activities, many of the problems experienced in the El Niño response would not have been so severe. It was also considered that there was a need to develop better weather monitoring mechanisms and information management systems, backed by comprehensive baseline data collections, and public education and awareness capabilities. Steps are already being taken to implement these lessons.

Lessons learned

A number of lessons were learned from the impact of the 1997–98 El Niño event on Papua New Guinea. Implementation of some of these has begun but others await the completion of an emergency management development package that has been discussed with Australia in 1999–2000. Major lessons learned include the need for the following:

Emergency management

- An emergency management structure with agreed roles and responsibilities that extend from Cabinet level down through national, provincial and district to village level that encompasses not only the official sector but also the non-government organization and the business sector.
- Comprehensive updated national disaster plans that are regularly exercised, tested, and reviewed to meet changing threats, administrative arrangements, and requirements. These plans should include supporting plans, not only at the provincial and district levels, but also in the various specialist sectors including health, transport, agriculture, and water.
- A comprehensive training program for all those involved in emergency and disaster management.
- A standardized, trustworthy, and auditable approach to dealing with funds donated by the public and by donors after a disaster.
- A standardized disaster impact assessment system with teams trained in its use.
- Arrangements under which funds for response operations can be made available quickly in an emergency.

Hazard monitoring

- A review of current hazard-monitoring capabilities and procedures and development of improved systems that will provide early warning of developing threats and regularly updated information on their characteristics and progress.
- A system that ensures that the warnings reach the right people in a timely manner.
- Agreed to and widely promulgated arrangements for communicating threat information to the general public accompanied by appropriate background information and action recommendations.

Public information and education

- Public education about the hazards that threaten Papua New Guinea, their origins, causes, and characteristics.
- Community education programs, using a variety of channels, that advise the population of the appropriate protective measures to take to protect itself from the hazards that may threaten it.

Disaster prevention and mitigation

- National hazard and vulnerability analysis followed by a risk management process that identifies the most appropriate management strategies to reduce the impact of the various threats.
- Collection of baseline information that will enable the impact of hazards to be forecast and, if necessary, monitored to enable the most appropriate prevention, mitigation, preparedness, response, and recovery actions to be taken.
- Greater attention to be paid to the maintenance of existing infrastructure so that it is better able to meet the requirements of the population in an emergency.
- A coordinated approach to dealing with the water supply needs of both rural and urban populations.
- Supplementing the existing power-generation arrangements to keep pace with increasing public and commercial needs in all population centers.

Information management

Particular attention needs to be paid to the management of information in relation to hazards and disasters. This requires the definition of channels for collection, organization, analysis and distribution of information and the delegation of appropriate responsibilities. It will require an information-management structure that extends from the top to the bottom of society and provides for a two-way flow of information with a change in culture that encourages an understanding of the information needs of others and a willingness to share information for the greater good. There is also a need for improved communications systems between national, provincial, and district level disaster managers that will continue to be available in an emergency.

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Paraguay country case study: Impacts and responses to the 1997–98 El Niño event

Team leader:
Benjamin Grassi
Coordinator Area de Meteorología
Facultad Politécnica
Universidad Nacional de Asunción
Ciudad Universitaria
San Lorenzo, Paraguay

Team members:
Dr. Grassi's team were members of the Facultad Politecnica at the Universidad Nacional de Asunción (see address above)

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Executive summary

The Republic of Paraguay is located in South America in the La Plata River basin. Its neighboring countries are Brazil, Bolivia, and Argentina. Paraguay can be divided into two well-defined natural regions, one from the Paraguay River to the east, encompassing 150,000 square miles of scalloped terrain and humid climate where almost 98 percent of the population of Paraguay is settled. The second region, covering 256,000 square miles is located to the west of the Paraguay River. It is called the Paraguayan Chaco and is composed of flat, dry terrain. It is sparsely populated.

The climate of Paraguay can be characterized by a warm spring and summer, temperate autumns, and cold, dry winters. Due to its being a mediterranean country, its climate is typically continental. The annual mean temperature across the country varies from 21 °C in the southeastern tip to 25 °C in the northern Chaco near the Brazilian border. Generally, the climate becomes warmer as one moves toward the northwest. June, July, and August (the Southern Hemisphere winter) are the coldest months of the year; temperatures can be around 16 °C with occasional frosts, which are more frequent in the southeast. December, January, and February (Southern Hemisphere summer) are the warmest months, with monthly mean temperatures rising to 28 °C in the north. During these months, heat waves are frequent with many rainless days, but with high temperatures and humidity. Occasionally, temperatures over 40 °C can be reached.

Rainfall has very irregular spatial and temporal distribution. The highest rainfall values are located in the southeast, with annual precipitation means ranging between 1,500 mm and 1,800 mm. The lowest precipitation amounts are registered in the western zone (in the Chaco), where annual means range between 400 mm and 700 mm. Paraguay is a very rich country in available surface water. Rainfall in the central part of the country and in the east is able to maintain a dense network of rivers that flow all year. However, in the Chaco, and especially in its western tip, rivers and other water supplies are scarce.

The government of Paraguay is designed as a unitary representative and democratic republic regulated by a national constitution proclaimed on 20 June 1992. It is composed of three branches of government: executive, legislative, and judicial. The executive power is exercised by a president of the republic, who is elected by popular vote for a five-year period. The legislative power rests with the National Congress, which is composed of two Houses, one for Senators (45 members) and the other for Deputies (80 members). Members of both legislative Houses are elected for a five-year period. Judicial power is in the Supreme Court (9 members).

The economy of Paraguay is predominantly dependent on agriculture, which generates more than 25 percent of the gross domestic product (GDP), while industry accounts for about 20 percent, and services almost 50 percent.

An important fact to be noted is the significant deterioration in agricultural productivity observed during the last few decades, basically due to important changes in land use. Extensive areas of forest were eliminated, producing severe losses from an economic and environmental point of view. Enormous amounts of biomass were burned and fertile soils degraded by erosion and salinization. On the other hand, construction of big hydroelectric complexes like Itaipú and Yacyretá caused permanent flooding of significant amounts of high-quality productive land. All these environmental impacts have brought about significant societal consequences by forcing important migratory movements of the Paraguayan population to big cities in South America, mainly to Buenos Aires, Argentina.

In 1991, the Paraguayan population was about 5,405,500 inhabitants, 54 percent of whom lived in urban areas and 46 percent in rural areas. The population is basically composed of mestees (Spanish and Guaraní Indian intermarriage) and immigrants from different origins (Europeans, Arabs, Japanese, Chinese, etc.). These facts define a multiethnic and multicultural country with two official languages, Spanish and Guaraní. There is religious freedom, although the most dominant religion in the country is Roman Apostolic Catholicism.

Historical meteorological hazards

Basically, almost all natural disasters in Paraguay are related to climate. Because of its geographical characteristics, other natural phenomena such as earthquakes, landslides, or volcanic eruptions are unknown. Only climate extremes produce events with such a magnitude or severity that they could be considered disasters.

Heavy rainfall events during some seasons in different regions over the high La Plata River basin cause increasing streamflows in the Paraná and Paraguay Rivers, flooding almost all the riverside cities and small towns. This causes significant negative impacts, not only in the flooded areas, but also to the infrastructure in the country and, therefore, its economic and development opportunities.

Long-lasting droughts have occurred in Paraguay also. They are mainly associated with La Niña events. The most recent major drought was related to the 1999–2000 La Niña. This drought produced severe losses in the economy of Paraguay, especially in the agricultural sector with consequent negative societal impacts in rural areas.

Heatwaves related to high levels of humidity without rain are very common in Paraguay, which mainly affect human health, agriculture, and the raising of cattle. One example is the heatwave of December 1997, when nighttime temperatures reached values above 28 °C and daily maximum temperatures remained above 37 °C with very high air humidity. Frosts occur in autumn and winter (between May and September, but mainly in July and August) when outbreaks of polar air masses affect the South American continent, bringing significant losses in agriculture.

Severe thunderstorms are the most frequent natural hazard in the country. They are observed at any season of the year, but their frequency is considerably increased during the warm season, producing heavy rains, strong winds, and hail. The Alto Paraná area is under the influence of frequent tornado tracks, which produce severe damage in the area. However, studies about this phenomenon and early warning systems are virtually absent.

Level of scientific research in Paraguay relating to El Niño

In a general sense, scientific research in Paraguay has not had the relevance that it should have had, because there are no national plans for supporting the few existing researchers who are spread out in various institutions, mainly governmental. There are other high priorities determined by government, and scientific research is not considered one of them. As a result of these conditions, scientific research related to El Niño in Paraguay is very scarce, mostly nonexistent. Only in the past few years and especially after the 1997–98 event has some interest about El Niño appeared in scientific groups, mostly in universities. This will be a difficult task in the near future because of the lack of funds and a general trend of diminishing economic support for universities in Paraguay.

Before the 1997–98 event, little interest about El Niño existed in Paraguay, in spite of the devastating effects of the 1982–83 El Niño. It is very common among the Paraguayan population to have a fatalistic feeling that natural hazards are unavoidable. In the political sector, there was no concern about how to cope with future El Niño events, and the media only occasionally published articles about El Niño. Much of the information released by foreign or international news agencies about El Niño was not published by the Paraguayan media. They did not consider this subject as relevant enough to merit publication.

The 1997–98 El Niño event

Institutions that first received information about the onset of an El Niño event were the media, the universities, and the National Meteorological Service. This information came from the Internet and other international media and was mainly focused on the general aspect of the extensive warming in the tropical Pacific Ocean. Other relevant information obtained by the National Meteorological Service came from NOAA in the United States. Regarding the event and its expected impacts, the government's Directorate of Meteorology and Hydrology was continuously required by the media to corroborate all the information received. This institution and the media played an important role in warning the population about an unusually long-lasting rainy season accompanied by significant flooding.

The media's printed and broadcast coverage of the 1997–98 El Niño and its impacts was acceptable. They transmitted a considerable amount of information related to the event. However, the media in Paraguay are not knowledgeable about scientific matters, and they do not have the capacity to understand much of the scientific information. This led, in some cases, to misinterpretations of the actual facts.

Teleconnections

El Niño events bring significant anomalies in the atmospheric circulation patterns over southeastern South America, which includes the northern half of Argentina, the southern tip of Brazil, Paraguay, and Uruguay. Anomalous wind systems induce anomalous fluxes of water vapor and heat over the region. In general terms, in Paraguay positive rainfall anomalies attributed to El Niño are observed in the second half of the spring and in the autumn with a wet summer (October to May), especially in the eastern region and the lower Chaco. These anomalies are responsible for severe floods in the Paraguay and the Paraná River basins, affecting important riverside cities such as Asunción (the country's capital), Bahia Negra, Concepción, Alberdi, Pilar, and Encarnación. Temperature is also modified by El Niño-induced anomalies. Winter is anomalously warmer as a consequence of high humidity and atmospheric pressure is lower than normal.

The severe floods caused by the 1997–98 El Niño event were not as significant as those that occurred during the 1982–83 event. However, the 1997–98 El Niño left the people with the general feeling of having experienced the strongest El Niño of the twentieth century. The main reason for this conclusion can be found in the type of rainfall that accompanied this event. Thunderstorms were probably more intense than on other occasions, to such an extent that the 1997–98 El Niño in Paraguay was named as the "El Niño of the Big Rains." Rain and consequent flooding were the primary cause for many of the major environmental and societal damages in Paraguay.

Rains during this event reached very high levels in October, November, and December 1997, as well as in February, March, and April of 1998. In the south, during October and November, rains were above 1,200 mm, almost 260 percent of the historical average. In the same manner, rain over the eastern region surpassed 1,000 mm. During the March–April period, heavier rains were concentrated over the southeast, with amounts near 1,500 mm, nearly 400 percent of the historical average for this period.

Although El Niño is usually associated in Paraguay with high rainfall amounts (a climatological fact), it could also be associated with short-lived intense thunderstorms as well. It can be particularly noted that during the 1997–98 El Niño, the highest number of severe storms ever registered in Paraguay occurred. The biggest impact in Paraguay was the intense rainfall over almost the whole country. Due to this meteorological condition, many areas of the country were flooded by main rivers and their tributaries.

The country's infrastructure was severely damaged by floods and strong winds associated with storms during the 1997–98 El Niño. Damage by strong winds was registered, mainly for bridges, roads, and buildings, accounting for over US$48 million. El Niño impacts were particularly severe over the central region, due to heavy rains in Asunción and neighboring cities. From October 1997 to May 1998, rains in this area accounted for more than 190 percent of the historical average, exceeding rainfall amounts during the 1982–83 El Niño, which was 165 percent of the historical average. Electric power supply was very much affected by rains and winds as well, when a high number of power lines and towers were completely destroyed.

Impacts on ecosystems were significant, mainly in the Paraguay River basin and the Chaco, where extensive areas, never before flooded, remained under water for a long time, causing a high level of mortality among trees and other vegetation. Thousands of wild animals died in the flooded forest.

Fishing was severely impacted by floods related to the 1997–98 El Niño, producing a considerable decline in production, which strongly affected food supplies to the population and caused a disruption in exports. Agriculture was a major economic sector hit by El Niño. The agricultural campaign for 1997–98 suffered serious damage caused by heavy rains, strong winds, and hail. Crops were adversely affected from seeding to harvest, resulting in very low productivity. Loss estimates for eight major Paraguayan crops were over US$23 million.

With regard to human health, the number of cases of diarrhea and dysentery increased considerably because of poor sanitary conditions in affected areas and in temporary shelters. The government had to construct in a very short time more than 84 refugee camps, where sanitary conditions were far from adequate. Floods and severe weather related to El Niño brought a number of social problems such as losses in habitat, losses in jobs, insecurity, vulnerability to disease, etc. This is very common whenever a population has to be concentrated in shelters or relocated in other "safe" areas.

During the 1997–98 El Niño, 49 people died in Paraguay from different causes attributed to its impacts. About 7,000 houses were damaged, and 19,089 families were negatively affected.

Responses

One of the main responses from the government of Paraguay for facing El Niño's impacts was the creation of a special institution called "Comite de Emergencia Nacional" (CEN), which had the responsibility to coordinate emergency responses to disasters. CEN was created by a decree from the President who placed it under the umbrella of the Ministry of the Interior. Its main task was defined as follows: *To prevent and to cope with the effect of disasters created by natural agents and other sources, as well as to promote and coordinate actions in public institutions, municipalities, and the private sector for the prevention, mitigation, response, and rehabilitation of those communities affected by the emergency.* CEN has an executive director, a general coordinator, and 22 people for operational support.

Since October 1997, the government has received financial support from international institutes such as the UN Disaster and Assessment Coordination Team for developing different vulnerability studies, the creation of a Contingency Plan, and a proposal for a national system for disaster prevention. In spite of this effort, the magnitude of El Niño's impacts surpassed the actual funding available and, as a result, many responses could not be carried out. CEN was then forced to request additional financial support from other institutions such as the World Bank (US$16 million) and the Inter-American Development Bank (US$35 million).

CEN has been an instrument for the establishment of shelters and camps through the country for the affected population. However, government policy was supposed to reduce the time that people had to live in these emergency facilities. This was not a big problem in Asunción, where affected people remained near their jobs or had created new sources of income in the informal sector. The government had offered to move people to other urban areas in the city with more facilities available, but some people rejected this offer in order to remain near their sources of income. However, in the more isolated areas where people lost all their possessions and means for income, the situation became much more critical.

Conclusion

Climate anomalies related to El Niño are better understood now. Society's confidence in climate forecasting is growing and, consequently, climate impacts could be better estimated. The application of climate information to societal needs is improving. During the El Niño of 1997–98, meetings between climate experts and users of climate information increased and, hence, more interaction and mutual learning took place. Now, institutions working on climate predictions and climate applications have more opportunities for closer contacts with users. However, many aspects of climate prediction have to be improved in order to appreciably increase confidence in forecasts. We also must work hard to improve our information flow and teach people how to avoid misinterpretations of climate prediction.

Now there is a basic structure to cope with emergencies. The creation of CEN gave the country an institution capable of taking quick action in emergencies and capable of coordinating with other national and international prevention institutions. However, important obstacles still remain for better responses. Funds are lacking, and almost all institutions in Paraguay are unable to react to an emergency as soon as their assistance is needed.

The 1997–98 El Niño taught Paraguay a big lesson. In September 1997, a prediction emphasized the development of a strong event. However, different sectors of society spent too much time discussing and assessing the veracity of the El Niño information and information about its impact on Paraguay. A very short time later, many Paraguayans began to suffer calamities brought on by El Niño and, consequently, our society began to suffer its direct impacts. Our reaction was very delayed and reality overrode our potential actions. Capacity building for the development of El Niño- (and La Niña-) related contingency plans has to be considered if we wish to cope effectively with climate-related natural hazards. Considerably more human and economic resources are needed, if we are to reduce El Niño's impacts.

Lessons learned

El Niño events have a significant impact in Paraguay, producing heavy rains from spring to autumn with damaging floods in the Paraná and the Paraguay Rivers, among other effects. More specifically, the El Niño of 1997–98 caused unprecedented floods and economic losses in almost all sectors of the country. In fact, the El Niño event caused a decrease in the living standards of the Paraguayan population. Currently, national preparedness programs are undergoing a significant improvement in increasing the capacity of the country to face natural hazards. However, there still remain important limitations to fast and efficient response (especially funding limitations). There is no societal consciousness about hazards and the ways to face them. Some sectors of the population visualize hazards as "forces" impossible to predict or minimize. Scientific research has not held an important place in the societal structure of the country. There is no national program to support sciences in any field, and research about El Niño is almost nonexistent. There is still a lack of confidence about the reliability of predictions about ENSO's extremes and their impacts.

At the present time, El Niño can be predicted with enough lead time so that preventive and mitigative measures can be taken in response to disasters. Also, there is enough early warning to provide for proactive planning as opposed to reactive response. Preventive measures can save money for the government and people.

Because of this reliable teleconnection between El Niño and climatic variability in Paraguay, the authorities should consider El Niño as a direct influence on natural disasters in Paraguay. In this sense, it is very important to provide the economic and human resources to cope with this natural disaster, as well as to develop an appropriate contingency plan. El Niño information and climate predictions should be considered by the authorities for planning and decision making as a strategic factor to be included in social, economic, and environmental development plans.

There are recurrent and very well known El Niño impacts in Paraguay. Heavy rains and floods take place because of this phenomenon, generating enormous economic losses and considerable environmental and social damage. This happened during the El Niño events of 1982–83, 1991–92, and 1997–98, to mention just the latest ones.

There are well-known sectors of Paraguayan society that are most vulnerable to El Niño's effects. Among the most important are those living in slums or marginal areas, such as in the rivers' flood plains, especially along the Paraguay River and its tributaries. Major cities are built along this river: Bahia Negra, Concepción, Asunción, Alberdi, and Pilar. Along the Paraná River is the city of Encarnación, among others. Thousands of families live in these areas. Many of them had to be relocated to temporary settlements without proper sanitary conditions. It was difficult to avoid the problems of outbreaks of infectious diseases and illnesses, as well as other problems associated with these emergency settlements. The rural populations, the majority of which are farmers, became isolated by the heavy rains and floods and by the collapse of bridges and of other transportation and communication infrastructures.

The media (TV, radio, newspapers, magazines, etc.) played a fundamental role in the dissemination of information about the impacts that El Niño events could generate. The media should be used to better inform the population about threats. The media in Paraguay are not yet specialists in such topics. For their part, scientists have a responsibility to educate the media and decision makers at various levels.

The expansion of the country's agricultural frontier over the last few decades has been based on irrational deforestation and it has notably affected the regional hydrological balance. This increased the vulnerability of society when confronted by an El Niño event, especially El Niño-related floods and the deterioration of the environment (loss of agricultural land, soil erosion, etc.).

The 1997–98 El Niño and the disasters it spawned exposed a major lesson. In September 1997, when the scientific community announced the development of a strong El Niño event, the lack of reliability or credibility among policy makers in the forecast meant that decision makers did not take the necessary steps to prepare for El Niño's likely impacts. Society had to suffer the consequences.

Peru country case study: Impacts and responses to the 1997–98 El Niño event

Co-team leaders:
Gastón Antonio Velasco-Zapata
Instituto de Estudios Peruanos
Horacio Urteaga 694
Jesús María
Lima 11
Peru

Kenneth Broad
University of Miami
Rosenstiel School of Marine and Atmospheric Science
Rickenbacker Causeway
Miami, FL 33149–1098 USA

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Executive summary

During the 1990s, an advanced process of neo-liberal reforms was implemented, radically transforming the Peruvian economy. A significant part of public sector enterprises was privatized and the market became the dominant mechanism determining the allocation of resources and earnings. Twenty years of populism paved the way to one of the freest economies in the world. During most of the decade, Peru was able to attract significant foreign capital contributing to the equilibrium of the balance of payments, counteracting a trade balance historically and consistently in the red. Indeed, imports continue to significantly outpace exports because the neo-liberal policies have not transformed the structure of production.

Peru continues to be an exporter of raw materials. During the 1990s the mining industry and fishmeal exports made up to three-fourths of Peruvian exports, echoing the last 40 years. The worldwide financial crisis of 1998 was born in Southeast Asia, moved on to Russia and finally reached the shores of Latin America, plunging Peru into a deep recession which cripples it still, into the new millennium. That recession was aggravated by El Niño, but its cause can be traced to the limitations of the neo-liberal economic reforms of the 1990s.[1]

The government and El Niño

Members of the scientific community in Peru issued a forecast about El Niño in June 1997, prompting the central government to set in motion a plan of preventive measures. It was the first time that a plan of this nature had been implemented in Peru. In all the previous El Niño events, the government reacted in the midst of the El Niño-related Southern Hemisphere summer rains. This time there were six months of lead time to implement a structured plan whose main merit was, in fact, the timeliness of its preventive measures.[2]

This plan accurately defined how to handle the approaching problem. It established the goal of facilitating the drainage of the excessive rainwater into the ocean. A series of riverside levees to contain the surging river waters were constructed; water-pumping equipment was acquired, in order to alleviate the inevitable flooding of the very low-lying areas. The response of the central government was, perhaps, incomplete because it ignored the issue of financial assistance to enterprises battered by El Niño. The response did, however, include an exact definition of how to face the main problem.

The government's stumbling block proved to be a flawed consideration of the "how," because the central government wanted to do everything itself without the assistance of other governmental agencies or of society at large. The central government was interested in highlighting its importance as a guarantor of the security and prosperity of Peruvians. In addition, the government of President Alberto Fujimori wanted to highlight its efficiency and start paving the way for a third term in office without the interference of another agency that might question or dilute its leadership.

In Peru, lamentably, the state machine is centralized, and its core is afflicted with disorder and dispersion. There are too many public entities and their operational areas are ill-defined. So, turf wars, conflict, and competition are the daily bread, even in the inner sanctums of the executive branch. During El Niño, this conflict became apparent in light of the government's inability or unwillingness to designate a team leader to execute the work of riverside levees; keystone of the master plan set in motion by the government itself. In addition, a coordinator was not designated to manage the overall plan, resulting in general chaos, featuring a big corruption scandal. Peruvians have been afflicted with the authoritarian aspects of centralization, without enjoying its potential advantage for orderliness.

Government-sponsored institutions

INDECI (National Institute for Civil Defense) is a specialized institution of the executive branch in charge of civil defense against acts of nature. The Peruvian government in the 1930s first adopted the concept of civil defense. It was initially seen as an extension of the military's duties into the area of civil society at large. In 1972 the system of civil defense was enacted into law, having been modified in the 1980s and again in the 1990s, and that continues to be the bedrock of the government's policy in the face of natural disasters.

