El Niño Early Warning for Sustainable Development in Pacific Rim Countries and Islands

Galapagos Islands, Ecuador
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DRAFT --- 12 November 2004

Organized by:

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Table of Contents

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Introduction

The workshop on "El Niño Early Warning for Sustainable Development in Pacific Rim Countries and Islands" was inspired by the deliberations of the earlier workshop held in Shanghai, China in October 2003 on *Early Warning Systems: Do's and Don'ts*. The Galapagos workshop was the ninth "Usable Science" workshop organized by the Environmental and Societal Impacts Group at NCAR in the past ten years, several of which were linked to various aspects related to El Niño: forecasting, impacts, responses to forecasts and responses to impacts of El Niño, and the extreme meteorological events that it often spawns. The goal of the Galapagos meeting was to regionalize early warning systems geographically and to focus on a specific climate-related phenomenon: El Niño. El Niño is known to spawn climate and weather-related hazards in many parts of the globe. Knowledge of El Niño, coupled with El Niño forecasts, provides one of the earliest warnings of possible climate-related impacts problems that a government might receive in time to take action.

Thirty-four participants from 12 countries (Australia, Canada, Chile, China, Colombia, Costa Rica, Ecuador, Germany, Mexico, United Kingdom, United States, and Uruguay) gathered together for four days, representing many disciplines, including marine biology, fisheries, oceanography, agriculture, communications, political science, economics, meteorology, anthropology, forestry, philosophy, and history. The initial grant that began the process leading to this workshop was provided by the US National Science Foundation, and the workshop was co-sponsored by NCAR and CIIFEN, with support from NOAA, CIIFEN, WMO, ISDR, UNESCO and the IOC, the UN Development Programme, and the Inter-American Institute.

Coincidentally, our Galapagos workshop was convened thirty years after the first "International Workshop on the Phenomenon Known as El Niño" was held in Guayaquil, Ecuador. The report from that 1974 workshop served as a catalyst to increasing interest among scientific researchers in El Niño at that time. The workshop was sparked by the devastating impacts of the 1972-73 El Niño on Peru's lucrative fishmeal industry, which was and still is wholly dependent on anchovy catches. Research on air-sea interactions in the tropical Pacific began to accelerate. One could argue that the 1972-73 El Niño was the "El Niño of the scientists." The participants prepared an international research plan for the physical and biological sciences. Its stated goals were to analyze the state of El Niño knowledge; to identify questions to allow understanding and prediction of El Niño; to devise a regional cooperative research program; and to develop a plan to study El Niño-fisheries interactions (Guayaquil, 1975). The 1982-83 El Niño, the first "El Niño of

the Century," was the episode that generated interest of governments around the globe in El Niño and its impacts.

While preparing the materials for this workshop, the organizers came to realize that El Niño information encompasses much more than simply an El Niño forecast as an early warning of potential harm. That realization led to the use of a shadow title for the meeting: "El Niño Knowledge for Sustainable Development." This seemingly subtle shift in words was, in fact, more than that. It was an attempt to broaden concern from one primarily about a forecast of a specific event (e.g., El Niño) at a given point in time to one that includes all available information about El Niño including forecasts but also includes historical and traditional, including indigenous, accounts of El Niño-related socioeconomic impacts that resulted from droughts, floods, fires, and infectious disease outbreaks. For example, people and governments in Mexico and Peru have been coping for a long time with droughts and floods, only some of which may have been related to El Niño. Thus, there is considerable knowledge, much of it unrecorded or unpublished, about El Niño's impacts at the local level.

There were two key objectives of this meeting in the Galapagos, in addition to networking among participants: (1) pursuing the notion of El Niño knowledge for sustainable development, and (2) to discuss the notion of "linking or sinking," that is, the linking of issues so that holistic (as opposed to piecemeal) solutions can be developed. As an example, it is not only necessary to link sustainable development issues and El Niño-related early warning issues in a meaningful way, it is obligatory in regions known to be affected by El Niño if they are to have any hope of achieving sustainable development at some point in the future. A goal of disaster assistance is to get life for victims of disasters back to a semblance of "normal." This raises a question about what normal means. In many parts of the world, "normal" does not necessarily equate with a good life, or with well-being, but rather a return to normal is in essence setting up the same society for similar disasters at some time in the future. Linking a longer-term perspective with short-term considerations can hopefully reduce vulnerability to similar hazards in the future. In other words, an issues-linked policy would likely be more beneficial that the sum of two separate policies that focus on either sustainable development considerations or on getting thing back to normal.

From the workshop organizers' perspective, all societies are at some level of unstable equilibrium, and early warnings can help to maintain, if not improve on, that level of equilibrium. In the absence of linking early warning and El Niño forecasts or linking disaster response with sustainable development, for example, the stability of governments can be at risk.

At the beginning of the workshop, it was noted that the theme of the meeting was multifaceted. By this, we mean that each word in the title of the workshop ? El Niño, early warning, knowledge, sustainable development, Pacific Rim countries, Pacific islands ? could have been the single focal point of our four-day workshop. Indeed, there have been numerous meetings (conferences, workshops, roundtables) on each of them. Our goal was to discuss them as a cluster of inter-related issues. These topics do not have

simple or uncontested resolutions because of scientific, political, and economic uncertainties that are embedded within them. We were seeking to generate new thinking about some of these issues and about their connections, the ultimate objective being "how better to use El Niño knowledge in a peoples' search for an improved sustainable future". There is much more to El Niño than a better forecast of its onset, the primary focus of attention today. Participants were told to work toward solutions as a contribution toward understanding but were also told not to expect resolution in the four-day meeting of many of the issues raised for consideration.

In addition to a paper copy of the Galapagos report and its appearance on the NCAR website (www.isse.ucar.edu/galapagos), it also appears on the website of the Exploratorium in California (www.exploratorium.edu/el_nino). The Exploratorium has made audio recordings of the discussions of each session and placed them on its website.

El Niño and Knowledge: A Few Definitions

El Niño (also referred to as a "warm event") is used by many people as shorthand for ENSO (El Niño-Southern Oscillation) cycle, of which the warm event is just one part of a cycle. La Niña, or a cold event, is another part. Some years ago, researchers noted that the sea surface temperatures are in an El Niño (warm) and a La Niña (cold) phase about 54 percent of the time. The other 46 percent of the time, the equatorial Pacific Ocean is in a neutral or average condition.

The Southern Oscillation Index (SOI) is the difference in sea level pressure between Darwin, Australia and Tahiti. Many Australian forecasters use the Southern Oscillation Index as a primary indicator for the likelihood of El Niño-related drought on their continent.

There are numerous definitions of "knowledge." The following list of definitions taken from the Internet was presented to the participants for their consideration.

- the psychological result of perception, learning, and reasoning;
- remembering of previously learned material, possibly involving the recall of a wide range of material, from specific facts to complete theories;
- information evaluated and organized in the human mind so that it can be used purposefully;
- the sum or range of what has been perceived, discovered, or learned;
- knowledge is information with guidance for action based upon insight and experience;
- understanding the significance of information;
- the final goal of the understanding in combining intuitions and concepts; and
- it is internalized by the knower over a long period of time, and incorporates accrued and embedded learning.

Clearly, the numerous definitions of knowledge are constructed to meet the needs of those creating the definition. However, there are recurrent themes among these definitions: perceptions, the mind, intuition, interpretation, and experience (by way of reading, observing, learning, living, etc.). A concern was expressed at the meeting that this particular list of definitions taken at random from the web is static and not dynamic, suggesting that in order to be useful, knowledge had to be linked to action. Beliefs though formed by knowledge are not necessarily action oriented. This generated a question about whether it is necessary as well as possible to distinguish between basic knowledge and applied knowledge. The former might refer to knowledge that is used to produce other knowledge. While the latter can be viewed as knowledge that leads to action, e.g., applied knowledge. Both aspects of knowledge can exist side by side because not all aspects of one's knowledge need to be at play for each problem that arises.

It was proposed to the participants that the notion of "El Niño knowledge" merited consideration. Usually, El Niño forecasts are considered to be the knowledge about El Niño that one needs to know. The forecasts are based on research about it as a geophysical phenomenon, using models and statistical correlations. It recurs every 4 ½ years on average, and can recur anywhere from 2 to 10 years apart. Not every event is an extraordinary one. In fact, some are quite weak. Therefore, as a societal problem, it does not receive a high priority, because it is not constantly on the minds of most policymakers or decisionmakers in various segments of society. Of those aware of it as a recurring phenomenon, many think there is little that they do to get ready for it some years ahead of its occurrence. The reality, however, is that El Niño knowledge is much more than forecasts of its occurrence.

It has a history; previous El Niño events have been observed in real time or in retrospect, through direct observations and using proxy indicators. Using a variety of research methods, El Niño events of the past have been identified with a degree of reliability, as have many of their teleconnected impacts. While El Niño was not named, as far as we know, till the early 1890s, its effects were felt in the form of recurrent droughts, floods, shifts in fish population location and species, outbreaks of vector-borne diseases, and the occasional (septennial) greening of desert areas (Sears, 1895). People in many places around the tropical and extra-tropical Pacific had been affected by and dealing with such anomalies for centuries or longer. Only in the past several decades have some of those anomalies in some locations been directly linked to the appearance of El Niño (or La Niña). The knowledge of such anomalies and coping mechanisms are now part of our expanding information base that can collectively be called El Niño knowledge. That knowledge is not just in the form of written reports and formal learning but is also in the form of traditional and indigenous knowledge. As cited in the workshop's viewbook, the following quote from the World Bank (www.worldbank.org/afri/ik/basic.htm) provides one comment on the importance of indigenous knowledge.

> Conventional approaches imply that development processes always require technology transfers from locations that are perceived as more advanced. This has led often to overlooking the potential in local experiences and practices.

- A careful amalgamation of indigenous and foreign knowledge would be most promising.
- Foreign knowledge does not necessarily mean modern technology. It includes also indigenous practices developed and applied under similar conditions elsewhere.
- To foster such a transfer a sound understanding of indigenous knowledge is needed.
- Indigenous knowledge forms part of the global knowledge.

Indigenous knowledge encompasses knowledge which local people (or people on the street) might have about climate-weather-environment-society interactions that relates indirectly as well as directly to the ENSO-cycle in general and El Niño specifically. There is also a considerable amount of folk wisdom associated with recurrent drought, flood, fire or disease outbreak that unknowingly may have been related to the occurrence of an El Niño or a La Niña event. Recent scientific findings and improved understanding can help researchers and the public to put that folk wisdom and indigenous knowledge into a broader climate-related context.