A small bureaucracy integrated by officials of the Peruvian army directs INDECI, in Lima as well as the provincial capitals. The system also determines the district-wide and local levels of responsibility of the mayors. However, the military is unaccustomed to consensus seeking and dialogue, while the mayors require consensus to carry out their initiatives.

In Peru, unfortunately, the army lacks a civil defense specialty. Consequently, the officers put in charge of INDECI lack specific training for their new job. After two years, these officers are rotated to new assignments and the new arrivals are, once again, lacking in the proper skills. Therefore, the INDECI has problems of management and stability, in spite of being overseen by the most solid institution in the Peruvian government.

There are four government-sponsored scientific institutions entrusted with activities related to the weather. They are SENAMHI (the National Meteorological and Hydrological Service), IMARPE (the Ocean Institute of Peru), IGP (the Geophysical Institute of Peru), and DHNM (the Hydrographic and Marine Directorate of the Navy). All these organizations belong to the executive branch, and are overseen by various agencies. They have a stable, coordinating organization dedicated to El Niño called ENFEN (National Study of the El Niño Phenomenon).

IMARPE is well aware that news of an impending El Niño leads to diminished investment in fishing. It is a time of panic for the various industries related to the harvesting of marine resources. Conscious of the importance of the fishing industry to the Peruvian economy, IMARPE is habitually cautious in the handling of information. For example, during the last El Niño, Marco Espino, the director of research in IMARPE told us that they had information of substantial fluctuations of marine resources as early as the Southern Hemisphere summer of 1997, but had waited until April before releasing information which amounted to a description of the initial (onset) phase of an El Niño without explicitly mentioning the name. It was only later on, after SENAMHI in June of 1997 explicitly used the term "El Niño," that IMARPE began to speak out on the topic openly.[3]

Scientific leadership in weather issues is held by the IGP, because its forecasting abilities offer significant advantages. Indeed, the IGP can issue forecasts that extend out for a full year, while SENAMHI's forecasts are for the following day.[4]

IMARPE and IGP have arrived at the Internet era, posting well laid out web pages that are updated regularly. The web pages of these Peruvian meteorological institutions offer ample information. Any journalist could put together a good meteorological section, accompanied by informative illustrations, by simply going to the web page and using the posted information. The problem is that there are no journalists with even a modicum of meteorological training that might allow them to understand the information on the web. This training should be carried out because of its key importance in the development of a national plan to disseminate for the purpose of making available weather information.

An evaluation of Peruvian scientists reveals the standout presence of a group of local experts that, in general, has been more accurate in forecasting than the big centers in Lima. The meteorologists in the provinces have taken advantage of the Internet to maintain a relationship with scientific research centers abroad. The increased communications with the international scientific community enhance the superior capability that researchers in the provinces have to observe changes in nature over time. In Lima the sky is always cloudy. The result is that some local scientists have been more accurate than the highly reputed investigators of the capital.

Many seminars and professional debates were held during El Niño. They were usually organized by the municipalities and could also count on the collaboration of the NGOs. Not surprisingly, the quality of these forums was very uneven, with some having been very productive and others quite the opposite.

The media and El Niño

In contrast with the high quality of weather programs in other countries, our lack of interest in the weather has made our underdevelopment in this area evident. Weather reporting in Lima is a minor and unelaborated subject. Another element to be considered is the political value of El Niño and the intense partisan struggle that it unleashed. In effect, the government tried to showcase the efficiency of its plans and highlight its efforts, while the opposition pointed out the opposite.

A lot of media coverage, often contradictory, was given to El Niño during the preventive phase between June and December 1997. A multitude of experts engaged in a somewhat confused public debate on the weather. The topic was the magnitude of the coming rains. The entire country was listening in on the debate between the scientists, including the elite and the decisions makers, on this increasingly important matter. The memory of the highly destructive ''Mega Niño'' of 1983 was still fresh in their minds, and the concerns of the public and of the government were justified.

Exasperated by the complexity of the debate on the intensity of the future rains, in September 1997, the executive branch reacted. President Alberto Fujimori ordered the state-sponsored scientific institutions to speak through one official spokesman. It was agreed that ENFEN would be the only entity authorized to emit an official opinion on behalf of the government.

This debate bombarded the public with scientific opinion and speculation. The focus of the debate was correct, because it was important to forecast as accurately as possible when and where the rain would fall, how much, etc. The problem was that the debate was limited to abstract scientific speculation, without embracing the concrete problems facing the citizenry. The citizenry did not receive guidance on what to do to protect itself under any of the scenarios contemplated by the experts. During the preventive phase, the scientists were not focused on formulating practical advice for families. They took refuge in their theories, many of which did not agree with each other.

Television coverage improved during the course of El Niño. In December 1997, a TV program directed by Abraham Levy and broadcast from America Satel, used visual techniques showing weather variations over time, a first for Peruvian television even though it is widely used in North America.[5] The America Satel experience demonstrates that TV has the technical means to make weather information available and it could offer very attractive weather programming which would be particularly welcome in the provinces. This has not yet happened, however, because everything revolves around Lima.

The radio-listening audience is quite large in Peru, especially in the blue-collar sectors. In a survey carried out by the Institute of Peruvian Studies (IEP) it was found that 74 percent of the Peruvian workers from these sectors regularly turned to the radio as a source of information. The same survey found that 82 percent of the workers watched TV frequently as a source of information. The audiences are thus pretty even, making it clear that both media compete and that radio has not lost its vitality.

The press is a singular domain whose rules are, in part, different from those that govern TV and radio. Excepting the so-called "chicha" dailies, most of the newspapers are directed to the middle class. The influence of the press, therefore, is of key importance in that it targets diverse elites, albeit lacking reach into the larger population mass.

The experience of the last El Niño burst upon a communications media ill-prepared to handle weather-related news, suddenly taking on major proportions. When this happened, El Niño became headline news for almost two years, even though it was highly politicized. In the end, however, it did not bear permanent fruit: Peru continues to be without professional reporting of meteorological issues in the news media.

Except for the occasional article in a scientific journal, the topic of El Niño had been absent for several years, at least in the mass media. El Niño had ceased to be news of current relevance in spite of the prolonged, if moderate, El Niños of 1992 and of 1994 that had only sporadically been mentioned in the press. In the early 1990s, El Niño was perceived as a potential threat that had not materialized.

Teleconnections to the southern Sierras

It was a well-known fact that El Niño, in addition to its direct effects on the northern coast caused by the increased ocean temperatures in the eastern tropical Pacific, had an indirect effect, due to atmospheric alterations, on the high Sierras – far from the sea. These teleconnections seemed to bring about droughts in the southern Sierras every time that the northern coast received heavy rainfall. The drought during the 1982–83 El Niño was a notorious fact. A less severe drought had occurred during the moderate 1972–73 El Niño. In 1998, however, a drought in this region did not materialize, disparaging news to more than one noted Peruvian scientific institution.

One of the goals of the government's drought response plan was to sow 15,000 hectares of fodder (i.e., grass) before January 1998 in Puno. Given that the drought did not occur, it would seem that, logically, these programs died out. On the contrary, they have proven to be quite successful. It so happens that the scarce amount of land devoted to fodder and the heavy overgrazing of natural pastures is a perennial problem of the cattle industry in the Sierras. Therefore, although the plan was developed to confront a drought crisis that did not materialize, it was successful because its goals addressed structural problems that needed to be confronted.

Societal impacts linked to the 1997–98 El Niño

El Niño has laid out a very tough challenge to Peruvian agriculture. An impoverished sector has had to support the embattlement of nature by whatever means. Farm losses have multiplied and have many causes, among which is the destruction of arable land. Thousand of hectares of farmland were washed away by swollen rivers, leaving deserts where farms used to be.

El Niño also silted up canals and drainage systems, and generally wreaked havoc on the system of irrigation. Consequently, agricultural output for the 1998–99 season was poor. During this period, however, the main irrigation systems of the coastal basins were rebuilt. The government's expenditures on reconstruction have been evident in that area.

Throughout 1997, the Ministry of Agriculture (MINAG) followed a proactive policy to protect the irrigation and drainage infrastructure, undertaking several civil engineering projects. The MINAG did not, however, address two important problems facing pre-El Niño 1997–98 agriculture: agricultural credit and technical orientation. Some products were doomed at the outset, but the northern farmers believed that rice would be a viable crop. Unfortunately, the farmers could not conduct a massive rice campaign in 1997, due to the lack of available credit to purchase supplies. They were finally able to do so in 1998, after arduously scraping up some capital. The results were not good. There was overproduction in 1999 and rice prices plummeted. To top it off, the Fujimori government, ever faithful to its neo-liberal politics, allowed rice to be imported from Southeast Asia at a time when they were exporting all that they were able to in order to alleviate their own economic crisis. Everything went wrong in the Peruvian rice business. The producers were harmed by the fall in prices and the importers were equally harmed by the same phenomenon that all the parties had inadvertently created.[6]

Next to El Niño, plagues have been one of the principal problems facing Peruvian agriculture. The elevated temperatures that "tropicalized" the winter season along the coast gave rise to new pests and crop stress starting in 1997. In 1996, the Peruvian coast had been distressed by a very cold winter and a very dry summer. After the 1997–98 El Niño, the plagues returned with a vengeance. Vermin decimated crops in the 1998–99 season and continued being dangerous into the year 2000, affecting many valleys and a variety of crops.

The availability of credit constitutes another of the major problems facing Peruvian agriculture that El Niño exacerbated considerably. From the 1930s until the early 1990s, there was an agricultural bank linked to the state. This bank was the great enabler and was well managed for many years, making it an effective economic agent that granted the minimum of credit necessary for the continuity of business. During the five-year government of Alan García, 1985–90, this bank was managed very poorly and was used extensively to further political ends. In the early 1990s, the credit institution was technically bankrupt and the government opted to liquidate it.

It is clear, however, that after the previous "Mega Niño" of 1983, there was an agrarian bank that financed the crop campaigns in 1984 resulting in a faster recovery of the sector. This time around, however, Peruvian agriculture had to face the aftermath of an El Niño without the presence of a solid credit institution. The 1997–98 El Niño has deepened the problem of agrarian credit, one of the structural weaknesses of Peruvian agriculture.[7]

Highways

The infrastructure of highways and roads was directly and negatively impacted during the last El Niño. This network extends for 75,000 km in Peru. A great majority, 50,000 km, are little more than dirt roads and trails. Only a third of Peruvian highways are either gravel or asphalt. Most of the 10,000 km of asphalt roads are in the Pan-American Highway that runs along the coast. Seen as a group, this network is very inadequate because its extension is limited compared to the size of the country. In addition, 80 percent of the merchandise in Peru makes use of the highways and roads. In that regard, the economic importance of the road network is immense, in spite of its inadequate size. Unfortunately, that same limited road network was severely battered during the last El Niño.[8]

Transportation companies and merchants have been hit hard by the vulnerability of the Peruvian highway system. The most affected, however, have been the towns and villages that were left isolated by El Niño. For example, the *Solidarity Bulletin* of Chiclayo noted dozens of cases, among which was a testimony published from Canchachalá in the mountains of Ferreñafe. Seven small villages found themselves cut off without adequate food or supplies. The task was immense and they faced structural problems of great magnitude that were impossible to solve in the short term. The highways cross a multitude of riverbeds inappropriately termed "dry," which they are in a normal year. In an El Niño year, however, these dry riverbeds channel an avalanche of water and mud, cutting the highway at several points. The solution of the highway engineers to deal with the dry beds that cut across highways is to build a pontoon. During an El Niño, the pontoons overflow and the water runs beside the highway eroding it. This explains the television images during El Niño showing a line of trucks traveling single file over severely eroded highways that had become but a thin shred of asphalt.

The strategy to protect bridges faced still graver problems. In effect, the bridges of the Pan-American Highway had been designed for relatively minor flows of water, much less than those that a "Mega Niño" would bring. For example, the famous Bolognesi Bridge in Piura collapsed when it was subjected to a flow four times greater than the maximum for which it had been designed. The magnitudes are so high that it is easy to understand that this type of problem could not be solved with a few months of warning and that it was not just a question of trying to gain a few extra months. The cleaning of riverbeds and drainage channels and shoring up the foundations are certainly useful operations, but insufficient if the bridges are designed for very low water volumes. Thus built, the bridges will inevitably collapse.

In 1998, for example, in the Department of Lambayeque six bridges collapsed, five of which had been reconstructed after the 1983 "Mega Niño." There are no easy answers and it is necessary to find intermediate solutions that might even include the altering of the course of some highways in order to avoid very low depressed areas where the "dry" riverbeds pose a heightened threat to bridges.

Some positive cases also point out that the most important decisions were those made during the reconstruction phase of the 1982–83 event. The highway that joins Piura with the port city of Paita, a 50 km stretch, is a triumph of forward thinking. The torrential rains of the 1983 El Niño created a lagoon that completely submerged this highway, cutting off Piura from its supply route. A period of famine and desolation ensued. Later on, the highway to Paita was rebuilt on a high embankment and rerouted around the lagoon-prone area. Thanks to these well-learned lessons, the 1998 El Niño did not isolate Piura from its port, and the highway stayed open in spite of the inclement weather. Coastal marine trading was enough to stave off another famine.

Fisheries

IMARPE managed the 1997–98 El Niño in a more prudent manner than it had done in earlier events. It did not allow over-fishing in 1997, before the warmer temperatures had set in. The marine biota withstood the trauma with enough vitality left over to bounce back after only two bad years. Biological normality returned to the seas by the third year. Actually, the two bad years were not really terrible because the catch still amounted to half of pre-El Niño levels. Its management of the marine biota during this El Niño has enhanced IMARPE's reputation.[9]

The financial difficulties facing the fishing industry are daunting and El Niño has aggravated them considerably. These difficulties are a consequence of the privatization process. This privatization process consisted in the auctioning off of the state-owned enterprises that were in turn formed by the expropriations of the sector in the early 1970s. The fishing industry was sold piecemeal, that is, each plant was sold separately which translated into a cost of entry that allowed many Peruvian industrialists to participate. In sharp contrast to all the other economic sectors that were privatized at the time, the fishing industry stayed in the hands of nationals with new, as well as the reappearance of old, managerial groups.

Technically the whole industry is in bankruptcy and some analysts maintain that El Niño has caused their financial situation. Another point of view, however, is that El Niño has merely revealed the fragility of a privatization process that favored Peruvian industrialists who had leaned heavily on Peruvian private banks. The debt was based on an excessively risky calculation that only contemplated a continuum of good years and made no provisions for safeguarding against the lamentably confirmed possibility of three bad years in a row.[10]

Prevention phase – 1997

As previously noted, the government's preventive plan consisted of civil engineering projects of riverbank fortification. Infrastructure protection was the government's *leitmotiv*. This strategy had virtues and defects, the main drawback being the absence of a plan directed at revitalizing production, which fell into severe recession. The preventive strategy itself, however, was very poorly implemented due to a centralist and individualist mindset abetted by a high degree of bureaucratic disorder. Overlapping areas of responsibility are one of the endemic secular afflictions of Peruvian bureaucracy that only got worse during the last El Niño.

Topping this state of affairs were the many delays in getting the civil engineering projects going, thereby diminishing their timeliness. The president acted quickly, but even he had to contend with the slow-moving wheels of the executive branch. For example, the drainage projects for El Niño in Piura did not get started until 9 August. These high-priority projects for the area that was going to be hardest hit still had not commenced as the emergency rolled into its seventh week.

Emergency and reconstruction

The emergency phase in the summer of 1998 was the critical period when all the proverbial Horsemen of the Apocalypse visited Peruvian territory.

The government's strategy during that period was to run in the face of each difficulty. At first, President Fujimori wanted to personally witness each one of the situations as they arose. Later, he understood that this was impossible and divided his attention between the various ministries. Fujimori did not include provincial mayors or other local authorities in the committees entrusted to carry out the daily fight of the provinces during the emergency. On the contrary, the president simply delegated his personal authority to his ministers. Again, the government persisted in its attitude of doing everything itself.

The government's reconstruction efforts have been considered a continuation of the civil engineering projects of prevention. The government saw itself as simply restoring the lost infrastructure at what was perceived to have been a very slow pace. It formed a committee entrusted with the reconstruction effort called CEREN (National Reconstruction Committee) in June 1998. This committee is presided over by the engineer Alberto Pandolfi, a minister who has held many positions in several of the cabinets of the Fujimori government and who has been a key figure in the adoption of policies on El Niño.

Former President Fujimori defined the role of the government during the reconstruction as that of a contractor and blocked other possibilities. The government's efforts have been so slow that they were not (as of this writing) even restoring the destroyed infrastructure, not to mention the linking of these efforts with regional development.

What actions might have been taken given a forecast in October of 1996

This is difficult to suggest because it deals with assumptions and not an analysis of facts. We are inclined to believe that nothing different would have occurred. The central government would have applied a similar plan, based on prevention with the same established goal, that is to say, facilitate drainage through a civil engineering project to shore up and protect the riverbanks. The problems that plague the inner workings of the central government would have been intact, as well as the tensions with the other institutions that represent local interests. These dynamic relationships define the structure of society and of the government in Peru. Six months of extra time to prepare would not have altered these old, strongly rooted political habits.

The only significant probable change is that scientists would have had extra time to organize their debates. But, as we mentioned, their lines of communication with the politicians were very weak. The latter make decisions without bothering to listen to the scientists. None of this would have changed with an earlier, even perfect, forecast.

The most proactive institute in promoting a relationship between the scientific community and society has been the IGP. For example, in November 1997, the IGP organized an important seminar with Piura's managerial community to debate new investment opportunities that might open up with El Niño. This seminar was well attended and the managers were eager to participate. The forecast of the IGP director, however, called for a moderate El Niño with rainfall levels of less than 1,000 mm, when in reality they exceeded 4,000 mm. What frustrated this interesting experiment was not the lack of time to implement the IGP's recommendations, but a forecasting error by scientists.[11]

Main strengths and weaknesses of the Peruvian government's response to El Niño-related problems

The study of the last phenomenon of El Niño in Peru has allowed us to x-ray the attitudes of society and of the government when confronted with natural disasters. First, we have the government's analysis, seemingly very quick to respond to the early warning signals and poorly organized for long-term prevention. Indeed, after receiving the forecast for El Niño, the state developed an integrated plan in short order and the presidency of the republic displayed unusual energy to implement it. However, the inertia of the government to face natural emergencies derives from the lack of an efficient organization and the tensions that exist with other domains of political and social power.

The northern coast's business community that was severely battered by El Niño has yet to receive the priority attention that it deserves from the government. Its capacity to react has also been limited. The weakness of the regional bourgeoisie in the provinces was confirmed when they were unable to participate in the economic effort of prevention and much less in that of reconstruction. This economic effort has fallen almost entirely on the central government.

The dialogue between the scientists and the politicians is inadequate or non-existent. The scientists lack the means to make themselves heard by the politicians. Only when the latter summon them can they converse, but no political decision of the government is subject to the input or opinion of the scientists, who are employed by the same government to study those same issues. The politicians consider the scientists to be *rara avis*, who do not deserve any measure of attention.

The government's reconstruction policy implemented during the post-

Niño does not seem to be the most adequate. The government created CEREN, the ad hoc entity that evaluates projects, requests bids, and then contracts out reconstruction work to private industry. The dominant characteristic of their work has been slowness and inadequacy causing numerous frustrations in the affected provinces. Reconstructing the irrigation and highway infrastructures has been the *leitmotiv* of the government in this period.

Lessons learned

- The ENSO warm event should be considered as a recurrent event in national planning (e.g., in civil defense, urban zoning, construction codes), rather than as an anomalous and unusual condition.
- Increased coordination among governmental scientific agencies concerned with the dissemination of El Niño information would result in a more coherent message for the public to act upon.
- Scientific institutions and government agencies must engage and educate the media so that they can convey their messages more clearly and minimize misinterpretation of ENSO information.
- It is misleading and dangerous to base preparations for an El Niño event that has been forecast solely on the impacts of the last event (regardless of its magnitude).
- The centralization of early warning and response activities in Lima, Peru hinders effective action in the provinces during crisis situations.
- Early warning of El Niño events will not enable the prevention of negative impacts and the exploitation of positive impacts if larger (i.e., more basic) structural changes related to economic and political development are not undertaken during non-El Niño periods (e.g., credit availability, transportation and health infrastructure, education).
- With the exception of Peru's northern coastal areas, there is inadequate scientific understanding of El Niño's teleconnections to different geographical regions within the country.
- Dialogue between decision makers and scientists ranges from inadequate to nonexistent, in large measure because of the poor opinion they have of their scientists.
- Financial assistance from the central governments to the regions that have been adversely affected must be improved upon in order to remove delays.
- The parts of the country that are usually affected by El Niño must receive priority attention from the central government. They must be directly involved in the planning of preventive, mitigative, and adaptive responses to El Niño-related hazards.

Notes

1. Refer to Efrain Gonzales (1998) for a treatise on the Peruvian economy in the 1990s.
2. We have explored the government's preventive plan in a book (Zapata and Sueiro 1999).
3. See *El Comercio*, 6 June 1997, p. 1.
4. The scientific activities of the IGP are described interestingly in its annual report (IGP 1997).
5. A preliminary overview of the role the media played during the 1997–98 El Niño can be found in Zelada (1998).
6. Overproduction and falling prices continued to affect Peruvian agriculture in the post 1997–98 El Niño era. This resulted in a dramatic fall in the price of potatoes, engendering significant rural rebellious activity. The latest agrarian strike in Andahuaylas clearly bears this out.
7. Both Alberto Fujimori and Alejandro Toledo, candidates in the May 2000 Peruvian runoffs, made public their decision to rebuild the agrarian bank, if elected.
8. A report on the impact of El Niño on the highway infrastructure was published by the Colegio de Ingenieros del Peru (1999).
9. The Fisheries Research Director of IMARPE, Marco Espino, was intensely involved in the scientific debate on the impact of El Niño. An example of his work can be found in Espino (1997).
10. Juan Carlos Sueiro has written several articles tracking the development of the financial crisis of the fisheries sector for *Analisis Economico* magazine. A somewhat different reading can be found in *Pesca*, a publication headed by Alejandro Bermejo.
11. Interview with Ronald Woodman, May 1998.

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Philippines country case study: Impacts and responses to the 1997–98 El Niño event

Team leader:
Sanny R. Jegillos
Director Asia Operations
Asia Pacific Disaster Management Center
No. 72 The Colonnade Residences
132 Legaspi Street, Legaspi Village
1229 Makati City, Metro Manila, Philippines

Team members:
Manny de Guzman (Office of Civil Defense)
Aida M. Jose (Climatology and Agrometeorology Branch)
Rose T. Perez (Natural Disaster Reduction Branch)
Fred Carpio (Department of Environment and Natural Resources)

Executive summary

The main purpose of the project was to enhance the understanding of El Niño issues through a review of current early warning and preparedness systems in national, regional, and global contexts; and through an assessment of the vulnerability of various socio-economic sectors and the information needs of decision makers in these sectors. Based on the assessment and the review, the project yielded preliminary guidelines for regional and national preparedness for El Niño events and their impacts. It also served to spark interest in initiating programs for capacity building for the international, academic, scientific communities and the media.