In sum, El Niño knowledge (more broadly, ENSO knowledge) includes forecasts (previous as well as current ones); modeling output (ensemble forecasts, climate change scenarios); various time series (sea surface temperature, thermocline depth, southern oscillation of sea level pressure, ecological, hydrological, meteorological, and demographic); satellite-derived information (imagery over time); case studies of suspected ENSO impacts on the physical environment and society (local, national, regional, global); folk wisdom (anthropological, sociological, anecdotal); the context in which an El Niño event takes place (political, social, economic, cultural). ***It is necessary to identify all facets that might be encompassed under the rubric of El Niño knowledge. This would help El Niño researchers from all disciplines to broaden their perspectives of the ENSO cycle and inform them about what societies need to know to better deal with it and its impacts.***

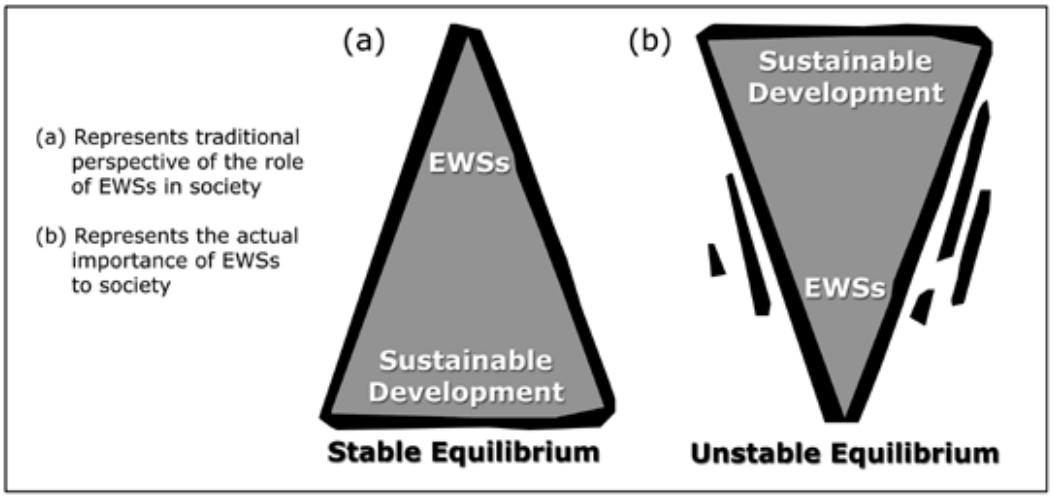
A few quotations were placed in the viewbook for participants to consider during the meeting and afterwards as well. The following quote, taken from a work of fiction, is particularly relevant here (Haddon, 2003). It is a response of an autistic teenager to his father who had praised him for something he had witnessed.

> I said that I wasn't clever. I was just noticing how things were, and that wasn't clever. That was just being observant. Being clever was when you looked at how things are and used the evidence to work out something new.

In a way, the quotation relates to indigenous knowledge, to qualitative information about climate-society-environment interactions, to climate and weather-related extremes and to anecdotal information. Having more data in the form of time series will not necessarily provide the insights needed to better anticipate and, therefore, cope with the forecasts of extreme events, as well as to cope with them and their impacts. Being clever depends on how we interpret and use that and other related information to improve our understanding

and responses to climate-related natural hazards and their impacts on environment and society.

The Shanghai workshop on "Early Warning Systems: Do's and Don'ts" (www.esig.ucar.edu/warning) produced a range of ideas about the need for, use of, and importance of early warning systems to governments and agencies worldwide. The diagram that was developed as a result of the Shanghai workshop deliberations succinctly suggests the way societies and governments and their relationship to early warning systems are, as opposed to the way we would like them to be.



The main point of view depicted in this illustration is that societies are in an unstable equilibrium. Early warning systems are needed to alert governments and societies about factors that might change that condition by increasing or decreasing their levels of stability. Whether a destabilizing factor relates to economics, politics, terror, or to weather extremes and climate anomalies, governments must pay greater attention to the early warning systems that are set up ostensibly to warn them about processes or events they want to avoid. Every government has several such systems. However, they are often poorly funded to carry out the tasks that have been so perfectly spelled out in documents and work so well… on paper and in PowerPoint presentations. El Niño knowledge about the phenomenon and its teleconnections, if appropriately used, can help more than a few governments and societies around the globe to mitigate if not avoid the worst impacts of El Niño-related hazards. The better applied the science to societal needs, the more secure will be the knowledge base upon which decisions will be made. Some key findings of the Shanghai report appear in the following list. (The entire list appears in Appendix A.)

Shanghai Early Warning Systems (EWS) Highlights

- One officially designated early warning system cannot meet all societal needs.
- Hazards and threats can change over time not only in intensity, frequency, and in location and duration, but also in importance and interest.

- Scenarios can help to uncover potential impacts of hazards that might otherwise have caught decision makers by surprise.
- Many early warnings knowingly and unknowingly activate other early warnings, as the time gap between a warning and the onset of a hazardous event shortens. This process can be referred to as a cascade of early warnings.
- Creeping environmental changes are in need of early warning systems because the impacts of incremental but cumulative changes on society in the long run may be more costly and disruptive than the quick onset hazardous events.
- EWSs should also report on advances in hazards research, advances in the development of early warning systems, and in new technologies and techniques that can improve the effectiveness of existing EWSs.
- Because of limited resources (human and financial) in many countries, it is important to distinguish between what is desirable for an effective EWS and what is essential.
- EWSs need to be treated as subsystems embedded and integrated into larger socioeconomic and political systems. Stakeholders need to be involved in the development of new EWSs or redesigning existing ones.
- Stakeholders can provide important insights into how warnings might best be prepared and delivered to the public, the media, and even to the governments at different levels.
- Early warning system operators face a dilemma: they are often criticized for a missed or erroneous warning, but are infrequently praised for having been correct.
- Early warning of hazards combined with the early warnings of underlying societal problems and processes can lead to a strengthening of resilience and a reduction in vulnerability.
- It would be useful to collect lessons of the past for evaluation by present and future EWSs.
- An early warning system is an important tool in a government's program to achieve sustainable development. In fact sustainable development prospects are very dependent on the effectiveness of the many early warning systems.

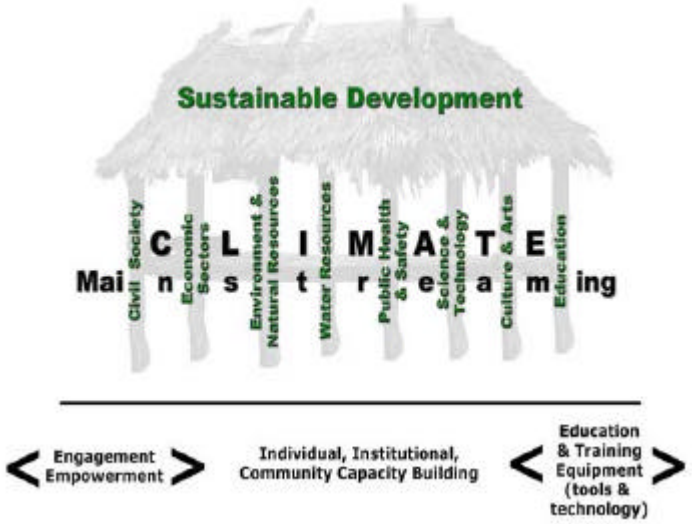
Linking Application to Science and Science to Application

The purpose of this session was to highlight the need for and application of scientific excellence and understanding to existing and emerging problems of concern to society. The necessity of this linkage was referred to in terms of "linking or sinking"; that is, societies need to link scientific output to societal needs in the area of early warning or face an elevated risk of development policy failure, e.g., sinking.

The more that reliable information can be made available in advance of the time needed to make a reasoned, objective decision, the better it is for society and for decisio makers.

They do not want to be surprised because surprise forces them to make decisions surrounded by considerable uncertainty on short notice. To avoid surprises a government or a group needs to have in place efficient and effective early warning systems (e.g., Streets and Glantz, 2000).

Sustainable development has been defined in the following way in the report of the World Commission on Environment and Development (WCED, 1987): "*Sustainable development is development that meets the needs of the present without compromising the ability of future generations to meet their own needs.*" Today, there are many definitions of sustainable development, and they appear to be tailored to the needs of the researcher or group producing its definition. A search on the web shows just how widespread the use of the notion of sustainable development has been. Definitions of sustainability that may meet the needs and interests of one group may impinge directly on those of another group.



From Eileen Shea's PowerPoint presentation 13 September 2004

Indicators for monitoring progress towards sustainable development are needed in order to assist decision-makers and policy-makers at all levels and to increase focus on sustainable development. Beyond the commonly used economic indicators of well-being, however, social, environmental and institutional indicators have to be taken into account as well to arrive at a broader, more complete picture of societal development. Based on the voluntary national testing and expert group consultation, a core set of 58 indicators and methodology sheets are now available for all countries to use. This core set was based on a working list of 134 indicators and related methodology sheets were developed, improved and tested as part of the implementation of the Work Programme on Indicators of Sustainable Development (ISDs) adopted by the Commission on Sustainable Development (CSD) at its Third Session in April 1995. (www.un.org/esa/sustdev). The following list of randomly selected web lines focuses on countries and organizations that have identified their own sets of indicators of sustainability (e.g., SDIs).

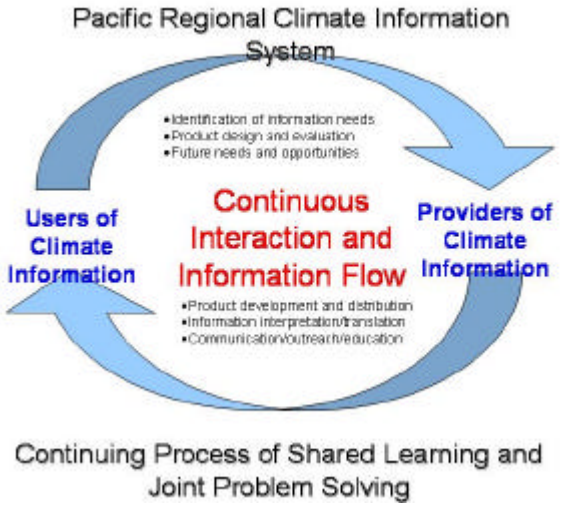
- Finnish set of sustainable development indicators (SDIs)

- Environmental and SDIs for Canada
- SDIs for the USA
- UK Government's core set of indicators of sustainable development
- SDIs for Wales
- SDIs for China
- SDIs for Sweden
- Scottish SDIs
- SDIs for Southeast Asia
- SDIs for urban water systems
- Gender and SDIs
- SDIs in the Mineral Industries
- Indicators of Sustainable Development for Estonia
- Jamaica Sustainable Development Network Programme
- The APEC Development Network

When it comes to El Niño-related climate and weather forecasts, it is difficult to maintain a high level of confidence and trust in them. Aside from the fact that forecasts (as early warnings) are usually in the form of probabilistic statements, for quasi-periodic events such as an El Niño or a La Niña, it is not easy to keep up that trust over the years when neither of those extremes is occurring. "Out of sight, out of mind" is an adage that seems to apply to El Niño as an extreme event that does not occur frequently enough for people to have developed confidence in the forecast of it or of its possible cascade of impacts. In addition, not all forecasts have been correct, and many people judge correctness of a forecast on a case-by-case basis, as opposed to thinking about them probabilistically.

Scientific output by itself is not automatically of help to societies that are seeking solutions to many of their existing climate-environment-society issues, not just problems. To move from potential to actual value in the near term, scientific findings must be applied. Often there is a need for a translator of the science so that non-scientists (the public, policy makers, and the media) can understand the benefits of those findings.

Different views exist about whether scientific findings should be applied from the top down or from the bottom up. The former suggests that the research community has identified an approach to sustainability that a government will impose on its citizens. The latter suggests that local inhabitants have tested ideas about what is needed to achieve sustainable development and societal well being. Governments and their agents often refer to stakeholders, with those stakeholders being found at sub-national levels. In fact, everyone is a stakeholder, even those making decisions at the national level that have a stake in the outcomes related to the decisions that they make. The application of knowledge must be applied from both directions and integrated. The participant from Hawaii's East-West Center provided the following schematic to show the flow of information required for a robust and effective climate information system:



Sustainability Science

Sustainability Science is a new concept, which is supposed to suggest a holistic (interdisciplinary) approach to sustainable development. At a conference on Sustainability Science held in Friberg, Sweden in mid-October 2000, it was recorded that "the goal of sustainability requires the emergence and conduct of the new field of sustainability science." It also reported that

> Sustainability Science seeks to improve on the substantial but still limited understanding of nature-society interactions gained in recent decades…. [It] will therefore need to employ new methodologies that generate the semi-quantitative models of qualitative data, build upon lessons from case studies, and extract inverse approaches that work backwards from undesirable consequences to identify pathways that can avoid such outcomes. Scientists and practitioners will need to work together with the public at large to produce trustworthy knowledge and judgment that is scientifically sound and rooted in social understanding".

Some reasons for developing a sub-field called Sustainability Science were provided by a university professor (Lowe, 2001):

> Science needs "a fundamentally different approach" if the goal of sustainability is to be achieved.
>
> - Modern science could be described as "islands of understanding in oceans of ignorance." Many environmental problems are the "direct result of applying narrow specialized knowledge to complex systems."
> - Instead we need to work backwards from undesirable outcomes to identify pathways to avoid these problems.
> - "Scientists and practitioners have to work together to produce trustworthy knowledge that combines scientific excellence with social relevance."

The reason for raising this concept briefly at the workshop was to make the participants aware of the interest in this sub-field of research and application. The contributions of such a new sub-field to an improved understanding of the concept of sustainability is yet to be shown, given the innumerable activities that are explicitly related to sustainable development that have been under way for more than a decade. The idea of Sustainability Science is user-oriented; i.e., the user defines the means. Sustainability Science is also about linking across fields of knowledge, breaking down the idea that science is about "islands of knowledge." If science is to be sustainable as an institution, it needs to be useful and connect to users. A new web-based journal has been created ? *Sustainability: Science, Practice and Policy* ? as part of this movement toward developing this sub-field: see http://ejournal.nbii.org/about/about.html

ENSO Science: El Niño, La Niña, and In-between

Tony Barnston (International Research Institute for Climate Prediction (IRI), Columbia University, New York) presented an overview of the ENSO cycle with a special emphasis on the science and the forecasts of El Niño. The session provided the participants with a broad overview of the ENSO cycle and an indication of the state of the art of El Niño forecasting. He provided responses to such questions as: What is El Niño? What are the indicators on the onset of an El Niño? How reliable are the forecasts? How credible are the models that produce the forecast? Also addressed were questions related to how good scientists were becoming at determining in advance the strength as well as duration of an El Niño.

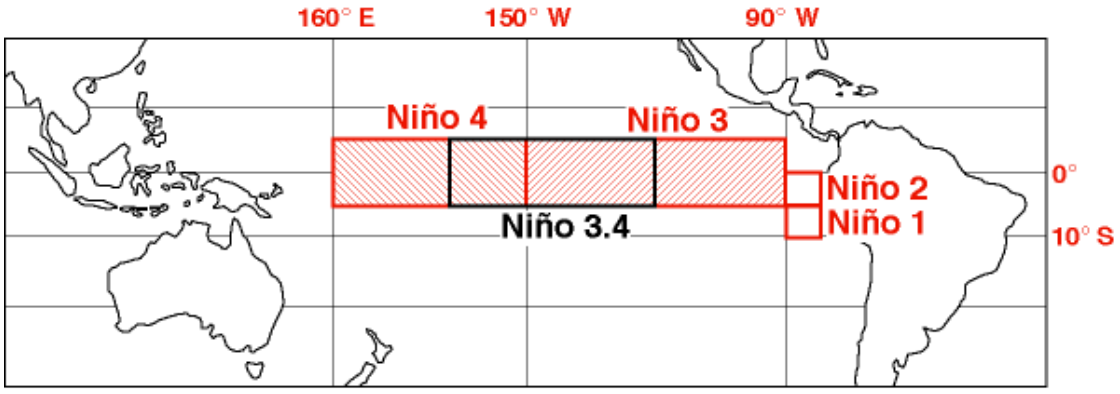
It was generally acknowledged that there is still considerable research needed to improve the reliability of El Niño forecasts. There are many groups and individuals with websites on the Internet that focus on forecasting El Niño and its impacts. Their level of reliability (e.g., accuracy and credibility) varies from one group to another and from one forecast to another. Many users of such forecasts around the globe are not yet good at distinguishing the forecast groups that are truly reliable from those that are unreliable. The problem is that all websites on the Internet can be made to look official and knowledgeable, when in fact they are not. It is important to note that different people are reacting in different ways to these forecasts. Even erroneous forecasts will have followers who believe them and act in response to them. There is no one group that has been authorized to provide a "seal of approval" to the various forecasts that are released to the public once an El Niño process is believed to have begun. As a result, forecasts should carry a "buyer beware" label. It is best to familiarize oneself with the qualification of the scientists, researchers and forecasters as well as of the websites offering their projections about the current and future state of air-sea interactions in the tropical Pacific.

It was noted that once indicators of an El Niño have been identified and generally accepted by some keystone forecast groups, it is relatively easier to forecast its evolution (although not necessarily its strength or duration). Once the process has set in, it runs for 12 to 18 months on average. It was recognized that there is a need to forecast El Niño

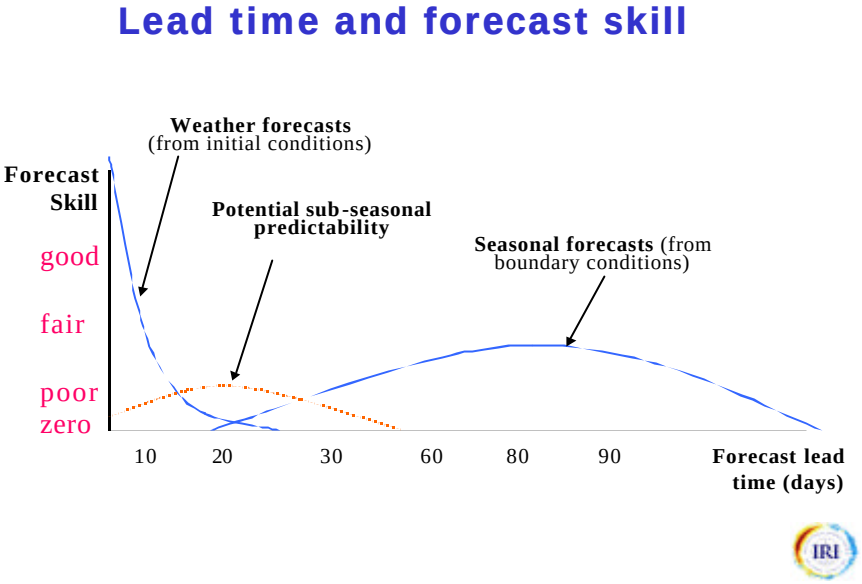
more accurately than is done at present. The good news is that the El Niño forecast models are improving. The bad news is that no two El Niño episodes are exactly alike, nor is the set of impacts associated with each of them. There are limits to the ability to forecast various aspects of El Niño as a result of the fact that the air-sea interactions are highly nonlinear. In other words, it is not simply a matter of forecasting sea surface temperatures in the equatorial Pacific or of projecting trends in the Southern Oscillation (the difference between sea level pressure at Darwin (Australia) and sea level pressure at Tahiti). El Niño knowledge then serves as an early warning for those responsible for societal and environmental well being.

There is controversy over whether the geophysical models, as opposed to the statistical models, are better at aiding forecasters (i.e., have more skill) in forecasting the onset of an El Niño event. The emphasis now is on ensemble forecast techniques. Data is still a problem for areas most at risk to El Niño's impacts, since the time series are often incomplete or are of short duration. Also, the reporting of meteorological information from many stations to some of the groups that forecast El Niño globally (as opposed to regionally and locally) is irregular or nonexistent, a situation that needs to be addressed and improved.

Researchers use different regions of the central Pacific to identify the fingerprint of the onset of an El Niño: some use the region known as Niño3 and others use Niño3.4; still others use Niño4 or the Southern Oscillation Index. It appears that there is slightly better skill associated with the Niño3.4 region. The following illustration shows the regions.



Barnston spoke about the spring barrier (in the northern hemisphere) to forecasting El Niño and the difficulty of forecasting across the barrier. He referred to the atmospheric phenomenon that can occur within a season known as the MJO (Madden-Julian Oscillation). An improved understanding and capability to forecast the MJO can supplement other forecasts of shorter duration (e.g., weather) and the longer term quasi-periodic El Niño or La Niña extreme, as suggested in the following graph.



From Barnston's PowerPoint presentation (September 13, 2004)

ENSO-Related Hotspots in the Pacific Region

This session's topic ? hotspots ? lived up to its name. It sparked lively exchanges about the notion of hotspots, the linkage of the hotspots notion to the ENSO cycle, and to its impacts on societies and environments worldwide. Hotspots can result from a single event or from the intersection of any combination of the following factors: political, economic, environmental, health, demographic, meteorological, and cultural.