Socio-economic setting

The Philippines, located in Southeast Asia, is an archipelago of 7,107 islands. It is home to 76 million people and is one of the most populous countries in Asia and the world (Department of Environment and Natural Resources 1999). While most of the population still reside in the rural areas, urban migration has increased steadily. In 1996, the total urban population constituted 55 percent of the total national population. The capital Manila, with its continued influx of rural migrants, has become a very densely populated place, more crowded than capitals Tokyo or Paris, according to various studies. About 13 percent of the country's population resides within Manila's limited land area, representing a mere 0.2 percent of the country's total land area.

From 1991 to 1996, economic indicators reflected national growth. Since 1991, the gross national product (GNP) and gross domestic product (GDP) have been on upward trends. In 1996, GNP grew to 6.9 percent and GDP to 5.7 percent. Despite the financial crisis of 1997, GNP registered 5.8 percent and GDP 5.1 percent.

In 1998, according to a report by the National Economic Development Authority (NEDA)[1] GNP grew by 0.1 percent. Meanwhile, GDP declined by 0.5 percent. The strong growth (12.9 percent of net factor incomes from abroad, which accounted for the difference between GNP and GDP) enabled overall output to achieve positive growth. The GDP contraction in 1998 was caused by the 6.6 percent drop in agricultural production, and the decline in construction and construction-related manufacturing by 9.5 percent. El Niño caused negative impacts on agricultural outputs in the first three-quarters of 1998. Palay, as well as other cash crops like coconut and sugarcane posted double-digit declines in the fourth quarter.

The country's Human Development Index (HDI) ranked ninety-eighth (out of 174 countries), according to the UNDP's World Development Report 1998, ranking lower than China, Thailand, Malaysia, and Singapore. Poverty remains to be the country's biggest problem with more than one-third of its people living below the poverty line. A disparity in the country's human development has also been noted in the different regions' HDI ratings: Manila ranks the highest and the southernmost regions, the lowest. The figures indicate unequal growth from improvements in the economy over the last ten years. Per capita income figures also show disparity in wealth and in development distribution in the Philippines, with Manila residents earning much more than residents of other areas (Alegre 1996).

Life expectancy in the Philippines increased from 66.5 to 68 years during the period 1992 to 1997. Basic health indicators have also improved. Communicable diseases such as acute respiratory infections showed a downward trend, as did the incidence of diseases associated with unsafe water supply and poor sanitation. Leprosy and malaria have ceased to be major public health problems.

The Philippines is vulnerable to many natural hazards. It is affected by tropical cyclones, volcanic eruptions, El Niño and La Niña episodes, earthquakes, tsunamis, droughts and floods. The worst of these disasters have caused the loss of human lives, homes and livelihoods, and resulted in economic disruptions in billions of Philippine pesos. In the last decade alone, the world witnessed the impacts on lives and property of a large number of Filipino communities because of the Mt. Pinatubo eruption in 1991, the earthquake in 1990, and the Leyte-Ormoc flash flooding in 1991.

The government responds to these climate-related impacts through at least eight major mechanisms. One such mechanism is the National Disaster and Coordinating Council (NDCC) of the Department of National Defense. This acts as the lead coordinating agency tasked to prepare for and respond to disaster situations. It partners the Department of Science and Technology through the Philippine Institute of Vulcanology and Seismology (PHIVOLCS) and the Philippine Atmospheric, Geophysical and Astronomical Services Administration (PAGASA) in delivering timely information to other government agencies, particularly the local governments, for their quick response.

The 1997–98 El Niño event

In anticipation of the 1997–98 El Niño, Filipino scientists and officials monitored the occurrence of known climatic indicators of ENSO's warm extreme such as the following: the delayed onset of the rainy season, weak monsoon activity, weak tropical cyclone activity, and less than average number of tropical cyclones entering the Philippine Area of Responsibility. Areas of vulnerability were identified and classified according to low, moderate and high.

Tracing and assessing the flow of information on the 1997–98 El Niño

PAGASA provided early warning about El Niño as of 1995 (Aida 1999); the first drought advisory in May 1997; and from May onwards, provided a monthly weather outlook to the Inter-Agency Committee for Crisis Water Management, and to the Presidential Task Force El Niño. A presidential directive, sent out to government agency heads in June 1997, enforced the monitoring of the development of El Niño closely. This resulted in concrete plans by key agencies to respond to the event.

The country also cooperated with international initiatives and sent a delegation to The Asian Regional Meeting on El Niño-Related Crises to discuss a regional climate outlook and opportunities for international cooperation in managing and reducing the effects of El Niño.

The print and broadcast media gave wide coverage of El Niño. This coverage could be classified in three stages: first, projecting impacts and identifying vulnerable areas, giving information and advice to the public about how to cope with the effects; second, reporting the actual impacts as they happened, and monitoring the responses of the disaster coordinating councils and local governments; third, in retrospect, providing analysis and assessment on the effectiveness of government interventions. The media received a brief assessment of their own role in reporting El Niño, specifically their uncritical reporting of conflicting figures on damages.

Teleconnections

Scientists have observed El Niño's teleconnections in the country to be strong. While more studies on El Niño are needed, existing research indicates that changes in rainfall pattern associated with El Niño, temperature fluctuations and wind fluctuations have impacted on the country's water resources, coastal resources, forests, and people's health.

The 1997–98 climate-related physical and social impacts of El Niño

The 1997–98 El Niño struck as the country was enjoying a continuous four-year growth. The effects and impacts of the 1997–98 El Niño episode were significant in the areas of physical environment (including water supply and forest/bush fires), health, and on economic aspects (reduced productivity and revenue for agriculture, reduced hydroelectric power).

(a) On the environment

- *Weather*. El Niño caused a dry spell between June and October 1997 and this lingered until June 1998. Drought affected 68 percent of the country, compared to only 28 percent in 1972 and 16 percent in 1982. El Niño dissipated in July–August 1998. Its effects, however, continued to be felt through mid-September (i.e., delayed tropical cyclone activity, recorded rainfall fell into the less-than-10-percentile rank).
- *Water supply*. Both urban and rural households in many parts of the country experienced a dwindling water supply. The lack of rain affected water reservoirs dependent on surface water sources. The multipurpose Angat Dam, servicing Manila and its environs, reached critically low levels so that the government's Metropolitan Manila Water Supply and Sanitation (MWSS) enforced drastic conservation measures such as the following: reduction of water supply by approximately 10 percent; shortened water service by four hours daily; repaired leaks and sanctioned water users with illegal connections. Water for irrigation of some 27,000 hectares of rice and corn paddies in one province was cut off, affecting 15,000 farmer households, which lost an estimated 100,000 metric tons of rice.
- *Forest/bush fires*. A total of 9,400 hectares of second growth and/or logged over forest burned in 1997–98, including 70 pockets of forest

fires in Palawan province, home to some endangered species. Estimated cost of damage was P150 million. No virgin forests were reported to have been affected.

(b) On social/health aspects

With the lack of drinking water and the prevalence of unsanitary hygiene conditions, communities were prone to communicable diseases. The extreme heat added to the deterioration of people's health. Outbreaks of malaria, dengue or H-fever, diarrhea and cholera were reported by early 1998. Acute malnutrition was prevalent among indigenous peoples (Aida 1999: 8). There were 72 reported deaths; 42 people had died of food poisoning from eating root crops not well prepared for human consumption (Tabang Mindanaw Secretariat 1998).

(c) On economic aspects

In the second quarter of 1998, the Philippine economy registered a GDP growth rate of only 1.2 percent as compared to a GDP growth rate of 5.6 percent over the same period in the previous year, reported NEDA. It was the economy's worst performance since 1992. However, the El Niño event was not solely to blame, as the Asian financial crisis contributed to its negative effects.

- *Reduced productivity and revenues.* The country's aggregate agricultural output dropped. In the first half of 1998, production shrunk by 7.15 percent of the target, considered the lowest in 20 years. Rice and corn production, respectively, declined by 43.6 percent and 26.6 percent of average production during the period (Aida 1999: 8). Coconut production was cut by 10 percent (*Food and Agribusiness Monitor* 1998). The Philippine Crop Insurance Corporation (1997) reported a 21 percent dip in rice insurance enrolment from P1.4 billion in 1996 to P1.1 billion in 1997 but reported increase in insurance enrolment by corn farmers and farmers of drought resistant crops. PCIC believes that this was attributed to El Niño.

  Fisheries incurred P7.24 billion in losses as of November 1998. El Niño led to dried ponds, constricted production cycles, stunted growth, and high mortality rates caused by stress, disease, and poor water conditions (Philippine Crop Insurance Corporation 1997).
- *Reduced hydroelectric power.* The small hydropower plants were the hardest hit by El Niño. The Department of Energy reported that from a high of almost 19 percent of total power generation from hydropower plants in 1992, its share went down to only 1 percent of total in 1998. A corresponding increase in thermal plant operation was estimated at an additional consumption of 313,145 to 439,363 barrels of fuel oil (Department of Energy 1997–98).

Responses

The government responded by creating a Task Force El Niño. This inter-agency body sought a better planning and implementation approach to be effective. With a comprehensive action plan drawn up, the Task Force needed an initial budget of P80 million to support a full-blown tri-media campaign. Within different agencies, other budgets were allocated for El Niño-related projects.

The work program of the Task Force focused on interventions in agriculture, domestic water supply, environment and other sectors (health, energy), and on the information/education/communication campaign.

(a) Agriculture

The government worked on the rehabilitation of communal/national irrigation systems; construction of small farm reservoirs; purchase/installation of shallow tube wells; small water-impounding dams; providing direct assistance to farmers; cloud-seeding operations; and research and development projects.

(b) Domestic water supply

The government identified and closely monitored 26 vulnerable areas and six major dams; prioritized projects worth P7 million for critical local water districts and for acquisition of water tankers to service locations dependent on surface water sources;[2] The National Disaster Coordinating Council provided P200 million from the Calamity Fund for the projects of the action plan (drilling of 20 new wells, rehabilitation of 53 existing wells, acquisition of 72 stationary tankers and nine mobile tankers; purchase of chlorinators, etc.).

(c) Environment

The Department of Environment and Natural Resources (DENR) launched a massive tri-media campaign against slash-and-burn farming (*kaingin*) and the prevention of grassland and forest fires in conjunction with the Philippine Information Agency. The DENR employed a 3,326-strong team of forest fighters to protect over 15.9 million hectares of forest land.

(d) Health sector

The Department of Health implemented an intensive health education campaign on personal hygiene and proper storage of water, among other activities.

(e) Information/Education/Communication (IEC) campaign

The communication strategy involved all government agencies in the IEC campaign. For example, the Department of Interior and Local Government conducted community education sessions through Water Sanitation task forces. The Philippine Council for Agriculture Forestry and Natural Resources Research and Development (PCARRD), the research arm of the Task Force El Niño, conducted training and seminars, and policy advocacy meetings. The Philippine Information Agency (PIA) provided news bulletins and carried out its own full-blown campaign in both rural and urban centers.

Outside of the government response, the private sector provided aid to at least 985,000 families through the Tabang Mindanaw campaign. As an informal collaboration of Catholic Church dioceses, non-government organizations, corporate foundations, media and the Mindanao Presidential Action Group, the group quickly used its existing network in affected local areas to provide relief assistance to tribal communities. It effectively mobilized more than 8,000 volunteers to assist in rice distribution and medical missions, and solicited cash resources amounting to P92 million for the benefit of 255,000 tribal families.[3]

Forecasting by analogy

Timing of information dissemination

PAGASA's early advisories on El Niño received full government attention following a memo of then-President Ramos to the Cabinet Secretaries of Environment and Agriculture and following the conduct of the National Caucus on the El Niño Phenomenon. The dissemination of information on El Niño increased significantly with the creation of the Task Force El Niño, aided by an allocation of funds for an intensive information education and communication (IEC) campaign. Because of a very dynamic local media that also covered international news extensively (e.g., CNN, BBC), information about El Niño was abundant.

Quality of information

While the flow of information was abundant, the quality of information being disseminated needed improvement, to wit:

(1) Messages needed to be corrected such as those linking El Niño with global warming, giving conflicting information on the beginning and end of the drought, relating global impacts of drought in the Philippine context, and notifying high-risk planting dates as low-risk planting dates.

(2) Two public surveys[4] reflected the people's increasing knowledge about El Niño and what they could do as it affected them. However,

people rated as low the government's actions to inform and prepare vulnerable sectors.

The National Disaster Coordinating Council (1998) assessed the government's difficulties related to information flow as:

- The lack of a monitoring system and information dissemination by local disaster coordinating councils.
- Non-compliance of local government units with the proper channel of reporting, so that feedback to higher-level disaster coordinating Councils was not sustained, but irregular and delayed.
- Non-synchronization of disaster assessment reports.
- Lack of communication and transportation facilities.

The above difficulties contributed to the government's weak response to vulnerable areas in the southern Philippines, areas that had not originally been identified as prone to the effects of El Niño.

The development and implementation of an effective set of actions to minimize the impacts of El Niño may have been unintentionally prohibited by the following factors: perception, policy, and vulnerability assessment and decision-making.

Perception

To most Filipinos, a severe drought scenario seemed improbable. Thus, actions were taken only when clear and obvious manifestations of drought already prevailed. But these actions were limited by the availability of economic resources that are constantly stretched to the limit by the occurrence of frequent disasters. Coupled with competing budget priorities, advocates for increased resources for disaster prevention, mitigation, and preparedness have found it a big challenge to convince policy makers to increase investments in order to minimize the likely impacts of El Niño.

Many Filipinos also perceive that the national government has to provide the solutions and resources to disasters, although local and community-based solutions are also effective in minimizing the impacts of El Niño.

Policy

Prior to the El Niño 1997–98 episode, the general public and most government administrators had fully accepted that pre-disaster actions (prevention, mitigation, preparedness, or PMP) are better than post-disaster actions (relief and rehabilitation). However, the national calamity and disaster preparedness plans and policy still prohibit the implementation of effective PMP programs. For instance, funds for disaster-related programs can only be allocated upon a declaration of a state of calamity by the national and/or local government.

The current policy also needs to be supported by a *contingency plan* specific to a particular type of hazard such as El Niño. Although it has wide coverage in terms of scope (perhaps the most extensive disaster-related policy in Southeast Asia), hazard-specific responses require further elaboration in the document.

Vulnerability assessment and decision making

The basis for deciding responses had been the climate map at the onset of El Niño. The climate map, however, provided static information of climate, distinguishing wet and dry season months in a very broad sense. Vulnerability on the other hand is a multidimensional issue encompassing several factors like the quantum of rainfall; distribution of rainfall over space and time; status of irrigation; socio-economic features and others. An improved vulnerability map that includes the information above will greatly enhance better decision making and action.

Lessons learned

The three most important lessons (among other lessons) learned in the Philippines case study on the 1997–98 El Niño are as follows:

- Political will and policy articulation are important. The involvement of the Philippine President in articulating clearly what needed to be done by two of the country's important sectors – agriculture and environment – ensured the accomplishments of various sectors in minimizing the adverse impacts of El Niño.
- The constitution of a Task Force (a multi-sectoral and coordinative body involving the highest officials of agencies) is a strategic response. The Task Force El Niño yielded a comprehensive plan that included forewarning, education, and strategic solutions such as the adoption of an integrated approach to water resource management through a decentralized, participatory and community-based approach. However, the Task Force must be supported by a national forum of sectoral experts that may provide ongoing guidance to it. This will enhance technical input to major decision making.
- Extensive information dissemination about El Niño to a wider stakeholders' body and public involvement in El Niño responses are needed. In the Philippine experience, it is remarkable that the IEC (International Electrotechnical Commission) campaign had changed the people's perceptions toward El Niño and its association to drought conditions. However, information dissemination must cover all vulnerable sectors. In the Philippines, this should have covered upland dwellers, fisheries, and indigenous Filipinos, and not just urban dwellers and a few selected sectors (agriculture, environment, and health); sector-specific information must be improved in order to communicate effectively.

Other lessons include the following:

- In providing an early warning of El Niño's onset or impacts, the value of long-lead forecasts in alleviating social and economic costs must be emphasized. This must be supported by an agro-climatic, map-based vulnerability mapping. This process must improve the usability of seasonal forecasts in agriculture (by providing the type of climate information needed and used in various stages of agriculture operations).
- Local contingency plans for agriculture should include a "conflict resolution mechanism" to ensure equity in the distribution of irrigation water, intervening in water markets to minimize exploitation, and aggressively promoting campaigns for taking advantage of the moisture availability in order to cultivate short-duration crops.
- Agricultural projects should consult and plan with farmers to ensure that they will be appropriate and useful interventions. The financial allocation for such projects should come in a timely manner. Otherwise, delays in making funding available could derail the project.
- Resources tend to flow to disaster preparedness faster when the president or the prime minister takes an interest in and sets up an interagency task force.
- The simultaneous occurrence of other hazards can confound the ability of scientists to make reliable attributions about disaster impacts to El Niño events (e.g., Mt. Pinatubo eruption in 1991) of various societal impacts.
- The Internet serves as a useful vehicle for keeping tabs on El Niño's development and impacts and for complementing national El Niño forecast efforts.
- There is a need to target at-risk populations in advance of the impacts. Asian countries' ability or interest to respond to an El Niño forecast in 1997–98 was adversely affected by the economic meltdown in Asia.
- Even with good forecasts and with appropriate response strategies, an El Niño event will still cause some level of impacts. Impacts cannot be reduced to "zero."
- A high level of transparency with regard to warnings and discussion of El Niño and its possible impacts on the Philippines generated a high level of awareness of what people should expect El Niño's impacts to be.
- There is a need for more accurate forecasts of El Niño and its impacts in order to improve societal responses.
- Funds should flow more quickly than in the past to areas that are expected to be or are already affected. The mechanisms for the delivery of such emergency funds should be re-evaluated in light of the 1997–98 El Niño event.
- There is a need for an improved communication and monitoring system and for the effective dissemination of warnings.

- El Niño exacerbates other known disasters in the country, but the different disasters are viewed as having varying levels of importance (e.g., droughts are considered worse than floods).
- Local communities cannot depend on the national government for assistance during an El Niño. They must also rely on their own efforts.
- In the Philippine case, a disaster had to be declared before emergency assistance could be rendered. However, this precluded agency preparations for the impacts of an El Niño.
- El Niño must be considered in medium and long-term development planning processes and not just for short-term disaster planning.
- Presidential involvement in an El Niño forecast or warning is an important asset when it comes to proacting in the face of an El Niño forecast.

Notes

1. UNDP Facts and Figures, sourced from the Internet, www.undp.com.
2. These were located in Tagkawayan, Quezon; Malaybalay, Bukidnon; Surigao in Surigao City; Guinyangan in Quezon.
3. See the *Tabang Mindanaw* brochure (1999).
4. Both by independent groups: the Philippine Information Agency and the Social Weather Station.

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Vietnam country case study: Impacts and responses to the 1997–98 El Niño event

Team leader:
Nguyen Huu Ninh
Center for Environment Research, Education, and Development (CERED)
A01, K40, Giang Vo
Hanoi, Vietnam

Team:
Hoang Minh Hien (National Center for Hydro-Meteorological Forecasting)
Tran Viet Lien (Climate Research Center)
Tran Quang Tuan (Humanity Magazine, Vietnam Red Cross)

Executive summary

Because of its geographical setting, Vietnam has had a long history of coping with weather and climate-related hazards such as severe storms, floods, and droughts. As a result, it has developed a comprehensive system of disaster management that, although constrained by limited resources and other factors, provides a high level of protection. This system continues to evolve.

Although scientific research has been conducted on the impact of El Niño in Vietnam over the past two decades, it has only been since the 1997–98 El Niño event that serious scientific interest in the subject has developed. It is now known that the El Niño-Southern Oscillation (ENSO) phenomenon has a substantial effect on the characteristics (frequency, intensity, duration) of certain natural hazards that affect Vietnam.

El Niño is clearly recognized as a factor that should be considered in disaster management by the Vietnamese government. This recognition largely resulted from El Niño predictions in early 1997 that were presented to the government. It also resulted from the emergence of impacts in Vietnam later that year which were accompanied by instructions issued by the Prime Minister's Office to relevant authorities to prepare a report on El Niño and La Niña and Vietnam. While this acted to raise official awareness of the issue, the official response to the 1997–98 El Niño event was through the existing disaster management system. In the period 1999–2000, the government organized an independent study on the phenomenon, with the Institute of Meteorology and Hydrology as the executive agency. The Hydro-Meteorology Service has commissioned sectoral studies, and Vietnam has proposed that national studies be undertaken by various international research programs. Public awareness of El Niño is high as a result of the publicity given to the 1997–98 event by the mass media. The first popular ENSO document was released by the Hydro-Meteorology Service and printed by the Science and Technology Publishing House in the year 2000, as a result of the 1997–98 event.

The broad effect of El Niño on the climate of Vietnam is established, but detailed impacts require more research. In general terms, the main effects on the seasonal climate of Vietnam are that, during El Niño years, cloud cover decreases and rainfall levels are lowered; temperatures increase as do radiation and evaporation. The impact is generally most evident during the winter half-year, with effects usually developing towards the fall of the year in which the El Niño warming in the central equatorial Pacific Ocean becomes evident. Though affecting the whole country, the effects are clearest in the south of Vietnam and parts of the central region. The frequency and other characteristics of the tropical cyclones that make landfall on the Vietnamese coast are strongly affected by El Niño. Generally, fewer but more intense storms are experienced during El Niño years and frequencies are highest during the earlier part of the cyclone season. There is a suggestion that storms that form or develop close to the Vietnamese coast may be more frequent in El Niño years. These storms are difficult to predict and, therefore, to respond to effectively.

The 1997–98 El Niño event had a major impact on social and economic well-being: drought, water supply, health, and storm impacts were the most notable effects. Drought concentrated in 1998 and caused serious impacts, especially for forestry and industrial farming. The total economic loss due to the drought in 1997–98 was estimated at 5,000 billion Vietnamese Dong (VND). Due to the lack of water caused by low rainfall and high evaporation rates, the area of salty land (i.e., salt water intrusion) increased rapidly in the Mekong Delta. Forest fire was also a serious consequence. Water supply for the 1997–98 winter crop had many difficulties. At the reservoirs of the Hoa Binh, Tri An, and Thac Ba hydroelectricity plants, the water level decreased to alarming levels, thereby causing these plants to reduce power production. Water supply in Hanoi, stressed in normal times, became a more serious problem in the first months of summer 1998. Dengue fever spread, starting in the south in 1997. In 1998, the disease came up to the coastal zone of Central Vietnam and the North. The peak occurred in the summer/autumn of 1998. The impact of Typhoon Linda, although it cannot be reliably attributed to El Niño, resulted in 4,502 people dead or missing. This was the highest number of losses caused by a typhoon in decades. There were 440,000 hectares of paddy land lost, of which 330,000 hectares were seriously damaged. 133,000 houses were also seriously damaged. The total loss reached thousands of billions of VND.

The main component of disaster management in Vietnam is the system for protection against severe storms, floods, and other natural hazards. This system has four main strengths. First, it represents the culmination of a centuries-long period of learning through experience. Second, the system is the result of an evolving pact between the elite, the government, and the people of Vietnam and has widespread support and commitment. Third, the battle against "invasion" by a tropical cyclone is as ingrained in the Vietnamese psyche as is the struggle against human invaders. Finally, the system's structure, although complex, ensures that all levels and sectors of the government's administration and, indeed, much of Vietnamese society are firmly linked into the process. It purposely contains a degree of duplication or redundancy, in order to increase the chances that information will be conveyed in the event of failure of any one channel. It also has some weaknesses related to: resource limitations; lack of cooperation and management efficiency; communications problems; cultural difficulties; scale issues; limited scientific and technical understanding; lapses and limitations in public awareness; and aggravating factors such as environmental degradation. Nevertheless, the system provides a high level of protection to the Vietnamese population.