The notion of hotspots is used in geology to reflect volcanic activity. On the societal side, it has been used in reference to zones of conflict (armed or otherwise) that are perceived to be dangerous. It has also been used to draw attention to desired vacation or amusement places. As far as the environment is concerned, there are biodiversity hotspots, locations on the earth in which the diversity of biological species is on the decline (see the website at http://www.biodiversityhotspots.org/sp/Hotspots). These adverse changes in biodiversity are due to a combination of human activities as well as climate variability, change and extreme "events" such as the sea surface temperature increases associated with El Niño episodes. It becomes clear that the use of the word hotspots requires the use of an accompanying adjective to clarify its meaning. So, there can be flood or drought hotspots, biodiversity hotspots, disease hotspots, agricultural hotspots, and so forth. Within these broad categories there are also embedded other hotspots: agricultural hotspots could focus on a type of crop or on a type of farming system or on the degradation of the land quality on which agricultural activities are dependent. See the FAO hotspots website at http://www.hiv-development.org/publications/climate_HIV.htm

In general terms a hotspot is any place, activity or thing of keen interest to a subset of people in society. A hotspot can be geophysical, biological, or socioeconomic. More specifically, an El Niño hotspot is a location in which there is an elevated likelihood that El Niño's occurrence would generate anomalous climate and weather and their impacts about which the affected society must be forewarned. Societal responses to the forecast of an El Niño, combined with El Niño knowledge in general, e.g., historical information about previous El Niño episodes (quantitative, qualitative and anecdotal), provides lead time for society to choose to react or to pro-act. It was pointed out during the workshop that the term "hotspot" does not translate directly into other languages; in Spanish, for example, the term "hazard" also carries a different meaning, and the word "hotspot" does not have an equivalent term. Nevertheless, the usage of the term "hotspots" is widespread.

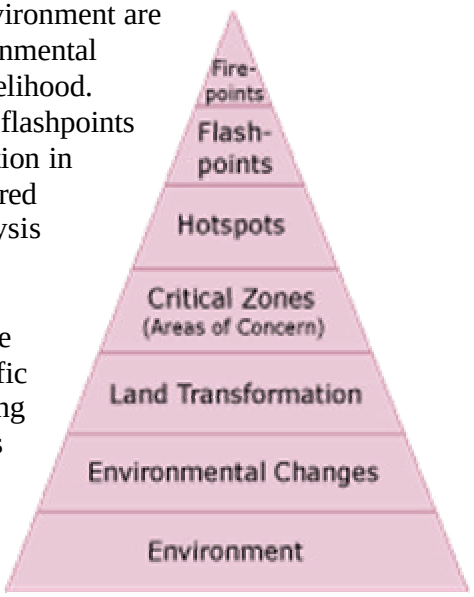
In the mid-1980s, researchers Ropelewski and Halpert (1987; revised 1991) prepared maps depicting locations and types of likely changes in rainfall and temperature that might be expected to accompany an El Niño (but not necessarily accompany every El Niño). The maps, though based on data available up to that time, were clearly meant to be suggestive and illustrative. Today, scientists refer to this type of map as a "cartoon graphic." Although they may provide a low level of scientific information, they seem to have a degree of policy credibility. In any event, the reality is that they provide the public with a view of the potential widespread influence and impacts of an El Niño event and have a role to play in educating the general public on this particular scientific process.

The maps provide a general view of hotspots location. However, any given El Niño can appear as a weak, moderate, strong or extraordinary event and can have impacts in places that had not been considered to be a chronic El Niño-related hotspot. Thus, each of the evolving forecasts of a specific warm episode can identify new, temporary (to that episode) hotspots. An example provided in the workshop was the following: with the forecast on a strong El Niño, vacation areas in vulnerable locations may be avoided, thereby creating an economic hotspot. This year, a group outside Florida suggested that this is not a year to visit Disneyland (in Florida) because of potential hurricanes. This comment created a political backlash as tourism is a primary source of revenue for Florida.

While the notion of hotspots seems to capture the attention on onlookers (the public, media and policy makers), it often lacks specific definition. The data on which the Ropelewski and Halpert maps were based are now more than twenty years old. The maps are in dire need of updating, if not for the sake of the scientific community then for the potential users of El Niño knowledge, including forecasts. The outdated maps are still heavily used by the public, media and policy makers for educational and decision-making purposes. ***The scientific community owes the public updated maps based on the additional 20+ years of research it has funded.***

The pyramid diagram shows the dynamic nature of changes in the environment. The broad base of the pyramid represents the environment. The successive levels as one moves toward the apex are: transformation of the environment (not all changes to the

environment are adverse); areas of concern (changes to the environment are beginning to show signs of negative impacts); hotspots (environmental changes have become serious with loss of productivity and livelihood. There can also be grades of hotspots, i.e.., hot, hotter, hottest); flashpoints (this represents the proverbial eleventh hour when the degradation in nearing irreversibility); and firepoints (too late to save the desired environment). As one can see from the pyramid, hotspots analysis tends to focus on negative impacts and their avoidance.



The function of this graphic is at least twofold. It highlights the location of hotspots along the continuum of changes to a specific environment. It also draws attention to the importance of dealing with environmental changes ***before*** they become hotspots. This would involve an effective and efficient monitoring and early warning system for those environmental changes that are labeled as critical or as areas of concern (AOCs). One could create another inverted pyramid adjacent to this one. At each corresponding level of the pyramid that depicts physical changes to the environment, there could be corresponding levels in the societal (inverted) pyramid that identify the human activities and natural factors that are causing or contributing to changes to the environment. An example for the Philippines was provided: vulnerability to El Niño's impacts had increased for the 1997–98 event, not necessarily because the event was extraordinarily intense but because the region's irrigation infrastructure had not been maintained by the farmers, the damage to crop production was high (e.g., a 30% reduction in the rice crop).

It was suggested that GIS (geographic information systems) approaches could be used in hotspots analyses by overlaying El Niño hotspots with other known hotspots such a biodiversity, at-risk coral reefs, floods, droughts, water resources (water quantity or quality), demographic, and so forth.
Several participants noted the importance to a range of decision makers with differing information needs of the geographic scale of hotspots maps. The broader the scale (e.g., national or global), the less likely is there to be usable detailed information. Yet, many decision makers would like to have detailed information about an El Niño's likely impacts in order to reduce impacts in their administrative, socioeconomic or political jurisdictions. Concern was also raised over how one might identify the borders of a hotspot region. How different and discontinuous is the situation within and immediately outside those borders (and how is that difference determined)?

An issue was raised concerning the boundaries of a hotspot. Why is one side of a line considered an El Niño hotspot while the other side of a line is considered not to be one? Let's look at the hurricane as another analogy. Forecasts of hurricanes identify zones of impact. These are envelopes surrounding the eye of the hurricane that are expected to be affected by the tropical storm's winds, rains and tidal surges. The zone of impact changes as the hurricane changes it trajectory as it moves toward landfall. There are locations immediately outside of the envelope at a given point in time and they too are at risk of

being affected by the hurricane. Further away from the boundary, the people and land are usually not affected by the storm. One must remember that areas are most likely on a gradient of risk. Although a simple graphic might be used to designate high risk (hotspot) regions, one must not take total comfort because their location is immediately outside the boundary line. Common sense should prevail when it comes to how one interprets such simple graphics. They serve as the lowest, and perhaps earliest, level of early warning of possible El Niño related impacts and problems.

As preliminary or as qualitative as El Niño-related hotspots identification might be, it can provide an early warning, a "heads up," to decision makers about the likelihood of El Niño-related hazards that an event could spawn in their jurisdiction. For some countries, decisionmakers will have considerable lead time to develop strategic responses to an El Niño forecast. For other countries decision makers will not have much time to respond and will have to resort to tactical and possibly reactive responses.

SWOC of El Niño Knowledge as Early Warning for Sustainable Development

The SWOC method is designed to identify Strengths, Weaknesses, Opportunities and Constraints of activities or processes of concern. In this instance, it is about the value to society of using El Niño knowledge as early warning for sustainable development purposes. The results of a SWOC exercise carried out in a session or two in a workshop setting is meant to generate ideas and discussion and is in no way meant to provide definitive results. The SWOC approach itself can be the target of a SWOC review.

El Niño is a real phenomenon with which people must deal. An El Niño "industry" is also real; that is, a community of people has developed, including scientists and forecasters, that benefit from the El Niño phenomenon in one way or another, directly or indirectly. When people on the street hear the shout (e.g., usually a media article about a forecast) that "El Niño is coming," they expect their governments or socioeconomic sectors to take some sort of action, preventive (e.g., evasive), mitigative or adaptive. There is likely, in any event, to be a response to the forecast of an El Niño occurrence, regardless of the correctness of that forecast. When a forecast is issued, someone is listening to it. Yet, the science of El Niño is not complete, nor have the responses by governments or socio-economic sectors been worked out. The question is as follows: Can responses to El Niño knowledge (again, including but not limited to forecasts) be used in ways that do not hamper development prospects and may even benefit from them?

Participants were divided into two groups in order to undertake a SWOC assessment. One group was asked to identify ***strengths and weaknesses*** of using El Niño knowledge as early warning for sustainable development purposes in Pacific Rim countries and islands. The second group was asked to identify ***opportunities and constraints*** in the use of El Niño knowledge as early warning for sustainable development purposes.

Strengths

There are at least two ways to look at the strength of using El Niño knowledge for sustainable development: conceptual and practical.

- Conceptual: Provides a new way of thinking related to learning to live with variability and thus can enhance the existing risk management framework. In particular, we are forced to think about a longer time scale than normal (e.g. the decision-makers' four-time term). Thus, it helps to build up institutional memory, capacity, and capability particularly for improving the existing risk management framework.

- Practical: Building capacities and capabilities is also practical, especially in that uncertainties can be reduced while sectors can separately take El Niño early warning and apply it for their needs; for example, meteorological services use the El Niño issue and related early warning knowledge as a development opportunity. But because this theme is of interest to many sectors, it could also be a stimulus towards increased cooperation and collaboration among them.

The notion of El Niño knowledge provides a new way of thinking about El Niño. It can provide decision makers (or, more broadly, stakeholders) with longer lead times needed for strategic thinking about how to cope with El Niño and its impacts, not just this event but all such events.