The existing disaster management system could be strengthened by the availability of reliable, detailed, and trustworthy El Niño forecasts that would provide the basis for, among other things, the more effective allocation of resources. The current system provides a strong basis for the communication of warning information to all sectors of society. If such forecasts were to be used, it would be necessary: to improve understanding of the sectoral impacts of El Niño; to increase awareness among relevant authorities and improve coordination and resources; to identify forecast users' needs; and to cultivate a change in attitude in support of a proactive response. Other obstacles to the effective working of Vietnam's disaster management system, which encompasses responses to El Niño-spawned extreme events, such as resource constraints, must be considered.

Lessons learned

- There is a need for El Niño-related impact studies on regions, institutions, disaster management procedures, and economic sectors of society.
- El Niño-related impact studies should be undertaken between El Niño events and not during them.
- El Niño tends to exacerbate existing hazards and disasters that the Vietnamese society has had to cope with for centuries: droughts, floods, fires, severe storms, and typhoon landfall.
- People not only need better El Niño forecasts (more detail at the local level and more accuracy) but they also need better forecasts of El Niño's impacts.
- Researchers must identify the needs of specific users in order to improve the effectiveness of early warning.
- It is important for an effective response to an El Niño forecast that the highest levels of government consider El Niño a problem and are willing to take actions based on the forecast in a proactive way.
- It is not possible to be absolutely confident in attributing a particular weather phenomenon or anomaly to the occurrence of an El Niño. The same is true for attributing societal impacts.
- A mechanism that turns awareness into effective public action is needed.
- There is a need to review in more detail what the El Niño-related climate impacts were during the 1997–98 El Niño event.
- Capacity building is needed in climate impacts assessment and in climate-related disaster planning.
- While there are many government agencies in the country dealing with some aspect of El Niño, there is a need for improved efficiency in transmitting warnings and forecasts throughout the government.
- Governments need to prioritize the allocation of resources in the planning stage for El Niño-related impacts, given the scarcity of resources in many developing countries.
- There is a need for capacity building in the area of El Niño forecast use.
- There is a need to convince the government at the highest level of the importance to society of El Niño research, especially about teleconnections (i.e., attributions) and impacts on environment and society.

Part IV

Other major executive summaries

The World Meteorological Organization's Retrospective Study on El Niño

What follows is an edited version of the executive summary (pp. 7–10) from the WMO's report published in 1999: *The 1997–1998 El Niño Event: A Scientific and Technical Retrospective*, which is available in several languages from the WMO, 7 bis, avenue de la Paix, PO Box 2300, CH-1211 Geneva 2, Switzerland.

The Executive Summary

The strong 1997–98 El Niño event brought to international attention the global scale of risks posed by extremes of climate, particularly for the developing world. Loss of life, destruction of infrastructure, depletion of food and water resources, displacement of communities and outbreaks of disease all occurred as manifestations of climate-related natural disasters concurrent with the event. The United Nations (UN) General Assembly took note of the intensity and global extent of natural disasters and requested the Secretary General, as reflected in Resolutions 52/200 and 53/185, to develop a strategy within the framework of the International Decade for Natural Disaster Reduction (IDNDR) (now the International Strategy for Disaster Reduction, or ISDR) to prevent, mitigate, and rehabilitate the damage caused by the El Niño phenomenon. An intergovernmental UN Task Force on El Niño was established.

This *Retrospective* reviews existing knowledge and capabilities for monitoring and forecasting El Niño-Southern Oscillation (ENSO) in order to establish a sound basis for new strategies to mitigate the negative impacts and capitalize on potential positive benefits. Although the focus of the Retrospective is on the scientific and technical aspects of monitoring and prediction of ENSO, it also identifies productive linkages to multidisciplinary impact assessment studies necessary to support preparedness and management of the economic, environmental, developmental, and societal dimensions of natural disaster reduction.

Within the UN Task Force on El Niño, the World Meteorological Organization (WMO) took a lead role to coordinate the gathering of scientific and technical information about the 1997–98 El Niño event and its primary impacts. In particular, during the course of the event, the WMO prepared a series of publications, called *El Niño Updates*, providing information on the current status; these were issued to National Meteorological and Hydrological Services (NMHSs) and made available to the media and international agencies.

The WMO, with the United Nations Environment Program (UNEP), the Intergovernmental Oceanographic Commission (IOC) of the United Nations Education, Scientific and Cultural Organization (UNESCO) and the International Council for Science (ICSU), working with the IDNDR Secretariat within the framework of the UN Task Force on El Niño, organized the scientific program for the First Global Assessment of the 1997–98 El Niño Event carried out at Guayaquil, Ecuador. The First Global Assessment (International Seminar on the 1997–98 El Niño Event: Evaluation and Projections) was co-sponsored by the government of Ecuador, the UN Task Force on El Niño, and the Permanent Commission for the South Pacific (CPPS).

The term El Niño, although not yet rigorously defined, is associated with a major warming of the surface layers of the central and eastern equatorial Pacific Ocean. An El Niño event occurs when warm water flows eastward from the warm pool of the western tropical Pacific Ocean and there is a reduction in upwelling of cold water in the eastern equatorial Pacific Ocean and along the Pacific coast of the Americas. Once initiated, an El Niño event typically lasts about a year, although climate anomalies in some parts of the globe may persist longer.

During mid-1997, sea surface temperatures across the central and eastern equatorial Pacific Ocean became significantly warmer than normal and a major El Niño event developed. Deep tropical atmospheric convection shifted eastward from the region of Asia and the western Pacific Ocean and, as a consequence, unusually heavy rainfall occurred over many parts of the normally dry Pacific coastal regions of South America. As the deep tropical atmospheric convection shifted eastward, subsiding dry air and reduced rainfall became the prevailing conditions over the western Pacific Ocean and parts of Southeast Asia. The El Niño event ended in mid-May 1998 when sea surface temperatures rapidly returned to normal (and then somewhat cooler than normal).

The dramatic changes in atmospheric circulation across the Pacific Ocean associated with El Niño are one extreme of what is referred to as the Southern Oscillation, and the overall coupled ocean-atmosphere processes are referred to as El Niño-Southern Oscillation, or ENSO. The other extreme of the Southern Oscillation is associated with colder than normal waters over the eastern equatorial Pacific Ocean and a piling up of warm waters in the west, referred to as a La Niña event. These extremes are often referred to as the warm phase and the cold phase of ENSO, indicating that they appear to be part of a single phenomenon.

The eastward movement of deep atmospheric tropical convection during 1997–98 also triggered a shift in seasonal patterns of weather systems over many subtropical and mid-latitude parts of the globe. The abnormal location of Pacific Ocean convection changed the source of tropical heating of the atmosphere and, through dynamic processes in the atmosphere (called "teleconnections"), affected the locations and mobility of subtropical and mid-latitude cyclones and anticyclones. Some regions received more seasonal storms and rainfall than normal, while other regions received less than normal seasonal rainfall, with attendant increased potential for drought.

The shifting of seasonal weather patterns, which was triggered by the 1997–98 El Niño event, produced climate extremes over many parts of the globe, often with major socio-economic impacts.

- More than 24,000 lives were lost because of high winds, floods, or storm tides that occurred during intense storms.
- More than 110 million people were affected and more than 6 million people were displaced as community infrastructures, including housing, food storage, transport and communications, were lost during storms.
- The direct value of losses exceeded US$34 billion.
- Waterlogging of fields as a result of recurring periods of rain reduced agricultural production in many parts.
- In other regions, the absence of the usual seasonal storms and rains led to prolonged dry spells, loss of crops, and reduction in water supplies.
- Outbreaks and spread of wildfires were also more frequent during extended dry periods.
- Increased incidence of disease was an outcome of prolonged disruption to weather and rainfall patterns over many months, which resulted in contamination of water supplies or a more favorable environment for disease-carrying insect vectors.

As an outcome of several decades of climate research and observing system development, there is now an extensive body of knowledge about the climate system and a capacity to monitor in real time aspects of its variability. The ability to watch the 1997–98 El Niño develop was made possible by the systems that had been established over the previous decade. There is also a developing capability to predict climate anomalies up to several seasons in advance over some parts of the globe, for some seasons of the year.

Science and technology provide tools that are essential to build better community preparedness against the hazards of climate extremes and provide early warning of events. For example, historical climate data, and understanding of the processes of the climate system, provide the basis for assessment of climate risk and vulnerability to natural disasters. Monitoring and prediction of the climate system provide early warning for implementation of rapid response in the event of climate extremes, including those associated with El Niño.

The global climate changes through a combination of natural and anthropogenic influences. Some of these changes appear through shifts in patterns of weather and regional climate, and especially in changing patterns of risk associated with extreme events, such as El Niño.

The Climate Agenda

The Climate Agenda is the existing organizational framework for coordinating international climate activities and for developing regional and global climate infrastructures. The Climate Agenda provides the scientific and technical capability necessary to support a global, multidisciplinary approach to mitigating the negative impacts of climate extremes and for the promotion of sustainable development.

Co-sponsors of the Climate Agenda are relevant agencies of the United Nations led by WMO, and non-governmental bodies led by ICSU. The four pillars of the Climate Agenda for addressing global climate issues are:

- Dedicated observations of the climate system;
- New frontiers for climate science and prediction;
- Studies of climate impact assessments and response strategies to reduce vulnerability; and
- Climate services for sustainable development.

Observations

Information about the climate of a locality is fundamental to understanding and developing preparedness against the hazards associated with climate extremes. Local climate record, in computer-compatible format, is the means for identifying and assessing the potential dangers of local climate extremes. It is for this reason that the WMO, supported by the donations of member countries to the Voluntary Cooperation Program, is assisting developing countries to preserve early manuscript climate records through the Data Rescue (DARE) project. The WMO is also assisting the NMHSs of developing countries to establish computer-based climate archives using a standardized data management package. The CLICOM (CLImate COMputing) project has been the means through which many developing countries have made the necessary transition towards modern computer-based climate information services. Accessible climate information allows community involvement at all levels in disaster preparedness and promotes good design and an appropriate pattern of development.

Despite recent advances in global climate monitoring, there are still serious data gaps. The WMO, the IOC of UNESCO, UNEP, and ICSU are cooperating in planning for a Global Climate Observing System (GCOS) to provide comprehensive meteorological, oceanographic and related environmental data necessary for detecting climate change, for climate research, climate forecasting, and operational services. GCOS includes new observing instruments and systems that have been proven through research, such as the Tropical Atmosphere Ocean (TAO) array of moored buoys across the equatorial Pacific Ocean and the altimeter of the TOPEX/Poseidon satellite. GCOS will build upon the long-established World Weather Watch system of the WMO.

Research

Many benefits from developments in climate monitoring and prediction were demonstrated during the 1997–98 El Niño event, but there are still many unknowns about the phenomenon and the associated teleconnections that affect global weather patterns. The Climate Variability and Predictability (CLIVAR) project has been established within the framework of the World Climate Research Program. Amongst its aims is the extension of the capability for climate prediction to larger geographic regions and longer time scales for the ultimate benefit of the world's communities.

Vulnerability and disaster preparedness

Data on the full extent of climate anomalies during the 1997–98 El Niño event are not available in many parts of the globe. For many countries it is only possible to provide general estimates of the type and extent of impacts from weather and climate extremes, including loss of life, destruction and damage to housing and infrastructure, and the extent of disease during the aftermath. Communities and economies were affected differently, and UNEP is taking the lead, within the framework of the Climate Agenda, for coordinating and arranging support for impact assessment studies. An initial study of the impacts of the 1997–98 El Niño event, supported through the United Nations Foundation and with a duration of 19 months, covered the impacts in 16 countries.

To be fully effective, impact assessment studies at the national and regional levels should be multidisciplinary, and policies for the mitigation of the impacts of climate extremes should be integrated into sustainable development strategies. Multidisciplinary risk assessment provides the basis for an effective preparedness and early warning system for the mitigation of natural disasters associated with climate extremes, such as El Niño events.

Services

The WMO has initiated the Climate Information and Prediction Services (CLIPS) project to assist the NMHSs in delivering an enhanced range of operational climate services, including prediction on seasonal-to-interannual time scales. CLIPS will strengthen the interface between national providers and sectoral users so that climate services are delivered in a framework that assists the various decision-making processes.

The development of regional climate centers, within the CLIPS framework, will establish a focus for cooperation in data management, monitoring, and prediction, and will assist technology transfer and capacity building.

National climate programs

Climate-related natural disasters, such as those linked to El Niño, are a major consideration by governments in the overall scope of community protection and well-being. The management of climate risk is multidimensional and involves agencies with economic, environmental, social, and developmental objectives. Many governments have established a formal national climate program as a framework for coordination and to ensure that, through the NMHSs, first, the appropriate scientific and technical infrastructures are adequately supported, and, secondly, to ensure that information and prediction services are accessible to policy and decision makers for planning, early warning, and better management across a range of sectors, including natural disaster reduction.

The evaluation of El Niño's impacts by the International Strategy for Disaster Reduction

The following report, based on a 16-country study, tries to identify the natural disaster management structure involved in natural hazard reduction in those countries that were affected or threatened by the El Niño/La Niña-related extreme events.

A brief introduction gives an overview of the main objectives of the report, as well as the development of major patterns in natural disaster management. The second section describes the international platform that has been established to deal with natural hazards under the umbrella of the ISDR Task Force Working Group on El Niño, climate variability, and climate change. This section also presents the aims and distinct experiences toward coherent, integrated, and proactive models of disaster management. The third part is dedicated to a presentation of the specific and concrete measures adopted by national governments (as presented in Annex 1) toward a proper "culture of prevention" and efficient natural disaster prevention. This section highlights how national governments contribute to the objectives and goals of the International Strategy for Disaster Reduction, in particular of the ISDR Task Force Working Group on El Niño, climate variability, and climate change.

Introduction

In December 1997, the Inter-Agency Task Force on El Niño was created within the framework of the International Decade for Natural Disaster Reduction (IDNDR). The Task Force was established for cooperative work between member agencies and their partner agencies outside the United Nations system. The Task Force provided a platform for combining efforts to improve general understanding of the El Niño phenomenon, for disseminating early warnings prior to the events, and for channeling technical assistance and capacity-building resources to member states threatened or affected by El Niño/La Nina-related disaster impacts.

The need for coordinated preparedness and response mechanisms at the local, national, and even regional level was clearly demonstrated following numerous small, medium, and large-scale disasters induced by climate variables and related weather extremes. There was, however, a consensual recognition among the members of the Task Force of the need for long-term risk reduction to avoid the repetition of the disastrous social, economic, and environmental impacts of the 1997–98 El Niño event.

The aim of this input is twofold: to present the concerted platform to reduce the impact of future El Niño events, and to provide a brief overview of disaster management structures in each of the 16 countries participating in the project. The information requested from the countries is precisely geared toward a longer-term, sustainable solution, looking beyond the traditional civil defense preparedness/response approach but requiring a multidisciplinary horizontal synergy between different ministries and entities involved in risk reduction.

The 16 countries participating in the project are: Bangladesh, China, Costa Rica, Cuba, Ecuador, Ethiopia, Fiji, Indonesia, Kenya, Mozambique, Panama, Paraguay, Papua New Guinea, Peru, Philippines, and Vietnam.

An international platform for reducing the impact of the El Niño phenomenon

The United Nations General Assembly established by resolution in 1997 the Inter-Agency Task Force on El Niño within the framework of the IDNDR. This process was initiated in view of the extensive disaster impacts caused by the 1997–98 El Niño/La Niña-related events. This activity recognizes the need for and the potential of applying the science and technology that exist in the field of climate variabilities, in order to more effectively prevent natural disasters caused by future ENSO events. These efforts must be based on effective dialogue and cooperation between the scientific and technological areas of the United Nations system and the UN's operational responsibilities in the fields of disaster management, humanitarian assistance, sustainable development, technical cooperation, and capacity building. This includes data collection, monitoring, and early warning systems at all levels of responsibility.

The experiences gained following the 1997–98 El Niño event and the subsequent La Niña have highlighted the need for concerted action among United Nation system partners and counterparts outside the system. The efforts made by the Inter-Agency Task Force on El Niño within the framework of the IDNDR will continue under the agreed successor arrangements, namely the ISDR.

The ISDR Task Force will assess global trends of risk from natural, environmental, and technological hazards. The Task Force will comprise a horizontal synergy to assess the relevance of risk reduction in relation to existing and/or emerging strategic domains of the United Nations system and define to what extent the ISDR needs to be injected into such strategic approaches (mainstreaming) and/or would benefit from such platforms for the conceptual evolution of disaster reduction and ISDR's strategy formulation.

The ISDR Task Force will provide platforms for action by establishing thematically specific ad hoc working groups, which relate to strategic domains such as (including the examples of ENSO) early warning as well as the quantification of risk, vulnerability, and impact of disasters. These ad hoc working groups will be chaired and coordinated by the ISDR Task Force member entity most concerned with regard to existing or evolving mandates. Within their areas of specific concern, the ad hoc working groups will develop proposals for concrete (model) activities, which involve the respective constituencies at large. They will also work out concrete action plans for the implementation of such activities.

The first meeting of the ISDR Inter-Agency Task Force was convened in Geneva on 27–28 April 2000. Task Force members indicated that it should be regarded as an interdisciplinary forum for advancing disaster reduction, identifying areas of common concern, and devising guidelines for the implementation of the ISDR. The Inter-Agency Task Force has four main functions: (a) to serve as the main forum within the United Nations system for devising strategies and policies for the reduction of natural hazards; (b) to identify gaps in disaster reduction policies and programs and to recommend remedial action; (c) to provide policy guidance to the ISDR Secretariat; and (d) to convene ad hoc meetings of experts on issues related to disaster reduction.

In addition, the ISDR Secretariat has mandated functions by the United Nations General Assembly with regard to problems associated with El Niño and other climate variabilities and climate extremes. The first ISDR Inter-Agency Task Force meeting agreed that ad hoc working groups would be created for those areas mandated by relevant UN General Assembly resolutions or identified by Task Force members as areas of common concern. The working groups will be comprised of a maximum of 10 entities/persons, with the majority being Task Force members. These groups will start their work immediately, with the support of the ISDR Secretariat, and prepare recommendations to be submitted to the ISDR Task Force for endorsement. The ISDR Task Force Working Group on El Niño, climate variability, and climate change was established under the leadership of the World Meteorological Organization (WMO) with the participation of UNEP, FAO, OAS/IACNDR, SOPAC, UNDP, UNESCO. Additional members will be identified from outside of the Task Force.

National disaster management structures

A crucial lesson of the IDNDR has been that effective disaster reduction strategies are possible and stand a better chance of being sustained if they are multidisciplinary in nature, and integrated within broader policy concepts pertaining to a society's economic growth and social development. The global IDNDR Program, conducted between 1995 and 1999, sought to improve coordination and increase the effectiveness of early warning systems, regardless of the specific type or combination of hazards involved. Similarly, it emphasized the importance of linking the scientific, technical, and communication responsibilities of early warning directly with the roles and public responsibilities associated with governance and public administration policies. It is equally a fundamental characteristic of comprehensive risk and disaster management practice that professional competence and public support are both motivated to the extent by which official policies and government officials embrace the importance of hazard awareness and risk reduction. Such a "culture of prevention" becomes even more important when applied to the consequences of recurrent phenomena, such as ENSO events, that can have varied and severe social and economic consequences.

The essential first step to enable a comprehensive and sustained involvement in risk reduction is to take stock and assess both the existence and the adequacy of existing structures, procedures, and prevailing states of knowledge, within the public, professional, and political or policy-making levels of each individual society. It is necessary to appreciate that the conditions of potential vulnerability are dynamic, affected as they are by changes in demography, land use, infrastructure development (or deterioration!), etc. over time. Such an ongoing multidisciplinary and intersectoral risk assessment is crucial in order to establish trends and relative priorities based on the people most immediately affected in local communities, as well as from a larger area perspective that can take account of neighboring regions or localities and their respective needs and/or resources. Existing gaps, outdated or inadequate procedural or material requirements, or important areas of required capacity building within either professional or geographical communities can therefore be identified for future attention. It is often overlooked that such a conscious approach to analytical monitoring of potential ENSO consequences on crucial segments of the continuously changing population, economy, and social conditions also provides a historical record and cumulative database. These data and the knowledge that they yield can become extremely valuable both for benchmarking future improvements and for evaluating accomplishments along with the associated costs and benefits. In fact, it is difficult to imagine a serious effort to reduce the socio-economic consequences of the El Niño phenomenon and other forms of climatic variation and change over time, without building into the strategy an explicit means to undertake and *record* professional capacity, ongoing policy, operational analysis, and risk analysis at national (and sub-regional) levels of governance.

Summary of major issues and conclusions

This section is a summary of the major issues and conclusions presented by the 16 countries taking part in the UNFIP (UN Fund for International Partnerships) project. Regional reports had been requested in advance in order to allow a comprehensive review of progress and challenges. Some ‘‘End of Decade Country Reports’’ were used to complete the information needed for several participating countries.

(a) All countries have a national disaster reduction plan, or are on the way to finalizing it. Most of them are working now in a more proactive and long-term approach including prevention, preparedness, mitigation, and response, to avoid the repetition of disastrous socioeconomic and environmental impacts of natural hazards. For example, the government of Ethiopia has endorsed a long-term plan in disaster prevention and preparedness including nine core programs that can help to reduce disasters. The Action Program in Kenya is intended to shift the current undue emphasis on short-term responses to a more proactive approach that prioritizes sustained prevention, mitigation, and preparedness measures. Mozambique developed an integrated Disaster Management Policy governed by the National Action Plan that combines prevention, preparedness, and response for sustainable economic development and growth. In Fiji the National Disaster Management Council (NDMC) sets policy and direction and induces participation of government ministries, statutory bodies, and NGOs through three subcommittees for prevention and mitigation, preparedness, and emergency. Natural disaster management in this respect is implemented on a complete cycle of programing involving before, during, and after phases. In the Philippines a Task Force on El Niño was constituted in March 2000 under the National Disaster Coordinating Council system to implement preparedness and mitigation measures for the expected El Niño occurrence. Although these national disaster management plans have thus far not always been translated into risk reduction legislation, the answers provided showed all in all a very good understanding of the need for long-term efforts and the need for the appropriate structures to support them. This is particularly encouraging in the African continent.

(b) Several countries have adopted an interdisciplinary approach to manage disaster reduction. The aim is to incorporate the most information possible to deal with natural hazards including experts from many different horizons (scientists, decision makers, the media, local community leaders, and so on). Although horizontal synergy, which is necessary to efficiently reduce the impact of climate variables, such as the ENSO phenomenon, is not always well established, a number of countries have taken steps in the right direction. For example, Papua New Guinea developed the National Disaster and Emergency Services to lead and direct key sector agencies and national government departments (e.g., health, public works, agriculture, defense, constabulary, civil aviation, environment, education, and telecommunications) in disaster management activities. The China National Center for Natural Disaster Reduction will make full use of the disaster reduction information and achievements of the relevant ministries, commissions, research institutions, and social groups to provide the country with comprehensive disaster reduction information services and suggestions on decision-making services.

(c) The results of the survey show that local organizations for disaster prevention and mitigation at the municipal and grassroots level have been strengthened, particularly in the field of training, education, and information dissemination. For example, in Cuba, "Meteoro" is a popular exercise demonstrating actions to take during disaster situations. Another example is the information sharing between organizations at different levels in Indonesia through the establishment of Bakornas PB (The National Disaster Management Coordinating Board) followed by the establishment of similar non-structural institutions to cope with disaster at the provincial as well as district level, namely Satkorlak PB (Provincial Disaster Management Unit) and Satlak PB (District Disaster Management Implementing Unit). Information is acquired either vertically (from Satlak and Satkorlak to Bakornas PB) or horizontally to link national level departments and agencies.

(d) Some of the countries taking part in the project have developed legislation. The Philippines, for example, has established through Presidential Proclamation No. 296 the first week of July of every year as "Natural Disaster Consciousness Week." Presidential Proclamation No. 705 declares 6 December as "National Health Emergency Preparedness Day." The Philippines has also integrated a Disaster Mitigation Component in the Development Administration Sector of the Philippines Medium-term Development Plan (1993–98). This has allowed the inclusion of section 31 of the General Appropriation Act that authorizes the use of regular funds by national government agencies (NGAs) for disaster management concerns.

(e) Countries reported on public education and awareness-raising activities through a variety of methods including the use of videos and the Internet. The importance of information dissemination increased with the growth of media channel support. China, for example, has set up a broadcasting network for disaster early warning information by using telephone, radio communication, and television, which obligates government officials to organize disaster prevention and relief work in a timely manner. In Mozambique activities carried out (e.g., talk fora, exhibitions, radio programs and plays) mobilize civil society and the business community.

(f) Several guidebooks were published to deal with natural hazards. The government of Bangladesh has formulated a methodology with a guidebook named *Standing Orders on Disasters* along with a "Comprehensive National Policy on Disaster Management and National Disaster Management Plan." Panama has published a study entitled *Natural Disasters and Risk Zones in Panama: Condition and Prevention and Mitigation Options*. Panama has progressed in the identification of areas at risk from earthquakes, the mapping of flood risk areas, and in studies on land use. They have also published a book called *Civil Protection: A Manual for Disasters*. In Paraguay a work entitled *Impact of the El Niño Phenomenon in Paraguay* was published in 1999.

(g) The most frequently raised future requirements by the countries are:

• *The need for international financial assistance*

In Indonesia, the 1997–98 El Niño-related dry conditions led to large-scale damage mainly due to uncontrolled forest fires in Sumatra and Kalimantan. Both the El Niño and La Niña phenomena may have significant implications for the agricultural and food security sector. This is a very important issue for the government, which is still struggling to overcome an economic crisis.

• *Strengthening the multi-scale cooperation (international, regional, national, and local)*

The government of Bangladesh has taken a number of significant steps during the last few years for building up institutional arrangement, from national to union levels, for effective and systematic disaster management in Bangladesh.

In Ethiopia, the natural disaster management structure is decentralized in such a way that its outputs can be used at the lowest administrative levels.

• *The enforcement of technology for the early warning system (meteorological and hydrological information)*

For years, China has gradually established and continuously improved its disaster monitoring and early warning system. In addition to the application of normal monitoring means, China has widely used advanced technology in disaster monitoring and early warning with satellite remote sensing, mathematical and physical modes, and modern communications technology.

- *Upgrading the dissemination of information at all agencies dealing with natural hazards*

In the Philippines, the National Disaster Coordinating Councils exist and operate at all levels and are tasked to disseminate warning information and implement measures to prepare for and mitigate the impacts of El Niño. In response to the 1997–98 El Niño event, the government launched a coherent and integrated multisectoral rehabilitation program for El Niño-affected areas.

- *The need to strengthen the legal framework*

In Mozambique, time and resources were unavailable to develop a real planning process for emergency management as a whole. Moving ahead with the process of creating disaster management mechanisms in Mozambique, a draft policy on disaster management has been completed. Among other aspects, it defines the competencies and responsibilities of each sector and their responsibilities in relation to disasters. This document is the result of discussions held in early 1997, following consultations with the districts, provinces, and line ministries.

- *Empowering the community's awareness for an active participation*

In Indonesia, the promotion of community awareness, specifically in disaster-prone areas, has to be prioritized. Mapping of disaster-prone areas therefore should be intensified and, most importantly, the dissemination of the information to the community and development agencies dealing with spatial planning must be fostered. The capability of community members and officials involved in the search, rescue, and prompt emergency medical services to the disaster victims has to be promoted. So, community protection against disaster hazards will be promoted through training and education.

- *Strengthening existing prevention and mitigation measures*

A comprehensive approach to disaster management in Kenya is still in the formative stage. In order to hasten the establishment of an institutional framework, the government of Kenya, the United Nations Disaster Management Team (Kenya), and other key players (NGOs and the private sector) have developed a National Disaster Management Action Program for the past year (1999–2000). The action program is intended to shift the current undue emphasis on short-term responses to a more proactive approach that prioritizes sustained prevention, mitigation, and preparedness measures.

Table 2 **Specific and concrete measures adopted by national governments**

Disaster management structure including specific structure dealing with El Niño	Structural and non-structural prevention measures	Future requirements
Bangladesh		
The government has taken significant steps to build up institutional infrastructure from national to union levels for effective and systematic disaster management. These are: • Establishment of a disaster management organization, Disaster Management Bureau (DMB), in 1993. • Renaming of the Ministry of Relief and Rehabilitation as the Ministry of Disaster Management and Relief (MDMR). • Establishment of Council and Committees at the national, district, Thana, and union levels for disaster management. • Establishment of Emergency Operations Center (EOC) at the MDMR for information exchange during disaster emergency. • Comprehensive National Assessment of Risks (NCAR) under process; National Disaster Management Plan being prepared. • Standing orders issued by government, legislation in process. • Weather forecasts and early warnings issued through media.	The government of Bangladesh gives emphasis now both in structural and non-structural mitigation measures. As structural measure: Construction of 1,841 cyclone shelters; 200 flood shelters; 3,931 km long coastal embankments; and 4,774 km drainage channels. As non-structural measure: New Disaster Management Legislation-Act, which provides the formulation of disaster management policy and planning related to preparedness. DMB is working to formulate the national disaster policy implementation and monitoring of disaster mitigation programs to build up awareness among students. The government of Bangladesh has formulated a methodology with a guidebook named "Standing Orders on Disasters" and a "Comprehensive National Policy on Disaster Management and National Disaster Management Plan."	• Upgrade dissemination of information and strengthen local authorities. • Updated technology, financial resources. • Humanitarian approach for development policies. • Regional or subregional warning system. • More effective coordination between government and NGOs for efficient and systematic management of disaster situations at the national level. • Collaboration in making timely provisions for meteorological and hydrological information including rainfall data from neighboring countries for cyclone and flood forecasting. • Regional and international cooperation for undertaking programs to construct cyclone and flood shelters in high-risk

Disaster management structure including specific structure dealing with El Niño	Structural and non-structural prevention measures	Future requirements
There was no specific structure with place, with respect to El Niño, to receive the early warning information and take necessary measures prior to the 1997–98 event. The El Niño scientific research is at preliminary stage. The Bangladesh Meteorological Department (BMD) is responsible for issuing weather forecast and storm warnings. Bangladesh Space Research and Remote Sensing Organization (SPARRSO) provides Landsat imageries for BMD. The research on the correlation between different climatic elements and Southern Oscillation Index (SOI) is in progress in DMB. After the 1997–98 El Niño the government of Bangladesh gave priority to improve the issuing of warnings (weather, cyclone and flood forecasting). The Storm Warning System (SWS) of BMD is issuing monthly weather forecasts, rainfall situations giving comments on air mass, tropical monsoon and the SOI (taken from the Bureau of Meteorology, Australia). The Flood Forecasting and Warning Center (FFWC) is issuing flood forecasts (river basin situation). So, forecasts of rainfall and flood situation, cyclonic storm, and heat wave/cold wave information are available now (quite helpful		and remote areas so as to match the size of population exposed to disasters. • Efforts of UN organizations to support the initiative of the government for improvement of national capability in weather and flood forecasting as well as overall disaster management. • Political commitment of governments of the neighboring countries to halt widespread deforestation in the upstream of the major rivers that flow through Bangladesh. • Long-term coordinated efforts to accelerate public awareness activities at the grass-roots level. • Further motivation of the line organizations, staff agencies, and field establishments concerned with disaster mitigation to work round the year instead of considering it a seasonal activity.

Disaster management structure including specific structure dealing with El Niño	Structural and non-structural prevention measures	Future requirements
to take necessary mitigation and preparedness steps.) The National Disaster Management Council (NDMC); Inter-Ministerial Disaster Management-Coordination Committee (IMDMCC); Cyclone Preparedness Program (CPP); Training and Public Awareness Building Task Force (TPABTF); Coordination Committee on Disaster Management (NGOCC).		• Regional conference on disaster management with all its aspects on periodical basis to identify weakness in disaster handling and establish regional cooperation for exchange of information about disasters and mitigation planning.
China		
China National Committee on IDNDR (1989) consists of 28 agencies, ministries, commissions and bureaus, the army and NGOs. It is responsible for drawing national disaster reduction plans; formulating general and specific policies of disaster reduction; coordinating departments and NGOs to carry out disaster reduction activities; and supervising disaster reduction work by local governments.	In March 1994 the government issued "China 21st Century Agenda," clarifying the important position of disaster reduction in sustainable development. It clarifies the relations between disaster reduction and ecological and environmental protections at the national level. The "National Disaster Reduction Plan of the People's Republic of China (1998–2010): Promulgation and Implementation of a Series of Disaster Reduction Laws and Regulations." For years, China has gradually established and continuously improved the disaster monitoring and early warning system.	• Information dissemination to be continued and strengthened. International assistance to be provided to China and the Third World. • Financial support, and annual meetings with those concerned. • Cooperation with UNDP, World Bank. • The UN should establish a special department for continuously promoting the coordination of international action on disaster reduction. • Formulate an information-sharing plan.

Disaster management structure including specific structure dealing with El Niño	Structural and non-structural prevention measures	Future requirements
	In addition to the application of normal monitoring means, China has widely used advanced technology in disaster monitoring and early warning with satellite remote sensing, mathematical and physical modes, and modern communications technology. National networks are formed for meteorological monitoring and forecasting, hydrology monitoring, earthquake monitoring and earthquake precursor observation systems, crops and forest diseases and insect pest early warning systems, oceanic environment and disaster monitoring, forest and grasslands fire monitoring, geological disaster survey, and disaster reporting systems. It has also set up a broadcasting network for disaster early warning information by using telephone, radio communication, and television, which guarantees that government officials organize disaster prevention and relief work promptly. Well-planned organization and mass participation in the fight against floods. Enhancing the construction of natural disaster reduction projects to control big rivers. Promoting the application of science and technology in natural disaster reduction work.	• Establish a UN Fund for the International Natural Disaster Reduction.

Disaster management structure including specific structure dealing with El Niño	Structural and non-structural prevention measures	Future requirements
	Establishment of a Chinese National Center for Natural Disaster Reduction: to strengthen the construction of a comprehensive information system for disaster reduction, and to enhance information sharing on disaster reduction, the central government has approved the establishment of a Chinese National Center for Natural Disaster Reduction. The center will be equipped with the disaster information system serving the state council, ministries, and commissions; the disaster information system linking the central government with provinces and municipalities; satellite remote sensing system; comprehensive management and display system of disaster information; disaster assessment system; disaster reduction policy and decision-making service system and disaster emergency relief information system. This center will make full use of the disaster reduction information and achievements of the relevant ministries, commissions, research institutions, and social groups to provide the state with comprehensive disaster reduction information services and suggestions on decision-making services.	

Disaster management structure including specific structure dealing with El Niño	Structural and non-structural prevention measures	Future requirements
Costa Rica		
The National Emergency Commission (CNE), attached to the Ministry of Public Works and Transport, is the institution most closely related to this role. However, its legal framework – or rather the gaps therein – do not empower it to undertake preventive actions. The national model of organization for disasters is intersectoral. The CNE has an inter-institutional communications network. The Technical Advisory Committees are composed of a wide range of experts. The Emergency Committees facilitate the transfer of technology at local and regional level.	Regulatory plans have been implemented for reconstruction in 14 events declared as national emergency. Access to regional meteorological information especially from the US. Risk assessment: annual publication of cantonal atlas of natural hazards; identification of hazards in specific areas; vulnerability studies in numerous communities as part of risk management projects. There is no specific legal framework for disaster mitigation, but there are several laws that regulate related issues. Activities aimed at determining risk levels; estimation of density of alluvium, building foundations code and various studies and research. A national education strategy for disasters has been proposed along with a national system of medical emergencies. The CNE has its own education and information department with 4 operational areas. The education and culture sector is given priority within the national emergency plan and disaster issues have been incorporated at all levels of education. The National Emergency Plan establishes responsibilities and a framework of action for the different planning bodies of the state.	• Adequate legal framework. • Minimize duplication of efforts and gaps in institutional actions. • Systematic research on vulnerability and its causes. • More input from scientific, technical, and academic sectors in the communities and involvement by these in planning efforts. • Strengthen local government. • Application of regulatory or contingency plans in high-risk areas. • Present scale of risk management that is useful to local planning. • Capacity building to manage and follow up on disaster reduction projects. • More involvement by state institutions and better planning system to guide the implementation of the strategic and operational plan.

Disaster management structure including specific structure dealing with El Niño	Structural and non-structural prevention measures	Future requirements
	There are 10 inter-institutional committees for specific thematic areas: Formation and training of a team for the design of disaster reduction projects; legal framework; strengthening of local and regional structures and of technical advice committees; training and resources for the municipalities; incorporation of risk reduction into reconstruction efforts; regional cooperation agreements; establishment of information center in the country; national policy on disaster reduction and creation of Disasters Office within the government planning structure.	
Cuba		
The governmental authority designated for disaster reduction activities is the National Chief of Staff of Civil Defense, composed of vice ministers and national leaders of popular organizations. Also involved are the Latin American Center for Medical Disasters, the Veterinary Center for Prevention in Cases of Disaster and the Engineering Center for Disaster Prevention and Mitigation. Steady improvements in planning for disaster situations. Plans are updated annually under the supervision of the respective government authorities.	Improve legal framework of defense system with the National Defense Law No. 75, decreed by Popular National Assembly in 1994, establishes the basic structure and development of Cuba's civil defense system. Executive No. 170 (1997) specifies in greater detail the aspects related to disaster reduction. During the 1990s, 3 laws, 7 executive orders, and 21 ministerial resolutions have been created. Most of these are related to prevention. Prevention and preparedness of citizens to respond to disasters and how to	• No information provided.

Disaster management structure including specific structure dealing with El Niño	Structural and non-structural prevention measures	Future requirements
	act in situations of disaster and recovery have significantly reduced the impact of disaster. "Meteoro" is a popular exercise in actions to take during disaster situations. Implementation of integrated Urgency and Medical Emergency System. Installation of Units for Analysis and Trends in Health. Risk assessment is carried out in various education, research, and study centers. Cuba reports improvements in its early warning systems and 44 legal instruments were developed in order to enhance disaster management.	
Ecuador In 1994 the National Planning Council (CONADE) incorporated the risk variable into national development plans. Access to the Tsunami Warning System through the Oceanographic Institute of the Navy, no local early warning system because of financial constraints. Mitigation is not the responsibility of civil defense but of other governmental bodies.	Training of authorities and population of the lower social strata. Incorporation of risk awareness in national development plans. Strengthening the role of technical institutions in research and monitoring of risks.	• Disseminate information about the seriousness of any natural disaster through various educational activities supported with materials that are accessible to communities. This includes materials in the languages of ethnic groups. • Internal and external financial support to provide training to all social sectors.

Disaster management structure including specific structure dealing with El Niño	Structural and non-structural prevention measures	Future requirements
Ethiopia		
The National Policy on Disaster Prevention and Management (1993), the Disaster Prevention and Preparedness Commissions (1995). Improvement and development of new early warning systems. Commission embodied in the government structure, budgeted by government proclamation under the Prime Minister's office. Early warning committees are set up at regional, zonal, and sub-district levels. The structure is decentralized in such a way that its outputs can be used at lowest administrative levels.	The government has endorsed a long-term plan in disaster prevention and preparedness including 9 core programs that can help to reduce disasters with a long-term approach. The main approach is through the introduction of Employment Generation Schemes (EGS) which focus on land preservation and drought-proofing projects, thus providing income and at the same time helping to rehabilitate the environment. The NPDPM has two major components: preparedness and prevention programs. Disaster preparedness is a pre-disaster activity designed to effectively respond to disaster. The following are examples of preparedness programs that the Ethiopian government is undertaking: Early Warning System, Emergency Food Security Reserve, National Disaster Prevention and Preparedness Fund (NDPPF), Non Food Contingency Stock and National Logistics Plan and Strategic Transport Fleet. Disaster Prevention Components: The policy has given emphasis to disaster prevention programs. The following are the main elements of disaster prevention: linking relief to	• Policy and government commitments are of prime importance to disaster reduction in the 21st century. With this comes strong emphasis on capacity building and intensive work in disaster awareness. • Budgetary commitments are also needed. • Disaster reduction programs should be encouraged at all levels, regional, national, and local. This involves network building and information dissemination.

Disaster management structure including specific structure dealing with El Niño	Structural and non-structural prevention measures	Future requirements
	development, vulnerability profile and vulnerability research, multi-year planning in disaster prevention. Maintaining an emergency food security reserve for unexpected food shortfalls.	
Fiji The Fiji Islands natural disaster management systems and programs in the pre-1990s and earlier years used to be governed under the Emergency Committee (EMSEC) of the Ministry of Home Affairs and the Prime Minister's Relief and Rehabilitation Committee (PMRRC) of the Department of Rural Development. In 1990, the two structures merged into one. The current Ministry of Regional Development and Multi-Ethnic Affairs (MRD&MEA) governs the affairs of natural disaster management for the country, whilst the Ministry of Home Affairs retained the man-made disaster component of EMSEC. Governing the implementation and coordination of the Disaster Management Plan (DISPLAN) was endorsed by cabinet in 1995 and the enactment of a Natural Disaster Management Act in 1998.The existing machinery and mechanisms of natural disaster management enabled the	An El Niño Steering Committee was formed in March 1999. Objectives: • To find appropriate mitigation measures to direct the study and support its effect examining measures that are recommended for mitigating impacts of future drought and the incorporation of these measures into development planning. • Need to introduce basic housekeeping methods such as ensuring water catchments are properly installed in both communities and schools, introducing water conservation measures, and developing drought-response plans for crop planting. Reactive disaster response focused on: emergency and relief, pre-disaster and disaster planning, disaster loss reduction, and heightening national understanding of the need for and benefits of linking disaster management initiatives to national development planning and	• No information provided.

Disaster management structure including specific structure dealing with El Niño	Structural and non-structural prevention measures	Future requirements
National Disaster Management Council(NDMC) under the Ministry to set policy and direction and induce participation of government ministries, statutory bodies, and NGOs at the 3 subcommittees of prevention and mitigation, preparedness, and emergency. Natural disaster management in this respect is implemented on a complete cycle of programing involving before, during, and after phases.	program. For the early warning and forecasting systems, improvements in meteorology have made it possible to forecast an El Niño event up to 9 months before the onset of the drought.	
Indonesia		
National coordinated arrangement for natural disasters was initiated in 1966 by the establishment of the Advisory Board for Natural Disaster Management. Its activities were still focused on emergency relief for disaster victims. In 1979 the National Natural Disaster Management Coordinating Board known as Bakornas PB replaced the old structure. This unstructured organization is directly responsible to the President and chaired by the coordinating Minister for Peoples' Welfare. Its membership comprises 4 ministries and 17 officials appointed by related ministries and heads of agencies. The 1979 Decree also includes the establishment	In the Sixth National Development Plan (1993/94 & 1998/99) specific issues have been addressed by promoting community awareness, human resources development, promotion of science and technology, and formulation of standardized operation procedure. Promotion of community awareness specifically in disaster prone areas has to be prioritized. Mapping of disaster prone areas, therefore, should be intensified and, most importantly, disseminated to the community and development agencies dealing with spatial planning. Capability of community members and officials in search, rescue, and the provision	• Economic crisis has badly affected the country; there is a need to integrate poverty alleviation programs to disaster management especially in disaster prone areas. • Regional and international cooperation related to natural disaster reduction should be strengthened with the main focus on community empowerment. • The current situation, as a result of monetary and economic crisis since the middle of 1997 has affected the whole country.

Disaster management structure including specific structure dealing with El Niño	Structural and non-structural prevention measures	Future requirements
of similar arrangements in provincial as well as in district levels. Bakornas PB: • Formulates policy and provides guidelines/ directives on policy and coordinates integrated natural disaster management. • Controls the implementation of its programs in the context of general policy as determined by the government. • Provides guidelines on policy outlines to be implemented by the provincial and district levels in preventive, repressive, and rehabilitative management activities. The Decree was revised in 1990 and is the one in effect presently, with the following major considerations: • That the management should also include man-made disasters and not only provide assistance during and after disaster. • That natural as well as man-made disasters must be managed before, during, and after their occurrence, covering aspects of prevention, mitigation, rescue, rehabilitation, and reconstruction. Bakornas PB is assigned with the following tasks:	of prompt emergency medical services to the disaster victims have to be promoted. So, community protection against disaster hazards will be promoted through training and education. The Sixth National Development Plan also clearly indicates the following programs: • Disaster preparedness and mitigation through research and mapping of disaster prone areas and application of appropriate science and technology. • Emergency response by strengthening the coping capabilities and provision of equipment. • Rehabilitation and reconstruction of infrastructure and relevant means required for the community ensuring their function is back to normal and able to cope with any disaster threat on self-reliant basis. Resettlement of the disaster victims will be made as required. Building construction is based on engineering structures; rehabilitate and relocate buildings which are non-engineering structures. Formulate regulations and their law enforcement; motivate mitigation efforts	• The impacts have greatly increased the extent and magnitude of social problems. The grave situation has been aggravated by the occurrence of El Niño causing large-scale forest and land fires, drought and even famine. Economic and environmental losses have undoubtedly drained the country's natural resources making it more difficult to sustain its development. • To deal with the impacts and related problems, the strategic approach is to apply principles of the social safety net to disaster management. • Promotion of community awareness particularly for those who live under disaster threat is vital. Empowering communities is conducted by optimizing their own resources

Disaster management structure including specific structure dealing with El Niño	Structural and non-structural prevention measures	Future requirements
(1) To formulate disaster management policy and provide guidelines or directives and coordinate disaster management before, during, and after disaster in an integrated manner. (2) To provide guidelines and directives on policy outlines in disaster management activities covering prevention, mitigation, rescue, rehabilitation, and reconstruction. The membership of Bakornas PB is comprised of: the Ministers of Social Affairs, Home Affairs, Health, Public Works, Transportation, the Commander of the Armed Forces, the Governor (whose province was struck by disaster), Director General for Social Assistance Development, and Department of Social Affairs. In carrying out its task Bakornas PB can involve ministers or officials or parties in disaster management and can establish the working groups as needed. The Decree also emphasizes the role of the district level as the front line organization to manage disaster at the local level. The district level is directly responsible to the chairman of Bakornas PB through the respective governor, so its activities will be integrated in manner and in accordance	through incentives; educate and train the community; increase social awareness; strengthen or empower institutions dealing with disaster management; improve early warning systems. The 1997–98 El Niño-related dry conditions led to large-scale damage mainly due to uncontrolled forest fires in Sumatra and Kalimantan. Both El Niño and La Niña phenomena may have significant implications for agriculture and the food security sector. This is a very important issue for the government which is still struggling to overcome the economic crisis. ADPC in collaboration with NOAA and USAIS/OFDA and Bakornas PB has started a 15-month program on understanding the extreme climate events and their impacts on society and environment in Indonesia, the Philippines, and Vietnam. It is expected that this program will prepare the ground for a longer-term comprehensive application of climate forecast for disaster preparedness and mitigation. Indonesian disaster management information system to enhance decision-making capability of Bakornas PB by ensuring flows reliable and up-to-date information on various disaster events and related disaster management measures. This	and potentialities, and by providing initial limited incentives to enable them to help themselves. • Bakornas PB encourages the public for active participation, and launches public campaigns, in line with ISDR programs.