Practically, El Niño knowledge can help to reduce uncertainties by drawing attention to the history of El Niño events and their regional impacts, thereby putting the quasi-periodic event in a context for the public. El Niño knowledge can be used to enhance institutional capacity to respond to forecasts and projected impacts of extreme events, not just ENSO's extremes. In this regard, El Niño knowledge can be used to make structural changes to public and private institutions.

El Niño knowledge can broaden one's view of El Niño from a focus primarily on El Niño forecasts of a specific event to the broader El Niño forecast system. It can also help to bring the players in a given region that are affected by the same natural phenomenon ? El Niño ? together to work on the development of coordinated regional responses to El Niño events in general.

El Niño knowledge also provides a bridge between environmental change and economic well being. Linking environmental impacts in general and, more specifically, those related to El Niño with economic growth prospects can help to identify options for decision makers in their pursuit of sustainable development policies and practices.

Weaknesses

Weaknesses were divided into three categories: conceptual, informational, and communications. The group came up with the following points.

- Conceptual: The main conceptual weakness is that the term "El Niño" has a lack of specificity regarding what is being conveyed. Is it a coastal El Niño or a basin-wide El Niño? What space and time scales are being considered? Which stakeholders should be concerned and how? Are we really talking about El Niño manifestations (the event itself), effects (its impacts on regional climate), or impacts (on human activities)? If so, then the overall framework of climate risk management and ecosystem response would be more appropriate.

  On the point about making the El Niño focus broader to climate risk, a participant questioned why going more general and to a broader concept would be more useful and specific to those coping with El Niño's impacts in specific locations under different socioeconomic and geophysical settings. To be sure they are dealing with other hazards as well; if one thinks El Niño science is difficult to make useful in an application to societal needs, how could broadening the overarching concepts make it any better or easier for decision makers? El Niño issues are a subset of climate and climate-related risk issues and need not be replaced by it. To do so would turn away those whose focus is on El Niño per se.

- Information: The conceptual weakness associated with using El Niño knowledge to address sustainable development issues relates directly to the weaknesses in the information that is conveyed. Weaknesses include inconsistent data, incomplete data, inconsistent interpretation, lack of communication of uncertainties, timing with which the data are available and poor pathways of communication for information and data.

- Communication: This leads to communication weaknesses, in particular translating the data into practical and operational outcomes. Often many people fail to take onboard data, which are available in addition to interpreting the consequences for which data are not yet available. Politicians, of course, usually do not gain points for climate- and risk-related information related to long-term processes, particularly when plenty of uncertainty exists and when consequences fall outside their tenure in office. Thus, communication problems arise as stumbling blocks regarding the direct link from science to policy.

El Niño science is not yet reliable at forecasting the onset of an episode or the severity and location of its teleconnected impacts. It is relatively more reliable once an El Niño has started, because it tends to lock in for 12 months or so. El Niño science is relatively young. The time series for observed El Niño episodes in short, although researchers have used proxy information to identify El Niño events back to the 1500s.

For some countries, the onset of El Niño is followed so quickly by the impacts that decisionmakers have little to no lead time to get people ready for its impacts ***(NB: the positive side of this, though, is that El Niño knowledge (as opposed to just one forecast) can provide decision makers (national to local) with planning potential for the long-term (strategic planning as opposed to tactical reactions).***

Opportunities

El Niño knowledge as an organizing theme helps to broaden the focus of attention away from a specific event and a specific forecast. It fosters longer term thinking and planning, even if the science of the ENSO cycle is still incomplete. El Niño episodes and their impacts, collectively speaking, can be put in a broader development (as well as risk) context. Such knowledge can find its way into development planning exercises.

There are known El Niño impacts that have been positive for development. Making these examples explicit alongside their other disaster-reduction activities and sharing that information with other El Niño-affected communities can benefit societies.

El Niño knowledge would add to existing climate forecast and information systems. Although an El Niño forecast might provide relatively short lead times to decision makers at all levels of society, El Niño knowledge would provide them with strategic information for increasing the range of their development options, while at the same time identifying activities or locations for development to avoid.

It was suggested that the ENSO cycle be addressed from a macroeconomics perspective by linking environmental impacts with economic growth and with sustainable development. How do El Niño impacts influence the national economy, e.g., economic growth? One can make El Niño knowledge relevant to the various policy-making (institutional) levels from local to global. In other words, an improved use of *ENSO knowledge* can help a society to generate as well as to save funds.

In sum, by focusing on the broader notion of El Niño knowledge, a basic toolkit for decisionmakers can be created, one that would contain a range of "no regrets" El Niño-related strategies.

Constraints

There has been a tendency to view El Niño episodes primarily and overwhelmingly in a negative light. It is "sold" to the public only as a hazard. After several decades of having done so, it will be difficult for the scientific community and the media to change societal and therefore decisionmakers' perceptions about the phenomenon.

The primary focus on El Niño forecasts is constrained by the public's relatively short attention span. El Niño episodes are quasi-periodic: they can recur anywhere from 2 to 10 years apart and recur on average every 4½ years. It is difficult to get society to focus on a phenomenon that occurs infrequently and irregularly. This could be addressed by elevating the importance of La Niña events and more broadly La Niña knowledge, thereby providing the public with information about one of the extremes of the ENSO cycle on a relatively more frequent basis. Both anomalous events can cause problems or can bring some benefits to different locations or socioeconomic sectors. Taken together, the 4½ year on average waiting period can be cut in half, with an anomaly of opposite

sign every couple of years on average. See the website at http://www.exploratorium.edu/la_nina.

However, it is difficult for the media and the scientific community to interact with the public about the ENSO cycle. It is difficult to explain ENSO in a few paragraphs, keeping the article or media message interesting to the public. Nevertheless, that may have to be a way to go in the future in order to maintain societal interest in the state of air-sea interactions in the tropical Pacific Ocean, as well as the potential impacts.

A SWOC review or assessment is useful in many ways, but one important way relates to a belief that weaknesses and constraints also provide an opportunity. Once they have been made explicit, tactics and strategies can be developed to surmount them. Once identified, existing strengths and opportunities must be protected if not enhanced.

Expectations about Early Warning Systems

When it comes to early warning systems, it is important for those concerned about them ? producers, intermediaries, and users ? to determine what it is that they expect to achieve from them. Often, expectations are high for the success of the warning system in that people expect to receive timely warnings that have a high degree of reliability. In reality, though, early warning systems, however efficient they might be, are not perfect. There are missed warnings, that is, there are warnings that are false and there are events for which there were no timely warnings. Early warnings about El Niño's onset, intensity and possible impacts must be calibrated against and combined with other relevant information. There is a tendency to expect too much from an early warning system. Nevertheless, one could argue that El Niño forecasts represent the earliest warning that a government might get about the possibility of climate-related anomalies. At the least governments and individuals should begin to pay attention to the warnings issued by El Niño warning systems that are considered relatively reliable and from then on to monitor changes in sea surface temperature and sea level pressure across the Pacific basin as warning are updated.

El Niño Forecast Cascade

The Use of El Niño Knowledge

An El Niño forecast from a reliable source sparks interest throughout society in various socioeconomic sectors. It tends to spark a cascade of forecasts of potential impacts in regions designated as, or perceived to be, El Niño hotspots. For example, decision makers responsible for water supply might begin to put into place strategies to assure water availability throughout the El Niño period, especially in those regions where water shortages are expected to occur, such as in the Pacific Islands. They may choose to lower reservoir levels in areas that receive above-average rainfall during an El Niño episode. In

regions where El Niño sparks malaria outbreaks due to excessive rainfall, local governments can order the spraying of swampy areas; and so forth.

Three separate cascade sessions were held, with each one focusing on a cascade of forecasts that follow an El Niño forecast: hazard forecasts, agriculture forecasts and forecasts for the fishing sector. The first of this set of sessions focused on climate-related hazards such as droughts, floods, fires, and infectious disease outbreaks.

Hazards

Each country has its own unique set of climate-related hazards with which it is concerned. Neighboring countries often end up "sharing" a hazard and its impacts, such as a hurricane, a drought, or a transboundary flood. When an El Niño episode has been forecast, its onset observed, its intensity known, and its potential impacts identified, decision makers in various socioeconomic and political/administrative sectors of society become catalyzed to action. They do not all respond at the same time to the forecast of an El Niño but, depending on their specific concerns about impacts, may choose when to take the forecast seriously. In those regions where the visible impacts of an El Niño follow the forecast by several months, those decisionmakers have time to prepare. Those in other locations where the gap in time between impact and forecast is short have fewer options for their response.

Today there are many examples of how governments, administrative units, sectors of society and individuals have reacted to each of the forecasts for the stages in the evolution of an El Niño from onset to decay. There is considerable experience with hazards (e.g., droughts, floods, fires, disease) to draw on in both space (e.g., on both sides of the Pacific Basin) and time (e.g., from the impacts of earlier El Niño events) available to those decisionmakers wise enough to look for and use it.

The original intention for this session was to look at the El Niño forecast cascade as it has been described: that is, a forecast is issued from a recognized reliable source and then perhaps the water resource managers might begin to issue projections about water availability during the El Niño period. This would then stimulate municipal and agriculture decision makers to issue forecasts of impacts on locally available water supply. The public in turn decides how it will deal with, say, water shortages. Again, not all of these decisions are made at the same time as each has a time lag of response to the previous forecast.

An alternative way to describe the forecast cascade was suggested: Manifestations, Hazards and Impacts. ***Manifestations*** refer to the impacts of a warming of sea surface temperatures in the tropical Pacific on physical attributes of the atmosphere and the ocean, e.g., anomalous changes in temperature, pressure, wind speed and direction, sea level and thermocline depth. ***Hazards*** refer to geophysical hazards such as droughts, floods, fires, mudslides. ***Impacts*** refer to social and ecological responses to the changes in the regional atmospheric or marine environment's "normal" condition. These are not incompatible or diametrically opposing ways to view an El Niño forecast cascade. Both

will yield the same results in terms of supplying a decision maker with the El Niño related information that he or she needs to make effective and timely decisions.

Health

Carlos Corvalan from the World Health Organization (Geneva) made a brief presentation about climate and health, noting that climate variability poses a big threat to health conditions. There is a known connection between health and El Niño episodes, as one expression of variability. The specifics concerning the connection of health conditions to El Niño, however, are quite difficult to identify with high levels of certainty. This is because of the many other variables that have to be taken into account that affect human health: poverty, geography, unemployment, nutritional status, sanitation, existing vectors, the availability of health services resources, pre-existing health of the ecosystems on which society depends, and so forth. Studies have sought to link each of these factors to health conditions for a given population. He also noted that health effects can be immediate or delayed, direct or indirect. Delayed health impacts that might appear in the out-months or out-years following an El Niño could include communicable diseases (e.g., cholera) and vector-borne diseases. One must also take into consideration the mental as well as physical health conditions of those who remain in or migrate from the region affected by El Niño's impacts.