Disaster management structure including specific structure dealing with El Niño	Structural and non-structural prevention measures	Future requirements
with the national policy outlined by the board. The establishment of Bakornas PB was followed by the establishment of similar non-structural institutions to cope with disaster at provincial as well as district level, namely Satkorlak PB (Provincial Disaster Management Unit) and Satlak PB (District Disaster Management Implementing Unit). District Unit as the front line organization can mobilize all related agencies at their respective districts, sub-districts, and villages as well as involve local community organizations. In 1995, the Chairman of Bakornas PB expanded the decree by issuing Decision No. 17 on Organization, Tasks, Functions and Job Description of the Board. The functions of the board are as follows: (1) Formulates planning of integrated, coordinated and sustained disaster management general policy and action programs; (2) Coordinates the planning of disaster management efforts before, during, and after disaster, covering prevention, mitigation, rescue, rehabilitation, and reconstruction; (3) Prepares and formulates guidelines on the implementation of integrated and coordinated disaster management; (4) Coordinates disaster management supervision,	information is acquired either vertically (from Satlak and Satkorlak to Bakornas PB) or horizontally to link national level departments and agencies.	

Disaster management structure including specific structure dealing with El Niño	Structural and non-structural prevention measures	Future requirements
control, monitoring, and evaluation; (5) Coordinates cooperation among governmental as well as non-governmental organizations in the field of disaster management, either nationally or internationally; (6) Coordinates the receipt, distribution and use of assistance for disaster management; (7) Writes report of disaster management activities to the President; (8) Other disaster management tasks as directed by the President. In 1998 Bakornas PB conducted a one-day seminar on natural disaster and the media. The participants mostly come from the mass media in line with the theme of the seminar, namely *Prevention Begins With Information*. The aims of the seminar are to build partnerships with national media.		
Kenya		
The national disaster management structure in place consists of an inter-ministerial task force chaired by the Office of the President and with the Ministry of Planning and National Development, created in 1992. The National Operation Center is the operational arm of the National Disaster Coordination Council (NDCC). Officers	A comprehensive approach to disaster management in Kenya is still in the formative stage. In order to hasten the establishment of an institutional framework, the government of Kenya (GOK), UN Disaster Management Team (Kenya) and other key players (NGOs and private sector) have developed a National Disaster	• Carry out regular vulnerability assessment. • Prevention, mitigation, planning and reviewing of emergency response capacity. • More coordination, resources, and planning capacity.

Disaster management structure including specific structure dealing with El Niño	Structural and non-structural prevention measures	Future requirements
drawn from various government departments and ministries operate the center. The center is responsible for the coordination of all activities before, during, and after a disaster. There is no emergency response plan that details the specific actions and responsibilities by the key actors within disaster management.	Management Action Program for the past year (1999–2000). The action program is intended to shift the current undue emphasis on short-term responses to a more proactive approach that prioritizes sustained prevention, mitigation, and preparedness measures. The momentum for establishment of a more systemic disaster management system in Kenya has gained momentum over the past 4 years as a result of persistent drought and the intensity of El Niño-induced rains which produced severe flooding in 1998. The following structures and departments have since been put in place with the Office of the President (OP) playing a leading role: • Under the Civil Service Reform Program, the Department of Relief and Rehabilitation, the Development Co-ordination and the National Disaster Operations Center (NOC) are to be combined into one department named Disaster and Emergency Response Department within the Office of the President, by July 2000. This is intended to eliminate duplication of efforts, reduce waste of resources and fragmented institutions charged with the responsibility of disaster management, and adopt a more proactive, integrated disaster management approach.	

Disaster management structure including specific structure dealing with El Niño	Structural and non-structural prevention measures	Future requirements
	• Establishment of the National Disaster Management System in January 1998 to manage disaster. • El Niño project (recovery program) funded jointly by GOK and the World Bank to rehabilitate and reconstruct road networks in the country devastated by El Niño floods of 1997–98. • Poverty reduction programs aimed at capacity building and empowering of vulnerable communities at the grassroots level nationwide to develop local coping capacities and tackle other underlying causes of vulnerability. • Kenya Action Network for Disaster Management (KANDM) action program intended to implement anticipated short, medium, and long-term disaster reduction activities and capacity building, to establish a viable institutional framework and ensure integration of disaster reduction plans into national development plans.	
Mozambique		
The Department for Prevention and Combat of Natural Disasters was created in 1980. Time and resources were unavailable to develop a real planning process for emergency management as a whole. Moving ahead with the process of creating disaster	National Institute of Meteorology. Mozambique developed an integrated Disaster Management Policy, which combines prevention, preparedness, and response for sustainable economic development and growth governed by the National Action Plan.	• Policy and budgetary commitments. • Network building. • Information dissemination. • International mechanism for coordination.

Disaster management structure including specific structure dealing with El Niño	Structural and non-structural prevention measures	Future requirements
management mechanisms in Mozambique, a draft Policy on Disaster Management has been completed. Among other aspects, it defines the competencies and responsibilities of each sector and their responsibilities in relation to disasters. This document is the result of discussions held in early 1997, following consultations with the districts, provinces, and line ministries. Approval by the government is expected shortly. In fact, in the many years of its existence, the Department for the Prevention and Combat of Natural Disasters' (DPCCN) activities have essentially concentrated on the creation of bodies for decentralized disaster management, for example, the District Emergency Commissions (CTE), the Provincial Emergency Commissions (CPE) and the Emergency Technical Committee (CTE), which functions at central level. Through these bodies, we provided assistance to the victims of the armed conflict that caused the displacement of thousands of people, both inside the country and over the borders into neighboring countries, as well as the destruction of social and economic infrastructure and the very fabric of Mozambican society. It should be noted that Mozambique created a task force to deal with the threat from the	Activities carried out (forums, exhibitions, radio programs and plays) to mobilize civil society and the business community. It defines the competencies and responsibilities of each sector in relation to disaster management. • National workshop on disaster management (1995). • District profiles on food security and nutrition (1996). • Vulnerability assessment and mapping (1998). • Disaster profiles and risks mapping (1999). • Disaster Management Plan (ongoing).	• Natural disaster management has to be a long-term objective. • Proactive approach.

Disaster management structure including specific structure dealing with El Niño	Structural and non-structural prevention measures	Future requirements
El Niño phenomenon. This involved various government bodies that harmonized the contingency plans to counteract the probable negative effects, as well as contingency plans drawn up at district level in the last 3 years. The district contingency plans were then reviewed by the respective CPE and by the CTE for the management of the floods that occurred in that period throughout almost the whole country. The country's development strategy includes an intrinsic link between development activities and preventing the risk of disaster, since the level of vulnerability to the various types of risk requires a rapid response, with action to reduce the loss not only of human life, but also of social and economic assets. In the context, Mozambique found the opportunity and a privileged position to strengthen more and more its relations of cooperation at the regional level. It sent representatives to various seminars and conferences (South Africa and Botswana) and on study visits aimed mainly at encouraging all-round cooperation among the SADC countries in a regional response to disasters and discussing the availability of resources and disaster management.		

Disaster management structure including specific structure dealing with El Niño	Structural and non-structural prevention measures	Future requirements
Mozambique elaborated a disaster plan for drought along with SADC in the context of El Niño.		
Panama		
The National Protection System created by Law 22 of 1982 consists of a general directorate, 4 national divisions, and a regional office for each province. The Consultative Council is made up of 42 state and private sector institutions. NGOs have made a significant contribution to civil protection. The system has agreements with scientific and teaching institutions and is coordinated with numerous international and technical cooperation agencies. • Civil Defense Project for schools (1996). • Project to Strengthen Local Structures for Disaster Mitigation (1997–98). • Project to strengthen Disabled People's Centers (1998). • Project: Vulnerability Reduction in Floods and Local Warning System (1998).	Continuous operational drills and equipping of system, training of more than 15,000 people per year, local organization program, installing Geographical Information System (GIS) in disaster management, emergency response plan implemented, application of "Desinventar" and SUMA systems, implementation of an electronic hydro-meteorological station, strengthening of joint search and rescue operations. There is an inter-institutional coordination program that has set up several working groups, The civil protection program for schools incorporates the theme of disaster in the curriculum, focusing on central issues. Publication of a study *Natural Disasters and Risk Zones in Panama: Condition and Prevention and Mitigation Options*. Publication of book *Civil Protection: A Manual for Disasters*. Progress in the identification of areas at risk from earthquakes, mapping of flood risk areas, and studies on land use.	• International coordination mechanisms. • Budget and political commitments. • Creation of action networks. • Form national information networks and consolidate participation on the Internet. • Improve technical resources in communications. • Strengthen the role of local authorities within organizations and communities. • Full participation in the achievement of the objectives and goals of the National Environmental Authority. • Strengthen existing prevention and mitigation measures. • Promote policies to reduce the effects of manmade and technological disasters. • Promote exchanges among researchers.

Disaster management structure including specific structure dealing with El Niño	Structural and non-structural prevention measures	Future requirements
		• Promote policies for the protection of the ozone layer and to lessen the greenhouse effect. • Redouble efforts to deal with adverse events.
Paraguay The National Emergency Committee (CNE) attached to the Interior Ministry. A council led by the Interior Minister heads it and it consists of the Ministers of Public Health and Social Welfare, Finance, Public Works and Communications, Education, and heads of the Armed Forces and the National Police.	With support from UNDAC, a National Contingency Plan was prepared and efforts were made to train authorities and operations officials. A package of mitigation projects is being negotiated. Various countries and international organizations have provided resources for repairs and reconstruction. The report mentions efforts to increase awareness among citizens, training for authorities, officials of public institutions, municipalities, and NGOs involved in operations. Compilation of hydrographic data and assessment of hazards and vulnerability zones. In 1998 an assessment was made of the hydro-meteorological situation, public health, and human settlements in affected areas. The impact of El Niño has accumulated over a long period.	• No information provided.

Disaster management structure including specific structure dealing with El Niño	Structural and non-structural prevention measures	Future requirements
Papua New Guinea		
The National Disaster and Emergency Service (NDES). Papua New Guinea is currently reviewing its National Disaster Management Plan in order to identify the National Disaster and Emergency Service's core business, key functions, roles, and responsibilities.	Capacity developed within the National Disaster and Emergency Services to lead and direct key sector agencies and national government departments (including at least Health, Works, Agriculture, Defense, Constabulary, Civil Aviation, Environment, Education and Telecom) in disaster management activities. The aim is to assist the National Disaster and Emergency Service in: • Supporting key sector agencies and government departments in preparing technical guidelines on issues related to disaster mitigation, preparedness, response, and recovery; • Supporting key sector agencies in the development of specific disaster management plans; and • Conducting training on post-disaster emergency operations management for government agencies, NGOs, and the private sector.	• No information provided.

Disaster management structure including specific structure dealing with El Niño	Structural and non-structural prevention measures	Future requirements
Peru		
The National Institute of Civil Defense (INDECI) relies on the following structure: 6 regional administrations at the national level, with headquarters in Piura, Bagua, Iquitos, Lima, Arequipa, and Cusco. They have the support of universities and specialized organizations in earth sciences, among them the National Service of Meteorology and Hydrology, the Geophysical Institute of Peru, the Sea Institute of Peru and the Geology National Institute. Due to the consequences of the 1997–98 El Niño event several regional subdirections have been created in Tumbes, Lambayeque, Moquegua, Tacna, Puno, and La Libertad.	Adopted measures between INDECI and the National System of Civil Defense (SINADECI) were a valuable experience in regard to the 1997–98 El Niño phenomenon. For the first time, at the national and regional levels, they took the following actions: • Timely identification (since 1996) of ocean water warming in front of Peru and Chile that originated from El Niño 1997–98. • Analysis of vulnerability of potentially affected areas. • Training of population and simulations. • Measures of specified prevention (engineering) of potential flood zones, mainly for the rivers along the coast.	• No information provided.
Philippines		
At the national level, the National Disaster Coordinating Council (NDCC) acts as the top coordinator of all disaster management efforts as the highest policy making body and the highest allocator of resources in the country to support the efforts of the lower-level councils in the system. By decree, the NDCC is headed by a chairman from the Secretary of National Defense. Its composition includes other department	A collaborative program on extreme climate events, funded by the Asian Disaster Preparedness Center, undertaken by NDCC, establishes correlations of El Niño and La Niña phenomena to determine the best measures to mitigate their impacts. Grasses were grown extensively on unstable slopes and riverbanks as natural and indigenous measure of erosion control. The 1997–98 El Niño event has spurred the	• Priorities for future international cooperation. • Resource sharing for capability building. • Mobilizing information technologies for disaster management. • Systematic disaster capabilities planning.

Disaster management structure including specific structure dealing with El Niño	Structural and non-structural prevention measures	Future requirements
secretaries, the director general of the Philippines National Red Cross, the chief of staff of the armed forces and some other key officials of the Philippines government. The civil defense administrator is a member and serves as the executive officer of the council. The Office of Civil Defense becomes the executive arm of the NDCC with the National Disaster Management Center as the operating facility of multisectoral coordination, response, and policy development. Non-governmental organizations participate at all levels in the system. At whatever scale of disaster, whether national, regional, provincial, municipal, village, or any level in between, an appropriate disaster coordinating council is established, organized, and trained to respond. National Disaster Coordinating Councils are existing and operating at all levels and are tasked to disseminate warning information and implement measures to prepare for and mitigate the impacts of El Niño. In response to the 1997–98 El Niño event the government launched a coherent and integrated multisectoral rehabilitation program for El Niño-affected areas. It has five strategies:	highest degree of cooperation and coordination across government agencies to plan and mitigate the effects of this climate event. Due to a well-executed plan from the preparedness aspect of mitigation, there was a significant drop in expected damages and losses. The Philippines experience was cited as a model for collective endeavors during the "Asian Regional Meeting on the El Niño-related Crisis" (Bangkok, 1999). In addition, under the National Disaster Coordinating Council's institutional infrastructure and framework of action, the following major accomplishments have been achieved since the inception of the decade in 1990: • Presidential Proclamation No. 296 declaring the first week of July of every year as Natural Disaster Consciousness Week. • Presidential Proclamation No. 705 declaring 6 December 1995 and every year thereafter as National Health Emergency Preparedness Day. • Integration of a Disaster Mitigation Component in the Development Administration Sector of the Philippines Medium-term Development Plan (1993–98).	

Disaster management structure including specific structure dealing with El Niño	Structural and non-structural prevention measures	Future requirements
(1) Generating livelihood and household income; (2) Enhancing health and nutrition services; (3) Protecting vulnerable communities from the anticipated impact of La Niña; (4) Agricultural development and modernization; (5) Reinforcement of the Disaster Coordinating Council. A Task Force on El Niño was constituted (March 2000) under the National Disaster Coordinating Council system to implement preparedness and mitigation measures for the expected El Niño occurrence in 2001. The Task Force is jointly directed by the Department of Agriculture and the Department of Environment and Natural Resources.	• Inclusion of pre-disaster activities within the purview of the Calamity Fund Use (1994). • Inclusion of section 31 of the General Appropriation Act CY 1998 and onwards that authorizes the use of regular funds by national government agencies (NGAs) for disaster management concerns.	
Vietnam		
The Central Committee for Flood and Storm Control (CCFSC), created in 1990, is the agency responsible for flood and storm control and natural disaster reduction in Vietnam. It is the inter-ministerial body under the direct management of the Prime Minister and consists of many key government agencies, and includes 20	Physical measures include dykes and reservoir building and other infrastructures for natural disaster reduction. Non-physical measures include the strengthening of the institutional framework, further development of education, preparedness, and mitigation programs. Preparations are underway towards a	• More budget resources. • Disaster reduction must be integrated in economic and social development process. • Strengthening legal system. • Capacity building.

Disaster management structure including specific structure dealing with El Niño	Structural and non-structural prevention measures	Future requirements
ministries and is chaired by the Minister of Water Resources, who is responsible for emergency response nationwide. Another important outcome of the *Strategy and Action Plan* was the joint establishment with the United Nations Development Program (UNDP) of a Disaster Management Unit (DMU) within the Standing Office of the CCFSC: since 1994, the DMU has been working with the CCFSC to join together over 1,000 years of the Vietnamese flood protection culture with 21st century western technology. The DMU has provided disaster management, communications, and assessment training programs for provincial and district officials throughout the country; set up a reference center and central database on disaster management with the use of the Internet and GIS technologies; and provided funding and expertise for the establishment of a nationwide communications network, which links all provinces of Vietnam to the Standing Office of the CCFSC in Hanoi. The CCFSC-DMU is currently preparing a new Master Strategy for mitigating all types of natural disaster in Vietnam (water disasters, forest fire, drought, industrial accidents, etc.). The DMU will also be	strategy for disaster mitigation in Vietnam. The strategy will focus on forecasting and warning activities, preparedness and mitigation activities, and emergency relief.	• Better information dissemination, and better mechanisms for international coordination: financial resources; quicker information exchange; regional network; technology transfer and technical assistance.

Disaster management structure including specific structure dealing with El Niño	Structural and non-structural prevention measures	Future requirements
assisting national and local officials to streamline Vietnamese disaster reporting and assessment procedures. In 1998–99, the CCFSC-DMU is developing a community-based grassroots disaster preparedness training program for schoolchildren. The grassroots training will build on the existing disaster preparedness experience of the Vietnam Red Cross Society (VNRC), with the assistance of the International Federation of Red Cross and Red Crescent Societies (IFRCRC) and with funding from the European Community Humanitarian Office (ECHO).		

Climate affairs as a next generation environmental science

The following section is based on an article by Michael Glantz and Zafar Adeel (2000).

An education and training program

Today, one could argue that governments are in the midst of creating a "Law of the Atmosphere." This is driven by the fact that a wide range of global concerns has been added to the traditional concerns about the atmospheric environment: air pollution, transboundary atmospheric pollution, and acid rain. Most obvious additions are related to greenhouse gas emissions and global warming of the atmosphere as well as stratospheric ozone depletion. Extreme climate events like El Niño and La Niña are thought to become greater in severity and magnitude as a direct consequence of global warming. Indirect impacts – such as tropical deforestation and biodiversity loss, changes in agriculture and food produc-

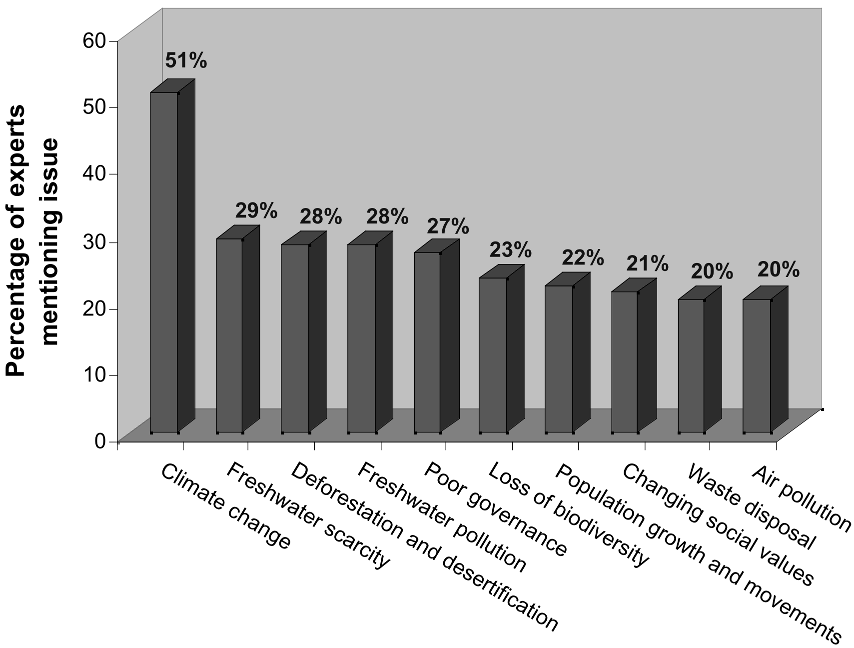

Fig. 6 **A survey involving 200 environmental experts shows that climate change issues are among the most critical problems anticipated to be encountered in the twenty-first century (UNEP/SCOPE 1999)**

tion, and increased health problems due to nutritional impact and vector redistribution – have also come to the forefront (Lindsey and Birley 1996).

We believe that the notion of an education and training program for climate affairs is a viable one, given the tremendous impact that climate has on society and the environment and vice versa. Whether that notion can be realized in a university or educational training setting is as yet an unanswered question. The notion of "climate" encompasses climate change and climate variability on inter-annual and decadal scales, and extreme meteorological events, such as droughts, floods, frosts, fires, severe storms, cyclones, and so on. Climate variability on time scales of decades and longer has respectively been referred to as climate fluctuations and more popularly as climate change.

A history of growing interest in climate affairs

Clearly, the scientific understanding of the global climate system has greatly improved since 1900. The tools used to study climate processes and their impacts have changed phenomenally since then with the advent of satellites, computers, the Internet, globally distributed sensors, and so forth.

It seems that the study of "climatology" until the 1960s was viewed as a "dry" subject – a somewhat specialized part of the atmospheric sciences and geography. A few specialists wrote about the history of climate changes such as the world-renowned British historian Hubert Lamb or French historian Emanuel Ladurie.

In the early 1970s climate began to come into focus as a global issue. Several articles and books appeared suggesting that the global climate was beginning to cool. This sparked concern at the highest levels of science and of governments that the earth was moving into an Ice Age. The argument was prompted by the fact that the period from the 1940s to the early 1970s was cooler than the long-term average. This multi-decade cooling fueled a debate about the stability of the global climate. Several examples were cited in support of the global cooling hypothesis. Books appeared in stores with titles such as *Fire and Ice*, *Ice*, *The Cooling*, *Genesis Strategy*, etc. Unusual inter-annual variability coupled with famines in Africa in the early 1970s and a list of subtle environmental changes served to reinforce this perception that the earth was moving into an ice age.

However, in the mid-1970s some scientists began to reconsider their understanding – for the third time in the twentieth century – on how the increased emissions of greenhouse gases as a result of anthropogenic activities might be heating up the atmosphere. Several industrial, commercial, and residential activities were thought to be contributing: burning of fossil fuels, tropical deforestation, fertilizer use in agriculture, and use of CFCs as a refrigerant and foam-blowing agent. In the latter part of the decade, concern about the stability of the West Antarctic Ice Sheet and a potential sea level rise raised fears about the possible impacts of global warming on ecosystems and on societies.

During the 1980s, scientific interest in the climate change issue grew to major proportions, resulting at the end of the decade in conferences on various science, impacts, and policy aspects of a potential global warming. In 1990 the Intergovernmental Panel on Climate Change (IPCC) issued its first report (Houghton et al. 1990; Tegart et al. 1990). It was a state-of-the-science assessment of the global climate system and the potential for a human-induced global warming. An interim IPCC report was issued in 1992, and again a new state-of-the-science IPCC report was issued in 1995. The 1995 report was controversial in that it clearly stated that human influence on the global climate system was identifiable. A regional assessment of the impacts of climate change was done in 1997 (Watson et al. 1997). Each successive assessment, produced by scientists from around the globe, provided additional research that tended to support the perspective that the earth's atmosphere was heating up and human activities were implicated.

The last decade of the century, the 1990s, witnessed the sharpest increase in sustained scientific, governmental, public, and media interest in climate and weather. The climate history of this decade appears to be outstanding, if not unique, when compared to earlier decades: multiple El Niño and La Niña events; blockbuster hurricanes (Andrew, Mitch, Georges, and Floyd); destructive typhoons; deadly floods and mudslides (China, Venezuela, Honduras, Yemen, Vietnam, eastern and western Europe, and the USA); numerous and widespread droughts; the spread to mid-latitudes of climate-related infectious diseases (malaria, encephalitis, and dengue fever); the occurrence of several of the globe's hottest years on record – further fueling concern about human-induced global warming of the atmosphere. It is also interesting to note that these events were not distributed uniformly across the globe and some regions appear to have been at a much higher risk.

Throughout much of the twentieth century, the popular belief was that climate was a boundary condition with which societies located in different regional climates had to cope. Most accepted it as an unchangeable boundary constraint, something that could not be altered by human activities. Despite numerous suggestions and attempts to deliberately alter regional climate regimes into more favorable ones for economic and

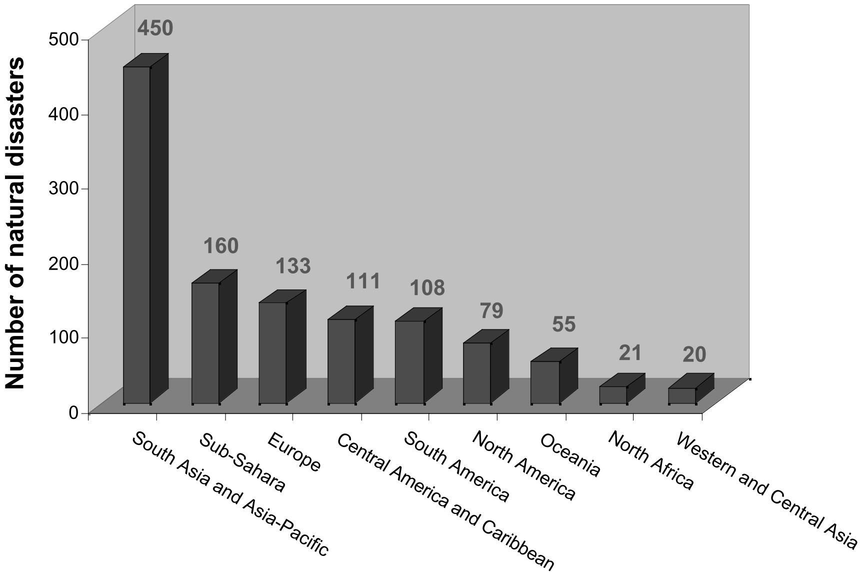

Fig. 7 **An assessment of environmental disasters around the world shows that natural disasters occur with a much higher frequency in tropical areas (CRED 1999)**

social development, few managed to do so (Glantz 1979). Drought, heavy rains, severe storms, cyclones, and frosts all occur naturally. While they cannot be prevented, they can be understood and their consequences prepared for. Societies today are increasingly searching for ways to be proactive – as opposed to being only reactive – with regard to the consequences for them of climate variability, and now of climate change.

In this historical context and present-day setting, the National Center for Atmospheric Research (Boulder, Colorado, USA) and the United Nations University (Tokyo, Japan) have joined with the World Meteorological Organization (Geneva, Switzerland) to explore and embark on climate-related capacity-building activities in developing countries. The purpose of this effort is to encourage educators at universities, colleges and training centers to teach their students – the future generations of decision makers – about the interactions among climate, society, and the environment.

Elements of Climate Affairs

"Climate Affairs" may be developed as a new multidisciplinary program or an evolution of existing ones at colleges and universities – and at other educational/training institutions – in developing countries. The first and foremost purpose of a Climate Affairs activity is to develop an awareness that climate affects all aspects of life in rich and poor countries alike and that these countries can improve the way they are affected by enhancing their understanding of climate affairs for decision-making purposes.

There is a growing awareness of the need for a better understanding of just how climate variability and change (on a variety of time scales from seasons to decades and geographical scales from local to global) affect ecosystems and the affairs of people and nations. Societies have also come to realize how their activities (e.g., industrialization and land-use processes) can alter not only the global atmosphere but regional climate patterns as well. An increasing number of governmental, individual, and corporate decisions are being made for which a knowledge of climate affairs is required. There is, at the same time, a lack of institutional capacity in developing countries to effectively impart relevant knowledge to such decision makers. This situation calls for capacity-building efforts by national and international agencies and organizations.

A Climate Affairs program would enable students to concentrate their education and training in areas of research, application, and policy that center on climate and climate-related issues. This may be achieved either by developing new academic units and curricula or by creating synergistic collaborations amongst existing academic units. Students who attain this training will be able to understand how climate affects societies and, conversely, how societies and ecosystems affect climate. The graduates of a Climate Affairs program – tailored to their national needs – would be better prepared to work in various disciplinary areas (e.g., economics, politics, anthropology, history, sociology, climate and ocean research and forecasting, economic development) and in various economic sectors (e.g., industry, commodities, agriculture, fisheries, mining, insurance, education, health, civil defense, government agencies, disaster prevention and relief).

The objective of a Climate Affairs program is to meet the special interests and expertise of the various universities and training centers. More specifically, a Climate Affairs program would universally comprise the following elements:

- climate science (variability, change, and extreme meteorological events)
- climate impacts (on societies and ecosystems)
- climate policy, politics, and law (domestic and international)
- climate ethics (intergenerational equity, discounting the future, and environmental justice)

Climate science

"Climate science" refers to the physical aspects of the climate system. It encompasses research on the various processes involved in global and regional climate variability and change. Climate varies on all time scales. The immediate focus is on variability from one year to the next and one decade to the next, realizing however, that it varies on century and millennia time frames as well. Global warming issues would also be well covered. Understanding the atmosphere and the ways that it is affected by biological changes in the marine and terrestrial environments and by anthropogenic activities is the main focus of "Climate science."

Climate impacts

"Climate impacts" relates to the impacts of climate on ecosystems and society. Ecosystems can be further subdivided into managed (e.g., agricultural and range lands) and unmanaged (some forests and wetlands) ecosystems. The impacts on society can also be further subdivided into direct and indirect impacts on human activities.

Impacts of climate and climate-related anomalies are of greatest concern to the general public and to their governments. Impacts can adversely (or positively) affect food production, water resource availability, fishery abundance, public health and public welfare in general. Although, for example, a drought may occur over a few months during a growing season, its adverse impacts can linger for years. The same can be said for other extreme climate and climate-related hazards.

The severity of the impacts of climate and climate-related anomalies, however, is not simply the result of the intensity of the adverse climatic conditions but is also a function of the level of vulnerability of a society. The time for recovery from the impacts of a tropical cyclone or a drought or an El Niño-related bush or forest fire will also depend on the level of resilience of a society. The impacts of an extreme event in the same location but at different times will probably vary depending on what is going on in that society at those particular times. In this context, developing countries are particularly vulnerable because of the lack of economic and human resources as well as an absence of the appropriate institutions to deal with these problems.

Climate policy, politics, and law

Today there is considerable interest and activity in developing a comprehensive body of regulations related to the climate system. An indicator of this interest is the fact that more than 180 countries have signed and ratified the UN FCCC and about 80-odd countries have signed the Kyoto Protocol. Additionally, there are other national and international laws dealing with air pollution, transboundary transport of pollutants (including acid rain) and, recently, stratospheric ozone depletion. Thus, there is a myriad of institutional and policy aspects of the climate system at the domestic and international levels. Some government agencies have focused on identifying transboundary water resources as potential flashpoints for conflict, which indeed can be affected by the climate system. On the whole, there is a wide array of issues that can be explicitly discussed and explored under "climate policy and law." "Climate politics" relates to the interactions among competing groups to achieve their favored policy.

Recently, the United Nations University has led the charge to investigate and evaluate interlinkages and relationships between various multilateral environmental agreements (UNU 1999; Schmidt et al. 1999). For example, the implementation of the Kyoto Protocol can have implications for land use and degradation, and ultimately desertification, in a number of geographical regions. Similarly, the policy implications of the climate change regime need to be viewed in the light of synergies and conflicts with other major environmental conventions – e.g., those dealing with desertification, biodiversity conservation, ozone depleting substances, etc. Such interlinkages can also be addressed within "climate policy and law."

Climate ethics

This is a new phrase, coined specifically for the notion of Climate Affairs. Climate variability, climate change, and extreme events each has its own set of ethical aspects. They could include, but are not limited to, the following: intergenerational equity, environmental justice, discounting the future, valuation of regional climate, winners and losers in various climate change scenarios, "polluter pays principle", "precautionary principle". Although these ethical aspects are important for action on climate issues, they are more or less neglected in academic settings. This wide array of issues points to the need for making "climate ethics" an integral part of the training and capacity-building process.

Where does "Climate Affairs" lead to?

It may be asked whether this is the "right" time for the academic community in various the developing countries to consider the development of Climate Affairs. The current settings in the international arena and the growing interest in developing countries indicate that this indeed is something that needs to be addressed on an urgent and proactive basis. It may also be asked whether students would benefit from an educational program that focuses on climate affairs – a program that encourages scientific study and the application of that science to address societal needs. Again, the apparent need for more informed decision making in developing countries leads us to believe that such a program will be truly beneficial in the long run. Finally – referring to the title of this section – is Climate Affairs going to belong to the "next-generation" of environmental science programs? Considering the fact that such a focused program will fill an existing gap and is a necessity for developing countries, we are quite confident that Climate Affairs – like Marine Affairs – will lead to a new generation of multidisciplinary programs. While each of these may be tailored to specific national, institutional, or organizational requirements, the essence of Climate Affairs, described by its four elements, would be universal.

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Part V

Supporting information

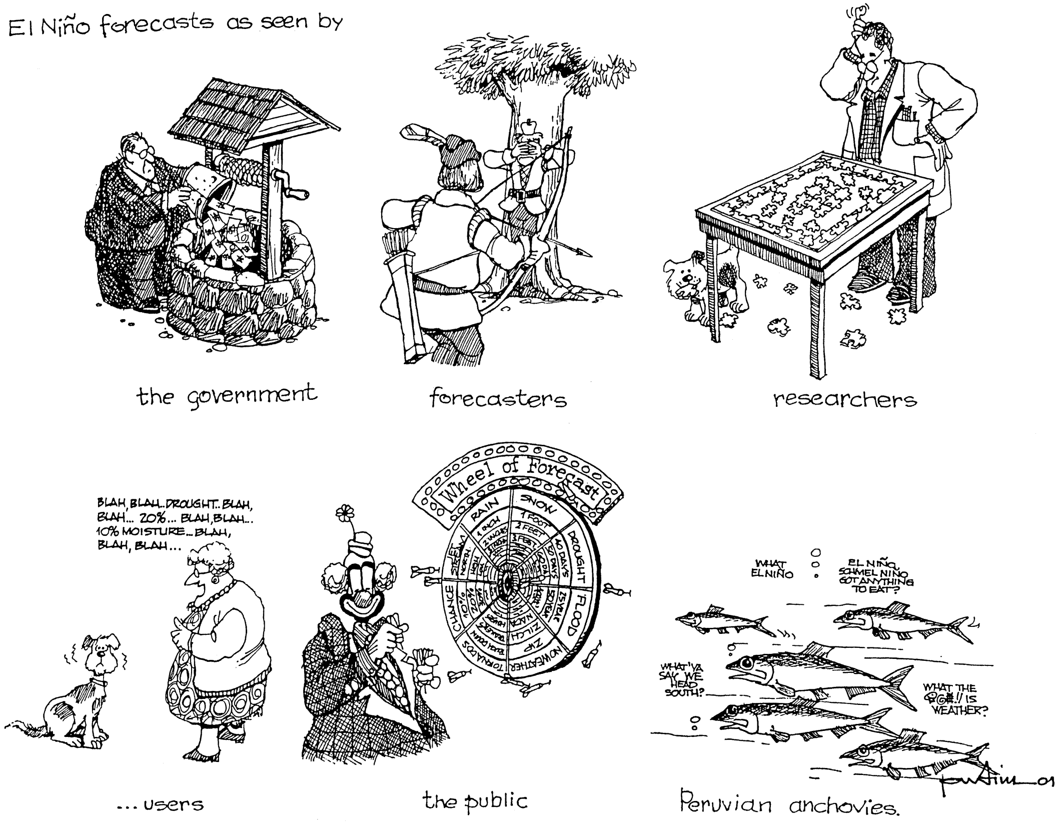
PI's (Principal Investigator's) postscript

As with any research project, regardless of its level of complexity, its duration, or its cost, numerous ideas are generated. Not all of them can be made to fit neatly into the final report. The choice is to omit these items and hope that there will be other opportunities to introduce them somewhere (an article, a workshop, a website) at some time in the not-too-distant future, or to put them in the report where they do not mesh so well with the surrounding text. A third option is to include them with the report but separate from the text. So, the following few pages represent these discrete items that I (as the PI) would like to share with the reader. Each item was inspired by some aspect of this project.

The El Niño cartoon

The first item is a cartoon that was sketched by the PI and was professionally drawn by Boulder cartoonist Rob Pudim. Its message is that there are competing perspectives in society of El Niño forecasting. For example, to governments, researching and forecasting El Niño is a sink for government funds. To forecasters, their goal is to "hit the target" of a reliable and credible forecast operation. Researchers see the El Niño phenomenon as part of a larger climate puzzle, and they are not yet sure

The El Niño cartoon (Rob Pudim)



that all the puzzle's pieces are on the table. Users have great difficulty in converting the forecasters' probability statements about El Niño into information they can readily use. The public, for its part, tends to focus its attention on missed forecasts and likes to joke about the inability of forecasters to produce correct forecasts consistently. In some places, forecasting is seen as a game of chance. And as for the Peruvian anchoveta, it suffers with El Niño events and is forced to dive deeper into the water column or migrate southward toward Peru's border with Chile.

Using an El Niño forecast

The following "How to" information suggests in a very broad-brushed way how one might react when one hears that an El Niño event has been forecast. It is meant to be suggestive and illustrative. Hopefully, it could spark individuals, organizations, and government agencies to make their own specific "How to" chart in response to an El Niño forecast.

How to use an El Niño forecast

An El Niño forecast can provide decision makers in many parts of the globe with their earliest warning of potential adverse climate conditions in their countries. This is so because researchers are improving their ability to forecast the onset of, and especially to project, the development of an El Niño event once it has begun. As the earliest warning, it can be used by governments and individuals to start the proverbial ball rolling with respect to strategic planning for possible drought, flood, fire, frost, or infectious disease outbreak. No longer would they have to wait to react until they are in the midst of such climate-related threats.

In reality, one forecast of the likely onset of an El Niño will not meet the needs of all of its potential users. Different users require different El Niño-related information, and they need it at different times, with some needing it earlier than others. Those needs will clearly change as the development of an El Niño progresses (how fast it grows and intensifies). Steps on how one might use an El Niño forecast will depend on what one needs the information for, when that first forecast is received, as well as the means by which the forecast is communicated (Internet, TV, radio, newspaper, word-of-mouth). So, the following example is for an individual. It is hoped that people in decision-making positions throughout society will undertake a similar hypothetical walk through the process of how he, she, or they might respond to the announcement of the first sighting of an El Niño event.

Let's assume that you are at home listening to the radio, watching TV, or reading the local newspaper. You learn from the media that scientists in the USA or in Australia have identified the possible onset of an El Niño event. What then are you *able to do with such an earliest warning of El Niño? For a start, and regardless of whether you believe the forecast is reliable, you can do the following:*

Do:
- Learn about what the El Niño phenomenon is.
- Learn about when it occurred in the recent past.
- Learn about the kinds of climate conditions and weather extremes that occurred in your area during previous El Niño events.
- Identify how you were affected by the last El Niño(s).
- Discuss with friends or work colleagues the possible impacts of El Niño during the different seasons.
- Identify your possible responses to those possible climate impacts.
- Identify the responses that you can do alone and within your means.
- Then identify the responses you might be able to take with assistance.
- Wait for a future update (on the order of a few weeks) of El Niño's progress.

Don't:
- Ignore it.
- Panic.
- Sell your house, farm, or personal possessions.
- Monitor El Niño's progress day by day.
- Believe everything you hear about El Niño.

Questions from the media

This item represents the PI's succinct response to the media questions during the launching of the brief executive summary at the United Nations in October 2000.

When interviewed by the media, the question most often asked about this project was, "What was learned as a result of this assessment?" In response to this question and given the time and space constraints, the following succinct points were made:

- The public needs to be educated about El Niño and El Niño forecasts (their strengths and limitations) and how best to respond to the event, its potential impacts, and to the forecasts of both of these.
- Governments and industries need to realize that El Niño forecasts (and La Niña forecasts as well) can provide them with the *earliest possible* warning of climate and climate-related impacts in their countries. As the earliest warnings of such impacts, they will have the chance to develop strategic responses to the forecasts and to the impacts. They must also realize that the impacts of an El Niño often highlight existing underlying chronic societal and environmental problems.
- Donor governments and agencies need to prepare for El Niño-related requests for assistance from the known at-risk countries so that they can proact to the El Niño forecasts as well as react to El Niño's impacts.

They also need to treat the recipient countries as equal partners, who have special insights into their needs in times of El Niño-related emergencies. In other words, not all experts come from outside the country!

- Forecasters of El Niño (and La Niña) need to be more open and forthright about the state of the science of El Niño and the state of the science and art of forecasting ENSO's extreme warm and cold events. Suggesting that their forecast capabilities are better than they really are (i.e., spin doctoring) leads to a loss of credibility with respect to all climate forecasting activities. Honesty is the best policy in the long run.
- It must be recognized that researchers are investigating a relatively recent area of research, given that El Niño as a regional phenomenon with global implications has been monitored closely only since the setting up of a Tropical Ocean Global Atmosphere (TOGA) array of buoys in the equatorial Pacific Ocean between 1985 and 1994. El Niño as a Pacific basin-wide phenomenon with global implications was only discovered in the late 1960s, although the phenomenon had been occurring for millennia. And, many researchers in developing countries are studying the physical, biological, and social aspects of El Niño under very difficult technological, scientific, economic, and political conditions in their countries. Researchers and research institutions in the industrialized countries need to support their research colleagues in developing countries.

Appendixes

1: Questionnaire

The list of questions addressed by the study teams was finalized at the Geneva, Switzerland, workshop (8–10 July 1999) during the First Meeting of Team Leaders. The questions are as follows, with the realization that each country team would not necessarily be able to address to the same extent each of the questions on the list.

Setting

(1) What is the socio-economic setting of your country? (Include a brief description of the government mechanisms for dealing with climate-related impacts; the ministries, task forces, and public safety mechanisms, etc.)
(2) What are the climate-related and other natural hazards affecting your country? (List them in order of concern.)
(3) What was the level of scientific research in your country relating to El Niño?
(4) Identify and document (with citations, if possible) the historical interest, if any, in the country (popular, political, media, etc.) in El Niño before the onset of the forecast and/or impact of the 1997–98 event.

1997–98 Event

(5) Trace the flow of information on the 1997–98 El Niño within your country, using the following guidelines:
- When did the various agencies first hear about this developing El Niño?
- Where did the information come from?
- When did they first hear it would be a strong event? From whom?
- Which agencies first received the information?
- Were these the appropriate agencies to first receive the information?
- How was the information obtained?
- How was the information transmitted?
- How did the media first report the developing El Niño?
- How did the media cover the event over time? (Quote headlines, names of radio stations, TV programs, etc., with dates.)
- Was the 1997–98 El Niño compared with any previous events?

(6) Before the mention of the 1997–98 El Niño, when was the previous mention of El Niño in the media?

Teleconnections (i.e., expected effects of El Niño)

(7) What are the scientific views about the existence and the strength of El Niño teleconnections to the country area? [WMO to address this question]
(8) If known, what were the climate-related anomalies and impacts in your country of the 1982–83 event?
(9) What were the 1997–98 climate-related physical and social impacts of the 1997–98 El Niño in your country? (Include agriculture, health, water supply, migration, etc.)
(10) What is the reliability of those attributions?

Responses

(11) Were any government reports or statements issued before the impacts of the 1997–98 El Niño appeared?
(12) Were any reports issued after the impacts appeared?
(13) What were the major responses to the event?
(14) Identify (with citations, if possible) the extent of national research (in the last 20 years) in your country on:
  (a) El Niño
  (b) Climate-related hazards
(15) Is there a national plan to respond to disasters? [IDNDR to address this question]
(16) Is El Niño explicitly considered to be a disaster in your country? [IDNDR to address this question]

(17) Identify (with citations, if possible) any international research about the impacts of El Niño events on your country.

Forecasting by analogy (i.e., using recent historical examples to plan ahead)

(18) If a perfect forecast had been available as early as October 1996 (knowing what is now known about the actual impact), what could have been done differently? (Do not take into consideration at this time any restrictions on possible actions.)
 (a) About information flow?
 (b) About preparing for the forecast impacts?
(19) What are the realistic obstacles that might have prevented these theoretical actions being taken?
(20) Can El Niño considerations be added explicitly to national disaster plans?
(21) Identify the strengths and weaknesses in the way your country responds to El Niño-related climate anomalies.
(22) Did the 1997–98 El Niño have any influence on your country's response to the forecast in early 1998 of an expected La Niña event?

2: Profiles table of the 16 countries

The following table provides general information about each of the countries for two periods of time during which this project's El Niño impact and response strategy studies were undertaken. The first period of 1997–98 represents, roughly, the duration of the El Niño (early 1997 until June 1998) and contains information centered on various economic, political, social, and military concerns of the specific country during this period. This is only meant to be illustrative of the types of issues with which a government and society must deal under non-El Niño conditions. However, an unexpected (timing-wise) El Niño occurrence just adds one more problem, albeit a potentially serious one, to the list of urgent issues that a government must face simultaneously.

This same type of information was also collected for the period of 1999–2000. This is the time period during which the study teams performed their research activities (more or less May 1999 through September 2000). It is also meant to be illustrative of the conditions under which researchers in developing countries have to work. It obviously does not tell the whole story, as there are other pressures on these researchers to produce their findings: occasional electric power blackouts, poor access to the Internet, difficulty in accessing the most recent scientific journals and reports, as well as the limited funding available for their activities.

This table, however, is not intended to be comprehensive. It is only meant to give a sample backdrop for each country and the circumstances therein.