The discussion of the concept of adaptation exposed the fact that there were several different perspectives on its meaning. There is still confusion as to the difference between mitigation and adaptation. These terms can be viewed in the following way: mitigation refers to pro-active adaptation and adaptation refers to re-action adaptation. So people in conversation can be referring to adaptation but mean opposite things: reaction to an impact or pro-action to avert an impact.

It was suggested that there is an implicit contention between early warning and pro-active adaptation. In many parts of the globe where El Niño's impacts are felt, health services are so severely stressed that their ability to respond effectively and in a timely way to a warning is severely limited. The at-risk population (whether in situ or migratory) requires water, food, medicines, sanitation, and protection from disease-bearing vectors (mosquitoes, flies, rats, etc.). In some countries the existing services are so weak to begin with that additional stresses on them cannot effectively be responded to. In Haiti, for example, there is little that can be done in-country to mitigate the impacts of an adverse event and, as a result, the inhabitants are forced to muddle through the disaster and recovery periods. They live in at-risk areas out of necessity, not choice. In other places in the richer countries (e.g., the State of Florida), people can choose to live in harm's way; that is, they are at elevated risk by choice to extreme meteorological events.

The 1997–98 El Niño made it quite clear that the health sector in El Niño hotspot locations needed to be an integral part of the planning activities for coping with El Niño forecasts and impacts. That means involvement in the pre-, during, and post-event activities. Also, capacity building in the health sector requires a multidisciplinary effort, because its activities must contribute to long-term solutions to the health problems at the

same time that it copes with the current event's health impacts. The media have proven to be a useful ally to the health sector in that they can be used to educate the public and various levels of decision makers about sanitation, nutrition, and so forth, making the population relatively healthier in the face of future El Niño related impacts. Addressing the well being of at-risk-to-El Niño populations, as a development goal, builds more resilience within a community while at the same time tending to reduce vulnerability. Increased resilience enables a society to withstand increasingly more severe climate-related (and other) shocks.

El Niño has received considerable and growing attention from the media, as well as from the scientific community. Users of information are lulled into a false sense of security because they only have to focus on the impacts of an El Niño event every several years or so. However, not every drought or flood is associated with a specific El Niño event. They also appear in non-El Niño years. Thus, decision makers need to be prepared for droughts and floods all the time. Thirty years ago, few people outside the west coast of South America knew or cared about El Niño. El Niño research, carried out with increasing intensity since the 1960s, is now quite mature and perhaps has had its moment in the spotlight of science. There are other forms of variability that decision makers must contend with, beyond the ENSO extremes. Putting all these points together, it became clear that it is time to view El Niño as part of climate variability. In other words, the participants expressed, almost unanimously, the idea to consider El Niño as one of several types of climate variability. The phrase used was as follows: *"**Perhaps it is time to put El Niño back in the climate variability box.**"*

It became evident early in the meeting that from the perspective of sustainable development and long-range planning purposes, the climate variability linked to El Niño is a special case in the sense that it reappears irregularly but with a frequency that forces societies to take it as a serious disrupter of human activities. On the other hand, there is growing skill in forecasting its development. Forecasting the onset is still apparently problematic for researchers and forecasters. There is still much to learn about how to most correctly forecast its intensity, as well as its impacts on ecosystems and societies.

With regard to El Niño's health-related impacts, a participant noted that it was time to get beyond event-based, and therefore forecast-based, thinking, if planners are to use El Niño knowledge for sustainable development purposes. This sparked an interesting discussion about the relative weights (that is, attention, concern, level of importance) that should be given to an El Niño event as opposed to climate variability and climate risk on the annual time scale.

The idea of "getting things back to normal" also received attention in this session. It is often the objective of emergency response personnel to get the affected populations back to their normal routine. However, in many of the regions affected by El Niño "normal" does not mean good. So, getting health conditions back to normal in a poor country may be a goal for emergency workers, but is not necessarily the goal for those interested in improving the human condition. The notion of normal with regard to affected populations

should be revisited in light of the needs for enhancing the well being of at-risk populations.

To reduce the adverse health impacts of El Niño episodes in general and of a specific El Niño event in particular, the underlying factors that increase vulnerability (which could be viewed as the "inability" to adapt to adverse impacts) and also reduce resilience (which could be viewed as the ability to rebound from adversity) of a society must be addressed. In this regard, it is necessary for impacts researchers to continue to try to separate out the adverse impacts that can be blamed on El Niño events from those that must be attributed to decisions made by policymakers. The bottom line is the realization that pre-existing societal conditions, before a climate anomaly takes place, play a strong role in the potential impacts on humans and on ecosystems of that anomaly.

> The irregular occurrence of El Niño and La Niña events has implications for public health. On a global scale, the human effect of natural disasters increases during El Niño. The effect of ENSO on cholera risk in Bangladesh and malaria epidemics in parts of South Asia and South America has been well established. The strongest evidence for an association between ENSO and disease is provided by time-series analysis with data series that include more than one event. Evidence for ENSO's effect on other mosquito-borne and rodent-borne diseases is weaker than that for malaria and cholera. Health planners are used to dealing with spatial risk concepts but have little experience with temporal risk management. ENSO and seasonal climate forecasts might offer the opportunity to target scarce resources for epidemic control and disaster preparedness **(Kovats et al., 2004)**.

Agriculture, rangelands and water

There already exists a considerable amount of literature, and it is growing, on the use or value of El Niño forecasts in the agriculture, rangelands, and water sectors for dozens of societies. In fact, most concerns (and searches for benefits) about the use of El Niño forecasts have been for these sectors of society. El Niño forecasts, while far from perfect, can provide farmers, rangeland managers and water resources managers with useful information in their decision-making processes on how to cope with El Niño-related anomalies. Studies have also compared the ability of small farmers in poor countries and rich farmers in industrialized countries to cope with the forecasts as well as with the impacts.

In each country the public appears to have some difficulty in understanding probabilistic climate and weather forecasts. They tend to view forecasts as having been either right or wrong. They tend to blame forecasters if their forecasts do not match real conditions each and every time. Whether proven to have been a good forecast or an erroneous one, people react first to a forecast before they respond to its impacts. And there are risks and consequences for those who take actions based on the forecasts. This is a tricky business for those in operational decision-making positions. The climate system is a non-linear one with many interacting processes. Forecasters have to make decisions based on

probabilities, while their constituents must bear the costs (or benefits) of the decisions. There are some clear downsides to an El Niño forecast for the agricultural sector. For example, if drought conditions in a given region are expected to accompany an El Niño, local banking institutions have been known to withhold loans to farmers and ranchers because, in the event of drought, they would not have been able to pay off their loans.

Examples were provided from various countries. In Central American countries, various forecasters come together periodically to determine the likelihood of the onset of an El Niño and to discuss its progress as well as its potential impacts on various sectors of their societies, especially on agriculture and water. They integrate various types of data, downloadable from the Internet, and combine it with GIS. In Ecuador there are monthly meetings of an El Niño study group. In the Pacific Island countries local groups get together to discuss the various forecasts (some are locally produced while others are produced in the US, Australia, Japan or the UK). NOAA's forecasts of El Niño are particularly influential in distant lands. For example, to NOAA forecasters El Niño is a process (part of the ENSO cycle), whereas many in Ecuador view El Niño as an event.

Sustainable development programs require strategic responses to El Niño episodes and not just a series of ad hoc, reactive (e.g., tactical) responses. While any subset out of a range of tactical responses to a specific El Niño can help a government or society to minimize the impacts of El Niño, the ones that ultimately are chosen to make up that set should not impede or set back the drive toward sustainable development objectives.

A presentation was made about El Niño in Ecuador and its impacts on agriculture. On 11 July 2002, NOAA issued an El Niño forecast with the headline "El Niño makes its official return." When people in Ecuador heard this forecast, they reacted but it became clear that what NOAA considers to be an El Niño, people on the west coast of South America might not. Heavy rains coming earlier than expected were forecast, but they did not materialize. Most adversely affected by the forecast were the small farmers in rural areas. Also, the media became confused by the forecast. NOAA is focused on the central Pacific changes, and those in South America are looking for changes in the coastal waters. It was suggested that El Niño forecasts be labeled accordingly: basin-wide El Niño versus coastal El Niño. It was noted that when the forecasts from different sources conflict, people in Ecuador get together to discuss the differences. The media have been invited to these discussion sessions, but they rarely attend, preferring to get their information from the Internet (this gives some credence to the misplaced believe that "experts come from out of town"). It was noted that forecasts needs to be contextualized, i.e., tailored to the needs of the specific users, such as agriculture, fishing, health, rangelands and livestock, etc.

In Australia, researchers tend to favor the Southern Oscillation Index (SOI) because it provides decisionmakers with a longer lead time than does changes in sea surface temperatures in the central and eastern Pacific, the indicator focused on by North American forecasters. In Australia the goal of cascade forecasters is to encourage farmers, rangeland and water resource managers to hedge against the potential (e.g., likely) impacts of an El Niño; that means taking tactical moves to lessen if not avoid the

impacts ("lean rather than jump" when it comes to making changes in the crop portfolio). For example, farmers have an option to dig up every third row of cotton plants in order to provide more soil moisture for the two remaining rows. Not to do so runs the risk of losing all three rows of the crop to poor soil moisture. However, it was noted that farmers need more specific information to accompany El Niño impacts forecasts for Australia, such as for wheat and other crops. For Australia, Indonesia, the Philippines and other Pacific Rim countries and island nations, even weak El Niño events can wreak havoc on their national economies.

Fisheries

Participants acknowledged at the outset of this session that a considerable literature exists on the impacts that climate and that El Niño have on the marine environment, especially on living marine resources.

While many examples can be found of serious adverse effects on fish stocks and fishing sectors, there are also many examples of benefits to some fish stocks and fishing sectors. In other words there are winners and losers among fish populations and fisheries during an El Niño episode. One country's loss of access to a certain favored commercial fish population may prove to have been another country's gain. Also, some fish populations that favor warm water benefit from El Niño, while those requiring cool waters for survival lose out in that particular location. A concern and a potential benefit for sustainable development with regards to the fishing sector would be to devise long-term strategies for coping with impacts in a designated El Niño-related fisheries hotspot. Strategic thinking involves using El Niño knowledge drawn from experiences and lessons learned for a given fishery, as well as fisheries elsewhere that are subjected to environmental changes similar to those that often accompany an El Niño. El Niño knowledge also includes fisheries' responses to the various El Niño forecasts that are issued from its onset to its decay. Again, there are several examples of societal responses to El Niño forecasts in Pacific Island countries (e.g., tuna), in South American countries (e.g., anchovy, sardine, mackerel, shrimp) and in North America (e.g., salmon).

It was noted that there are several competing models based on assumptions about fish population dynamics: maximum sustainable yield, safe yield, optimal yield, and so forth. It was suggested that these models are often used for purposes beyond which they were originally intended: as an input, among others, to a decisionmaking process, or as ***THE*** input on which the decision is to be based. Despite the enormous literature on fish populations and fishing industries, it appears that the lessons learned from one fishery's experience by another, or within the same fishery but at different points in time, are often not applied. As a consequence, fishermen and scientists argue over the relative adverse contributions of fishing pressures and of natural variations to the long-term health of commercially favored fish populations. Management strategies are developed depending on a manager's perceptions about which factors to blame for recruitment failure and for fish population collapses.

So much information on fisheries exists that it was suggested that the problems with managing the exploitation of fish stocks, scientific uncertainties notwithstanding, were based more in institutional arrangements and decision-making processes than on forecasts. The concept of "tragedy of the commons" has been used in a fisheries context since at least 1954 (Scott, 1954). There are also many theories about how best to exploit a common-property fish population in a sustainable way. So far it seems that just about every fish population that has taken on a commercial value collapses. Adding to the pressure on fish of overfishing, R.C. Murphy (1954) suggested that "man is the only insatiable predator."

An example of the impacts of El Niño on a Pacific island fishery was noted. An El Niño can literally mean going from a good economy and easy fishing of tuna to a condition of no tuna at all and a poor economy (i.e., no income for many in the fishing sector such as those in canneries). Because the tuna population has migrated eastward, those in the eastern part of the Pacific basin benefit. It was proposed that all would benefit if those dependent on the tuna fisheries could devise an arrangement where they share in the benefits as well as losses of each other, throughout the impacts of the extremes of the ENSO cycle. Using El Niño knowledge (not just a specific forecast), planning in the region can be done in a more cooperative, supportive, and sustainable manner.

During this session, a representative of the CPPS (Permanent Commission for the South Pacific) made a presentation about the history and activities of the organization. CPPS, created in 1952, is devoted to an improved understanding and management of living marine resources in the eastern equatorial Pacific along the western coast of South America. CPPS is responsible for the maritime policies of its member states (Colombia, Chile, Ecuador, and Peru). He discussed the structure and functions of this regional organization and focused on a wide range of issues related to marine affairs (El Niño, fisheries, management, research, etc.). This generated considerable discussion about fisheries management and the models used as management tools. The presentation made clear the point that fisheries exploitation in the face of El Niño or in the face of any variability or extreme of climate must be considered in a multidisciplinary context. Decisions made on land, as much as changes in the ocean or the atmosphere, can be a destructive force as far as the sustainability of living marine resources are concerned.

World Conference on Disaster Reduction

Another presentation was made by the representative of the ISDR. He focused on a description of the World Conference on Disaster Reduction (WCDR), which is to be held in Kobe, Japan in mid-January 2005. This conference aims to increase the profile of disaster risk reduction in development planning and practice by promoting a strategic approach at the national level to address vulnerabilities and reduce risk to natural hazards. Human and economic losses to natural disasters continue to rise and remain as a major obstacle to sustainable development. The conference will build on the findings of the Yokohama Strategy and Plan of Action (ISDR, 1994).

Based on the objectives set out by the UN General Assembly, the main outcome of the conference is foreseen in the following areas: (1) increased awareness, recognition, and political endorsement for implementing disaster risk reduction and mobilizing local, national, and international resources; (2) clearer directions and priorities for action at international, regional, national, and local levels to ensure implementation of the ISDR and to support the achievement of the objectives of the Johannesburg Plan of Implementation and the Millennium Development Goals; (3) adoption of a set of goals and policy measures to guide and stimulate the implementation of disaster risk reduction, both on what to achieve and "how-to-do" risk reduction; and (4) launching of specific initiatives and partnerships to support the implementation of the ISDR.

Roundtable: El Niño's Impacts on Flora and Fauna in the Galapagos

An evening roundtable, open to the public, was held on "El Niño's impacts on flora and fauna in the Galapagos." Opening remarks were made by Jose Luis Santos from CIIFEN, and Mayor of Isla Santa Cruz Alfredo Ortiz Cobos. A presentation by CDRS (Charles Darwin Research Station) scientist Stuart Banks was included. Banks provided an overview of the marine and coastal environment, its exploitation and the major threats to living marine and terrestrial resources of the Galapagos Islands.

[MORE INFORMATION FROM TUESDAY EVENING GOES HERE]

The workshop organizers reviewed the evening session on Wednesday morning, noting that many local people came to the roundtable, and that the session was very lively, and was presented in both English and Spanish. They also noted that the question of winners and losers came up repeatedly: there are winners and losers related to responses to the forecasts, as well as winners and losers related to the impact of El Nino. One participant raised the interesting idea that governments might be convinced to divert 10% of what they think the impacts will cost them in order to prevent at least half the impacts.

Winners and Losers Issues Related to El Niño

In the short term, for a given event there are winners and losers as a result of El Niño's impacts. Heavy precipitation may bring good news to some (hydropower) and bad news to others (destruction, erosion, disease outbreaks). The good news can be in the same country, with one sector benefiting and another losing out. Or it can be between countries (good rains can lead to two crops in a year); it can lead to an increased market share of a given commodity if a competitor is hard hit by impacts, such as in the case of coffee.

In the longer term relating to sustainable development, those who can use El Niño information and knowledge to their advantage can benefit over those who ignore the information. It may be ignored by choice (the skill is not seen as high enough for use in decisionmaking or the information and knowledge has not as yet been shared) Those with access to high-tech communications can benefit with increased knowledge acquired

between events, as well as benefit from a given forecast for a given event. Those without access to that knowledge (it is not broadcast in the local media or not translated into the local language or not expressed in user-friendly terms) would not have the benefit for their land-use activities of this knowledge.

The issue of trust appeared again with regard to the use of forecasts related to El Niño or its cascade of forecasts. Trust between users and forecasts, between stakeholders and governments, is very important when it comes to encouraging increased use of forecasts. Trust, however, needs to be developed between forecasters and users, users and forecasters, users and other users (in various sectors of society that may be dependent in some way on each other, such as farmers and banks that provide loans), and forecasters and other forecasters (in the cascade of forecasts spawned by the forecast of El Niño's onset).

Lessons to be Learned from Lessons Already Learned

> *The Compact Oxford English Dictionary: Definitions*
>
> *lesson* – noun: **1** a period of learning or teaching. **2** a thing learned. **3** a thing that serves as a warning or encouragement, etc.
>
> *object lesson* – noun: a striking practical example of a principle or ideal.

At the outset, it is important to say that some people do learn lessons from past experiences: theirs and the experiences of others. With regard to hazards and disasters, there are many lessons that have been identified for application, but for a variety of reasons ? some political, some financial, some cultural ? have not been applied. This may be more true for intermittent, aperiodic events and for creeping, incremental changes that it is for recurrent quick-onset events in known locations. The European Environment Agency (EEA) produced a report entitled *Late Lessons from Early Warnings* (EEA, 2001) that provides a dozen cases where scientific uncertainty was used to block policies to change human behavior toward environmentally related problems. That raised the proverb, "If you stay on the path you are on, you will get to where you are going." Thus, in the absence of changing harmful behavior in various environments, bad consequences are likely to result: in other places or at other times, the end result of the same type of bad behavior can be witnessed.

Many reasons can be identified as to why lessons are not necessarily used by successive policymakers, governments, or generations. Some people believe without question that the latest articles are better than earlier ones. This is an example of "discounting the past." A participant drew attention to the distinction that can be made between ignorance and "ignore-ance." The former refers to a condition in which the information is just not available, whereas the latter refers to a situation in which the information is available but purposely not used. In many instances, those affected by the impacts of El Niño are not directly involved in policy decisions about how to deal with forecasts, with impacts, and with reconstruction following adverse impacts. Those involved in the process, having some ownership in the outcome, are more likely to apply those lessons that they helped to identify. Governments change from time to time, and new governments want to remake

the bureaucracy in its own image. As a result, good lessons from previous governments are discarded, regardless of their level of effectiveness.

NASA has a website devoted to lessons learned. It contains information on the specific problems of the engineering kind that NASA has had to face and the solutions undertaken to fix those problems. The site is open to the public and is labeled **"**Public Lessons Learned System (PLLS) Database." As one might guess, those are lessons some of which are hard-earned lessons. But these are for the most part engineering problems for which lessons have been learned: failure of mechanical parts or processes that require engineering or technology fixes (http://llis.nasa.gov/llis/plls/).

And maybe, while there have been management decision-making problems at NASA, there have been lessons learned on how better to make decisions that carry lower risk for others, such as astronauts and space craft launchings and re-entries. So, I think one could effectively argue that lessons are generally not only *learned* but also *applied*, when it comes to engineering and technological problems. If an engineering system fails it is ***in everyone's interest*** to identify the reasons for the failure and to learn from the engineering mistakes.

> About 5 years ago I was the Principal Investigator for a 16-country study on the use of El Niño forecasts in various sectors of these different societies. When preparing the lessons-learned section of the report for this project, I looked back at other reports related to natural hazards and disasters to see how those PIs had reported the "lessons learned" from their disaster assessments. I looked at some reports only a few years old along with others published ten or twenty years ago or more. To my surprise, our study had come up with several of the same lessons that had been learned as a result of earlier floods, droughts, fires, volcanic eruptions, earthquakes, even El Niño events, and so forth. That raised a concern for me: Are we misusing the word "learned"? I have come to a personal conclusion that in many instances of coping with a previous hazard, several of the lessons allegedly learned by a society, government or researcher had really not been learned. They had only been identified. For lessons to have been learned would mean that societal behavior (more generally, decision making) in the face of similar hazards would be different than from in earlier situations. **--M.H. Glantz (2001)**

There are identifiable reasons why people (society, government, etc.) do not pay heed to lessons identified earlier as a result of the adverse impacts of a similar hazard. Lessons are identified but not necessarily learned; lessons learned are shelved and forgotten; lessons learned and known are ignored; lessons known are rejected. It is an issue worthy of discussion.