Table A1 **Country profiles for two periods**

During El Niño years 1997–98	During study years 1999–2000
Bangladesh	
1997 Tests continue that began in 1996 on arsenic-contaminated water found in significant percentage of country's 4 million tubewells – the major source of drinking water. **May** Powerful cyclone hits southern coast killing hundreds; 8,000 injured; 400,000 homes destroyed; thousands of fishermen missing. **Dec.** Peace pact signed with Chakra rebels in north Chittagong Hill Tract after 22-year conflict. **1998** **July–Sept.** Worst flooding in decades causes at least 1,500 deaths; hundreds more die from disease; leaves millions homeless; deprives 30 million people of their source of income.	**1999** Opposition coalition calls numerous general strikes, shutting down banks, businesses, and schools in attempts to force out Prime Minister Sheikh Hasina Wajed. This causes serious economic hardships with an estimated $68 million lost each day of strike. Violent protests in Dhaka. **2000** **Aug.–Sept.** Floods affect millions of people; millions are left homeless; major problems with food and medicine shortages and disease.
China	
1997 **Feb.** Paramount leader Deng Xiaopeng dies, allowing President Jiang (elected in 1993) to consolidate his power. **June 30** China regains control of Hong Kong after 156 years of British colonial rule. **Aug.** 2 typhoons kill hundreds; hundreds more injured; thousands homeless; millions affected. **Dec.** Internet restriction laws passed. Criminal punishment/strict fines for users deemed illegal. **1998** **Jan.** 6.2 earthquake in north kills 50; injures some 11,400, 44,000+ homeless. **Mar.** Congress elects new premier, Zhu Rohgji, replacing Li Peng whose term expired.	**1999** **June–Aug.** Floods kill approximately 725; 5.5 million homeless in Yangtze River Valley. **May** US accidentally bombs Chinese embassy in Belgrade resulting in 3 deaths. Mass protests in China. **July** Tensions heat up with Taiwan. China announces "wartime mobilization drills" and reiterates threat to use force against "splitting the motherland." **Sept.** Earthquake in Taiwan kills 2,000+. China offers aid despite political tension. **Nov.** Landmark trade pact signed with US. **2000** **Jan.** Earthquake in southwestern Yunnan province kills 5; 1,200 injured;

Table A1 (cont.)

During El Niño years 1997–98	During study years 1999–2000
June–Aug. Floods kill 3,656; 5.6 million homes destroyed; 65 million acres of farmland inundated; $30 billion in economic losses. **Nov.** 2 earthquakes in southwest kill 3; injure 4,000+; leave 23,000+ homeless.	100,000 homeless in brutally cold conditions. **Mar.** Chen Shui-ban elected president of Taiwan. Vows peace with China and cooperation on "One-China" policy.
Costa Rica	
1997 End of President Figueres' term, which saw the economy on a major downswing and accumulation of billions in foreign debt (approximately $4 billion, or 40% of GDP). **1998** Influx of Nicaraguan Hurricane Mitch victims. Puts pressure on country's limited resources. **Feb.** Election of new president, Miguel Angel Rodriguez, of opposing party. Peaceful election and transition.	**1999** No major events. **2000** **Mar.** Two North American girls are murdered outside of Cahuita, which receives a lot of media attention in the US and elsewhere. Concern the news could damage economy through loss of tourism revenue.
Cuba	
1997 No major events. **1998** **Jan.** Pope John Paul II makes historic visit. **Mar.** Clinton administration announces US will ease restrictions on cash remittances and travel to Cuba. **Aug.** Severe drought forces Cuba to ask for international aid. Hurricane Georges follows in Oct. causing even more severe damage and the need to ask for more aid. Cuba refuses a pledge from the United States.	**1999** **Jan.** Clinton administration eases segments of US embargo/blockade on Cuba. **Nov.–Dec.** 5-year old Elian Gonzalez, sole survivor of capsized refugee boat, rescued and brought to Miami. Conflict arises over his return to Cuba. **2000** **Apr.** Elian Gonzalez seized by US officials and returned to father and eventually to Cuba. Major international media coverage. US heavily criticized for use of force. Castro pleased with Elian's return.
Ecuador	
1997 **Feb. 6** President Abdala Bucaram ousted on grounds of "mental incapacity." Alarcon named interim president.	**1999** **Feb.–Mar.** Economic crisis. Sucre devalued 50%. Rush on banks to exchange sucres for US dollars. **Mar.** President Mahaud closes banks for 5 days to protect reserves. Emergency economic austerity

Table A1 (cont.)

During El Niño years 1997–98	During study years 1999–2000
1998 Crop damages from El Niño are a major factor in economic downturn leading eventually to worst economic crisis in 70 years. **June** Gas prices quadruple. 285 people die in El Niño torrential rains and floods. **July** Quito mayor, Jamil Mahaud Witt, elected president. Sworn in Aug. 10. **Sept.** Economy in decline – currency (the sucre) devalued. **Oct.** Peru border treaty signed ending long-term dispute.	measures imposed to stabilize economy. Bank accounts frozen. Strikes ensue led by various labor and transportation groups. Eight of the country's 39 banks closed. State of emergency declared 8 Mar., then lifted 18 Mar. **July** Another state of emergency declared in response to transportation workers strike. Strike ends after government agrees to roll back gas prices. **Dec.** Sucre has lost 67% of its value. **2000** **Jan.** Mahaud calls another state of emergency as a result of student and labor protests. Announces very unpopular measures to deal with economic crisis, namely pegging currency to US dollar. Coup led by indigenous protesters and military dissidents overthrows Mahaud. Rebels announce plan for 3-man junta to rule. Three days later military dissolves junta and installs vice president, Gustavo Noboa, as new president. **Feb.** Bank accounts thawed. Up to $4,000 cash can be withdrawn with government bonds issued for excess. **Mar.** Noboa signs bill adopting US dollar as national currency. **Sept.** Currency officially changes to US$.
Ethiopia **1997** **Nov.–Dec.** Floods kill more than 200 people. Millions in need of aid due to failure of crops because of droughts and floods. Grain production declined by 26% from 1996. **1998** **Jan:** Incidence of malaria reached alarming proportions in areas flooded by unseasonable rains at end of 1997. **Feb.** Saudi Arabia bans import of cattle from Horn of Africa for fear of	**1999** **June** Ethiopian forces capture a Somali regional capital with little resistance. Gives Ethiopia control over much of southern Somalia. **Aug.** FAO report estimates 5 million people, including 400,000 displaced by conflict with Eritrea need emergency food. Need was increased due to failure of the belg rains. **Dec.–Jan.** UN country team presents donors with "Relief Action Plan" and "Appeal for 2000" to support victims.

Table A1 (cont.)

During El Niño years 1997–98	During study years 1999–2000
Rift Valley fever with negative impact on economy. **Mar.** Desert locust swarms in Somali region contained. **May** Border conflict with Eritrea led to war. Hundreds killed and thousands displaced. Eritran port of Assab closed and port of Djibouti used, leading to many bottlenecks. Eritrea confiscates commodities destined to Ethiopia, including 50,000 tonnes of relief provided by USAID.	**2000** **Mar.–Apr.** Forest fire destroys more than 70,000 hectares of forest. **Apr.** Drought puts 8 million at risk of famine if aid not provided. Hundreds already dead from starvation. UN Resident Coordinator extremely worred about low response to appeal for non-food aid to Ethiopia. **May–June** War with Eritrea reignited and Ethiopia successfully expels Eritrean troops from Bulomakada and Irob. **June** Peace treaty signed with Eritrea to stop violence. Arrival of UN peacekeepers. Repatriation of Ethiopian and Eritrean refugees begins. International aid received to assist with peace process and combating starvation and disease.
Fiji **1997** **Mar.** Cyclone Gavin hits causing $27 million in damages, 7+ killed. **April** New constitution replaces 1990 constitution with the objective of creating a multiracial government that would, namely, allow for minority Indo-Fijians to hold office. **1998** Major drought damages crops and threatens thousands with starvation. Cyclone and flood follow causing 7 deaths and need for more foreign aid.	**1999** **May 19** Labor leader and first Indo-Fijian prime minister, Mahendra Chaudhry, sworn in. **2000** **May 19** Businessman George Speight leads coup capturing Chaudhry plus 40 other hostages. Military imposes martial law and establishes interim government. President Mara officially fires Chaudhry and resigns in reconciliation attempt. **July** Australia and New Zealand impose sanctions. On 9 July Speight signs peace accord with the military, and on 13 July releases Chaundhry and last of hostages. Great Council of Chiefs elects former vice president, Ratu Josefa Iloilo, as president.
Indonesia **1997** 860 people die from drought and food shortages in 1997. **Feb.** Hundreds die in ethnic clash on Island of Borneo.	**1999** **Jan.** Violent unrest continues throughout the archipelago. At least 159 killed in ethnic clash between Christians and Muslims in Ambon,

Table A1 (cont.)

During El Niño years 1997–98	During study years 1999–2000
26 Sept. Jet crashes on Island of Sumatra killing 234 people. Same day supertanker and Indian cargo vessel collide in the Strait of Malacca killing 29. Both are widely attributed to forest fires burning out of control creating a haze that eventually covers much of Southeast Asia. **Oct.** Government closes 16 banks after major devalue of the currency (rupiah) and decline in economy. By Dec. rupiah has declined 57%. IMF pledges some $40 billion in aid under condition that strict economic reforms are implemented. President Suharto is reluctant. **Nov.** University students killed in clash with police in East Timor. **1998** **Mar.** Following Suharto re-election to 7th term, students wage daily protests demanding reform and his resignation. Riots erupt in several cities as food prices skyrocket and rupiah continues to decline. IMF delays disbursements until Suharto agrees to major economic reforms. **Apr.** Suharto renegotiates IMF deal and agrees to cut government subsidies of fuel and food prompting widespread rioting. **May** 500+ die in rioting in Jakarta; 5,000 buildings destroyed; estimated $1 billion in damages. Students occupy Parliament building demanding Suharto resignation. 21 May Suharto resigns ending 32-year rule. Suharto crony, Vice President Habibie, sworn in as successor. **Aug.–Nov.** Drought and economic crisis cause severe food shortage. 271 people in Irian Jaya region die from starvation and disease. Over 1 million affected.	while scores of others die in clashes elsewhere. **Aug.** Vote for independence in East Timor with rejection of government proposed autonomy plan. **Sept.** Indonesian militia backed by military sack E. Timor capital, Dili (and elsewhere), killing independence leaders, burning buildings, and forcing thousands to leave the province. UN peacekeeping forces arrive, but militia attacks continue. 27 Sept. Indonesian troops withdraw. 200,000 E. Timor refugees in W. Timor terrorized by militia. Mass graves found in Dec. **Oct.** Election of new Muslim president, Abdurrahman Wahid. First democratic transfer of power in nation's 49-year history. Violent protests in Jakarta erupt led by supporters of opponent Megawati. Protests end when Megawati is chosen as vice president. **2000** Suharto is charged with corruption and assets seized. **May** Acech (separatist movement) cease-fire signed on Island of Sumatra ending 20-year conflict that claimed 5,000 lives. UN peacekeepers begin moving back refugees. Militia violence continues. **June** Sumatra earthquake kills 120+. Unrest continues between Muslims and Christians in Ambon leaving 4,000 dead over 18 months.

Table A1 (cont.)

During El Niño years 1997–98	During study years 1999–2000
Kenya	
1997 **Nov.** Floods affect 20,000 people in north. **Dec.** President Moi reelected for second 5-year term. Elections plagued with violence and corruption. Police brutality and ethnic conflicts widespread, especially on Indian coast where many are killed. **July** IMF suspends $216 million loan to Kenya because of government corruption. **Aug.** World Bank suspends credit for same reason. **1998** **Jan.** 86 die in floods. **Feb.** Rift Valley ethnic violence, where more than 100 killed. **Aug.** Terrorists bomb of US embassy in Nairobi, hundreds killed, thousands wounded.	**1999** Rampant corruption and abuse of executive power continues. Standard of living for average person drops for fourth year in a row. Police brutality and oppression of government opposition. Crisis and failure of constitutional reform process. **July** Richard Leakey appointed cabinet secretary and head of civil service. Begins anti-corruption campaign. **2000** **June** Severe drought – President Moi appeals for international aid to help severe economic crisis with 80% of the population at risk and 3 million "absolutely destitute." **July** IMF ends 3-year suspension of loans with renewed confidence as a result of the Leakey anti-corruption campaign.
Mozambique	
1997 El Niño-related drought forecast issued and government begins preparations. Floods and epidemics leave hundreds dead, thousands affected. Major de-mining project started in 1992 continues. **1998** Cholera epidemic that continues into 1999. Hunger problem affecting some 300,000+ as a result of flooding in previous year.	**1999** **Jan.** Flooding leaves thousands homeless. **Dec.** Second free election since end of civil war in 1992. President Joaquim Chissano is re-elected and his ruling Liberation Front Party is reinstalled. **2000** **Feb.–Mar.** Cyclone and flooding cause worst floods in nearly 50 years. Hundreds, perhaps thousands, dead; almost 1 million displaced. Floods exacerbate landmine problem by dislodging signs marking their whereabouts and shifting location of mines.
Papua New Guinea	
1997 Major economic slump in 1997–98 with devaluing of currency. Drought and frost lead to major famine.	**1999** **June** Collapse of Prime Minister Skate's government.

Table A1 (cont.)

During El Niño years 1997–98	During study years 1999–2000
Mar. Prime Minister Chan resigns after protests against him for corruption and his policies regarding the Bougainville Island conflict. **June** Bill Skate elected new prime minister. **1998** Australian National University survey shows P. New Guinea's crime problem among the most severe in the world. **Apr.** Cease-fire agreement on Bougainville Island. **July** Tsunami kills 1,300+.	**July** Prime Minister Bill Skate resigns. Parliament elects Sir Mekere Morauta. **2000** **Mar.** Bougainville Island independence referendum signed. Interim government established. **June** W. Papua separatists declare independence.
Panama **1997** No major events. **1998** Panama backs out of preliminary agreement with US to keep anti-drug forces in canal zone. **Jan.** Drought forces Panama Canal officials to restrict shiploads because of low waters. **Aug.** Voters reject proposed constitutional amendment that would have allowed President Balladares to run for re-election.	**1999** **May** First woman president, Mireya Moscoso, elected in free and fair elections. **Nov.** Last of US military forces leave the Canal ending 95-year control. **Dec. 14** US hands back control of Canal to Panama. **2000** First year of country's absolute control of the Panama Canal.
Paraguay **1997** President Wasmosy orders arrest of Colorado Party's presidential candidate and 1996 attempted coup leader, Lino Oviedo, for accusing him of corruption. **Dec.** Oviedo surrenders after a month in hiding. Supreme Court confirms his candidacy for May 1998 elections. **1998** **Mar.–Apr.** Oviedo sentenced, convicted, and barred from presidential bid while leading in the polls. Oviedo crony, Cubas, named party candidate. **May** Cubas elected president.	**1999** **Mar.** Congress votes to impeach Cubas for abuse of power. Vice President Argana, who was head of impeachment movement, is assassinated. Congress blames Cubas. Cubas resigns amidst violent protests and flees the country. Senate president, Gonzalez, sworn in as president. **2000** **May** Oviedo allies make failed coup attempt. 30-day state of emergency imposed.

Table A1 (cont.)

During El Niño years 1997–98	During study years 1999–2000
Peru	
1997 **Apr.** 4-month hostage crisis in Lima ends. 71 hostages freed after shootout with the Marxist Tupac Amaru rebels. All 14 rebels were killed. Fujimori's approval rate soars. **1998** Fujimori, with the help of his corrupt government, manoeuvres to allow his re-election to a third term in the 2000 presidential election. Shining Path (Marxist guerrillas) violent activity continues in some areas. Government uses threat of leftist terrorism to keep over one fifth of the population governed under emergency powers.	**1999** **July–Aug.** Shining Path leader, Ramirez, captured, convicted, and sentenced essentially marking the end of terrorist threat. **Dec.** Fujimori announces he will run for third term in April 2000. Official polls show strong support. **Oct.** Economic austerity plan announced to deal with Peru's declining economy. **2000** **May** Amidst protests and riots, Fujimori wins runoff election after sole opponent, Toledo, drops out 6 days before, claiming fraud. International observers left before election in protest. Strong condemnations from US and other countries. **July** In Lima 6 die in violent protests against Fujimori's inauguration. **Sept.** Fujimori announces he will step down and call re-elections in which he will not run. Impetus is release of a videotape showing head of intelligence service, Montesinos, making bribe to a government official. Congress eventually fires Fujimori and names interim president.
Philippines	
1997 **Sept.** In Manila hundreds of thousands protest President Fidel Ramos moves to seek re-election. **1998** **May** In ''relatively peaceful'' election (at least 7 killed in election day violence) Joseph Estrada is elected new president.	**1999** **Feb.** Deadly clashes with Muslim separatist movement (MILF) on southern island of Mindanao. **Aug.** Torrential rain kills 160+. **Aug.–Sept.** Protests against Estrada's attempts to remove constitutional provision limiting president to one 6-year term. **Oct.** MILF withdraws from peace talks with government.

Table A1 (cont.)

During El Niño years 1997–98	During study years 1999–2000
	2000 **Apr.** Beginning of hostage crisis that continues through the summer. 2 Islamic separatist groups take hostages in south. Drain on economy by using up government funds and scaring away foreign investors. **Sept.** Military launches assault on Muslim rebel camps to rescue hostages.
Vietnam **1997** **Sept.** Elections with peaceful transition of president and prime minister. **Nov.** Typhoon kills 778; 1,232 injured; 2,123 missing; 495,495 affected. **1998** Year of natural disasters and disease claiming 625 lives and affecting almost 4 million.	**1999** **Aug.** Floods kill 24. **Nov.–Dec.** Floods kill 768. **2000** **Jan.** Effects of 1999 floods still plaguing country with major aid needed. **Sept.** Worst flooding in several decades leaving 500 dead, millions affected.

3: Contact information, core advisors, and team leaders

Principal investigator

Michael H. Glantz: Environmental and Societal Impacts Group, National Center for Atmospheric Research, PO Box 3000, Boulder, CO USA 80307. Tel: 303-497-8119. Fax: 303-497-8125. E-mail: glantz@ucar.edu

Core advisors

IDNDR (ISDR)
John Harding: International Strategy for Disaster Reduction, Palais des Nations, CH-1211, Geneva 10, Switzerland. Tel: 41-22-917-9720. Fax: 41-22-917-9099. E-mail: harding@un.org

UNEP
Alex Alusa: Program Officer, UN Environment Program, PO Box 47074, Nairobi, Kenya. Tel: 254-2-623455. Fax: 254-2-623410. E-mail: Alex.Alusa@unep.org

UNU
Zafar Adeel: Academic Program Officer, Environment & Sustainable Development, United Nations University, 53-70, Jingumae 5-chome, Shibuya-ku, Tokyo 150-8925, Japan. Tel: 3-3499-2811. Fax: 3-3499-2828. E-mail: adeel@hq.unu.edu

WMO
Michael J. Coughlan: Director, World Climate Program, World Meteorological Organization, 7 bis, avenue de la Pais, Case Postale 2300, CH-1211, Geneva 2, Switzerland. Tel: 41-22-730-8269. Fax: 41-22-730-8042. E-mail: Coughlan_M@gateway.wmo.ch

Bangladesh
Ekram Hossain: Bangladesh Public Adm. Training Center, Savar, Dhaka-1243, Bangladesh. Tel: 880-2-832-145. Fax: 880-2-933-2016. E-mail: ehossain@bangla.net

China
Qian Ye: Director, Center for Development and Application of Atmospheric Sciences Res., Institute for Atmospheric Physics, Chinese Academy of Sciences, Qi Jia Hou Zi Hua Yan Li #7, Beijing, 100029, P.R. China. Tel: 86-10-6203-1710. Fax: 86-10-6202-8604. E-mail: qian_ye@263.net

Costa Rica
Jeffrey R. Jones: Laboratorio SIG, CATIE, Turrialba, Costa Rica. Tel: 506-556-1530. Fax: 506-556-7954. E-mail: jjones@catie.ac.cr

Cuba
Lino Naranjo-Diaz: Centro Nacional del Clima, Instituto de Meteorología, Aptdo 17032, Havana 17, Cuba. Tel: 537-57-0718. Fax: 537-33-8010. E-mail: naranjod@met.inf.cu

Ecuador
Pilar Cornejo-Grunauer: ESPOL/Ecuador, Campus Prosperina, PO Box 09-01-5863, Guayaquil, Ecuador. Tel: 593-4-269451. Fax: 593-4-854587. E-mail: pcornejo@goliat.espol.edu.ec

Ethiopia
Tsegay Wolde-Georgis: Embassy of Ethiopia, 3506 International Drive NW, Washington, DC 20008. Tel: 202-364-6388. Fax: 202-364-6887. E-mail: tsegaywg@bellatlantic.net

Fiji
Atu Kaloumaira: South Pacific Applied Geoscience Comm., Private Mailbag, General Post Office, Suva, Fiji. Tel: 679-381-377. Fax: 679-370-040. E-mail: atu@sopac.org.fj

Indonesia
Kamal Kishore: Information Manager, Asian Disaster Preparedness Center, Asian Institute of Technology, PO Box 4, Klongluang, Pathumthani 12120, Thailand. Tel: 662-524-5378. Fax: 662-524-5360. E-mail: kamal@ait.ac.th

Kenya
Fredrick Karanja: Chairman, Dept. of Meteorology, University of Nairobi, PO Box 30197, Nairobi, Kenya. Tel: 254-2-441045. Fax: 254-2-441661. E-mail: fkaranja@ics.uonbi.ac.ke

Mozambique

João-Paulo Borges-Coelho: Department of History, Eduardo Mondlane University, CP No. 2511, Maputo, Mozambique. Tel: 258-1-490081. Fax: 258-1-491269. E-mail: zumbo@mail.tropical.co.mz

Gary M. Littlejohn: 7 Dean Close, Rhodesway, Bradford, West Yorkshire BD8 0DD, United Kingdom. Tel: 44-124-820412. E-mail: gary@littlejn.org

Panama Canal

Maria Concepción Donoso: CATHALAC, Antigua Base de Clayton, Cuidad del Saber, Building 801, Panama City, Panama. Tel: 507-317-0053. Fax: 507-317-0127. E-mail: mdonoso@cathalac.org

Papua New Guinea

Joe Barr: Pacific Emergency Mgmt. Assoc. Ltd., 1, Lalor St., Ainslie, ACT 2062, Australia. Tel/Fax: 61-2-6247-3973. E-mail: joebarr@pcug.org.au

Paraguay

Benjamin Grassi: Coordinator, Area of Meteorology, Facultad Politecnica, Universidad Nacional de Asunción, Ciudad Universitaria, San Lorenzo, Paraguay. Tel/Fax: 595-21-585588. E-mail: grassi@pla.net.py

Peru

Gastón Antonio Velasco-Zapata: Instituto de Estudios Peruanos, Horacio Urteaga 694, Jesús Maria, Lima 11, Peru. Tel: 511-332-6194. Fax: 511-332-6173. E-mail: zapram@terra.com.pe

Kenneth Broad: International Research Institute, now at: University of Miami, Rosenstiel School of Marine & Atmospheric Science, 4600 Rickenbacker Causeway, Miami, Florida 33149-1098, Tel: 305-361-4581. Fax: 305-361-4675. E-mail: kbroad@rsmas.miami.edu

Philippines

Sanny Jegillos: Asia Pacific Disaster Management Center, 72 Collonnade Residences, 132 Legaspi St., Legaspi Village, 1229 Makati City, Metro Manila, Philippines. Tel: 632-810-5444. Fax: 632-817-0894. E-mail: sannyj@nsclub.net

Vietnam

Nguyen Huu Ninh: Center for Research & Development (CERED), A01, K40, Giang Vo, Hanoi, Vietnam. Tel: 844-851-511842. Fax: 844-851-5213. E-mail: cered@hn.vnn.vn

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