Some reasons that learned lessons are not applied might include the belief that in the intervening time between hazards (or disasters) society (and decisionmakers) had become more knowledgeable about those hazards and how to deal with them, that our scientific understanding *must have progressed* might be a typical perception. But, had it? Would having had that knowledge in hand in advance of the second occurrence of a similar hazard have made a difference with respect to the hazard's impacts on environment and society? Another reason lessons might not be applied is because *other* researchers,

governments, companies, and cultures identified them. This rejection of identified lessons relates to the "not invented here" problem.

Participants raised the question "Who learns from whom?" They then suggested that a top-down approach has not been effective in their parts of the Pacific Rim, and that community-to-community communications on hazards such as El Niño worked best. Most likely it will be a mix of top-down, bottom-up and a "bottom to bottom" sharing of information (providing and receiving) that will be the most effective way to use El Niño knowledge for strategic sustainable development planning.

Yet another reason might be that lessons learned are sometimes taught to people who are not in a position to use them. People attempt to teach some lessons to people with whom they have not developed rapport and, hence, those lessons are not taken as seriously as those provided by local people whom they know or to whom they can relate. Lessons (e.g., knowledge) acquired over time by trial and error at the local level can be used to inform higher-level decision makers in a given society. It is necessary to find ways to "scale up" local knowledge, as the locals may have insights into coping with climate-related risks; it is simply not enough for decision makers to call for better interactions with "stakeholders." They must treat them as equal partners in an ongoing dialogue.

As one participant correctly noted, learning lessons also comes from the process on communication. Decision-making is a process, the end of which is not the decision itself. The process of decision-making continues with feedback as to the appropriateness of the decision for the situation. Adjustments to the original decision need to remain as a constant possibility. The notion of an "end to end" process (forecast to policy) is misleading because it suggests a process that starts in science and ends in a policy statement. It should really be an "end-to-end-to-end" process in which feedback to the policy is taken into account in case there is a need to modify it in light of existing realities in a given society.

Lessons can come from a variety of places and, if used, can stimulate a range of possible responses. Before one judges the correctness of a response to an El Niño forecast, one must first review the setting is which the decisions to respond in certain ways were reviewed. For example, the 1997-98 El Niño event had been forecast officially in mid-June 1997 evoked very different responses from the governments in Kenya, Costa Rica and in Peru (see Glantz, 2001).

It is necessary to remind the public and decision makers that, though we often refer to ***an*** El Niño forecast, we are really talking about a process in which there are several El Niño forecasts issued in series. Several forecasts refers to (1) the fact that there are several organizations, legitimate and otherwise, that issue forecasts (in the strict sense of the term) as well as issue their perspectives on what might be happening with regard to sea surface temperatures or sea level pressure across the Pacific, and (2) what the public would consider a forecast ? an outlook, a diagnostic, a projection, a watch, etc. With regard to (2), once there is a hint that an El Niño episode might occur, the public is bombarded with a stream of forecasts that are constantly updated throughout the

development, duration, and demise of the episode. Most attention of the general public, one could argue, focuses on the forecast of the onset of an event, whereas different users (stakeholders) tend to focus increasingly their attention on the succeeding forecasts and projections from a range of sources.

The reasons that known lessons may not be used by others is a question that demands immediate consideration. Societies can learn from history, their own and that of others in similar situations (i.e., by analogy) or they can learn the hard way, that is, from direct experience of the adverse effects of recurring El Niño events and their teleconnections.

It was proposed that for those decisionmakers not yet convinced of El Niño's influence on their economies, it is necessary to identify the economic interests of a government, society, or sector of society in improving its knowledge about the ENSO cycle, its extremes and its impacts. Activities related to learning about and studying known lessons are best undertaken *between* El Niño events and not in the midst of them. After 30 years of awareness of El Niño in the forecasting community and in governments, societies have still not learned well how to cope with a climate-related phenomenon whose frequency is irregular (it can recur anywhere from 2 to 10 years apart). Apparently, the forewarned are not always the forearmed. A bottom-line research question that was posed in the workshop is the following: ***Why is it that some lessons identified are learned and applied by some people and not others?***

Media and Early Warnings

> **media**
> • **noun 1** the means of mass communication, especially television, radio, and newspapers collectively. **2** plural of medium. (Oxford English Dictionary)

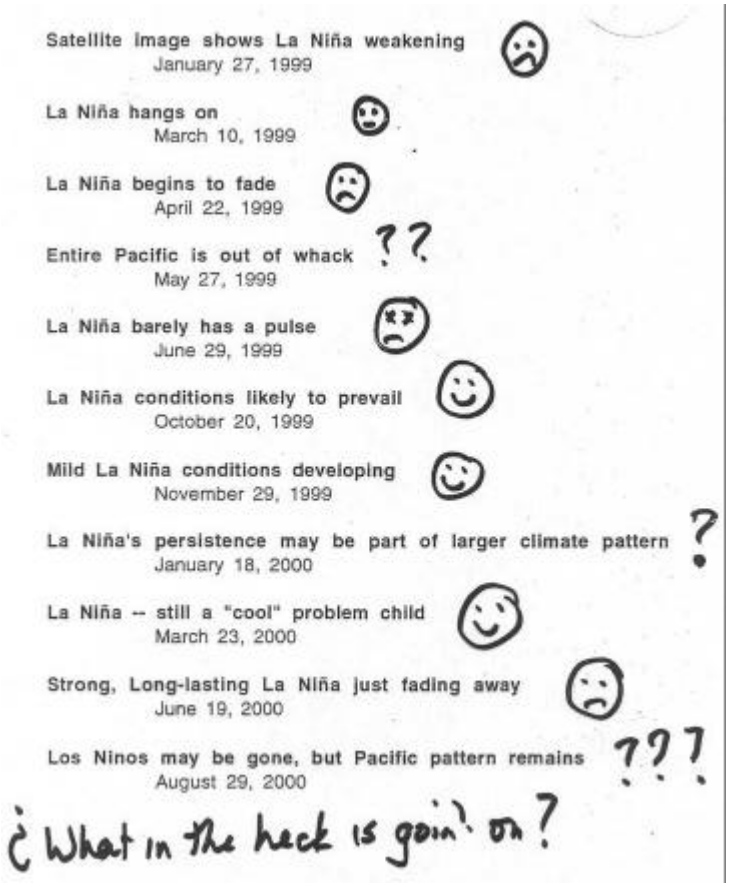
When we refer to the "role of the media," it is apparent that each media may have its own set of roles and rules, despite some common basic functions that each must perform to be classed as media. To media definitions, one must add the Internet as a contemporary means of mass communication.

Some people believe that the media have responsibility to educate the public. In fact some parts of each of the above-noted media do take on that responsibility; for example, National Public Radio, or National Public TV. For the most part, however, the media are businesses. They sell products through advertising on the airwaves or in print. It is necessary to cultivate that aspect of the media that can or already does serve to educate the public.

Media representatives are eager to capture headlines of newsworthy events. Usually such headlines fall into the "doom and gloom" category. The media also do well with topical and quick-onset events. El Niño events are episodic and irregular, as noted earlier. This infrequent occurrence poses a problem for media coverage. It is also problematic for the media to cover slow-onset, creeping changes of any kind, and especially those in the

environment. With few exceptions, the media tend to focus on abrupt changes as opposed to creeping ones. To be fair, one could argue that there have been some creeping environmental changes that the media have covered with increasing frequency, e.g., ozone depletion and global warming. In general, though, they tend to view warnings coming out of the environmental community as representative of the "crying wolf" syndrome, and that every environmental problem to environmentalists is a crisis. As a result media editors tend to discount much of what the environmentalists want them to put into print on the airwaves. In this regard, the Internet fills in the gaps left by the other media sources.

When it comes to forecasting El Niño, there are many people making their projections known to the media about El Niño, and that includes the Internet. To be first and correct with a forecast adds to the credibility of the media outlet reporting it. However, the pressure (or desire) to be first among forecasts runs the risk of announcing erroneous forecasts, or "jumping the gun." Look at the following memo (private communication to Glantz) received about the projections related to the other ENSO extreme, La Niña. The happy face symbol identifies when the forecast turned out to be correct and when it was not. This represented the forecasts issued by one government group, among the many operating at the time.



Forecasting El Niño's onset is quite difficult, despite the constant monitoring of air-sea interactions in the tropical Pacific. Once an event locks in, however, it becomes easier to project its development over the course of the next several months. Attention then shifts to forecasting the distant impacts of an El Niño. The media jump on impacts, as they are often timely, newsworthy and potentially disastrous to different regions around the globe. Most of the El Niño impact stories are about negative impacts. It is very difficult to get the media to cover its positive aspects, wherever they may be.

The media can both generate interest in the public and can also follow the interests of the public. They believe that they are giving the people the kind of information that they want. So there are stories occasionally about tropical deforestation in the Amazon or about the disappearance of the Aral Sea. However, they do not see it as their responsibility to monitor such changes. Media also tend to follow the leader; that is, the first to release a story that generates public interest is soon followed by others in the media following the lead of the first to cover a specific issue.

Meshing together the above comments suggests that the media in theory have a role in the use of El Niño knowledge as early warning for sustainable development. However, the best time to undertake an educational campaign for the public (and policy makers) is when there is no event in play, as pointed out in the previous workshop session on lessons learned. That is when decisionmakers have the lead time to make appropriate strategic changes to the way their societies cope the El Niño's impacts. During an El Niño, the focus shifts to tactical responses to those impacts, and tactical responses in some cases conflict with sustainable development objectives.

It was generally acknowledged that the media taken as a whole have performed much better in recent times, when it comes to reporting science and environment issues. There are media that are excellent, objective, and fair in their portrayal of climate-society-environment interaction. For forecasters' part in communicating science to the public, they should avoid terms that are doomed to fail, such as "drought-proofing," "weather-proofing," and, more generally, "hazard-proofing" through engineering and technology. Every time such a notion has been mentioned, nature has undermined it. Hence, a credibility problem arises between researchers and forecasters on one side, and policymakers and the public on the other side.

Vulnerability and Resilience

A considerable body of writings relates to the concepts of resilience and vulnerability and to their operational use in hazard, disaster, and risk studies. Some observers say that resilience is the opposite of vulnerability. Others say it is not. There are many definitions of both concepts. Both concepts are of value to making more effective the use of El Niño knowledge as early warning for sustainable development.

Susan Cutter (1996) identified three distinct clusters of definitions of vulnerability: as risk of exposure to hazards, as a capability for social response… and as an attribute of

places (e.g., vulnerability of coastlines to sea level rise). To Cutter, "vulnerability is the likelihood that an individual or group will be exposed to and adversely affected by a hazard. It is the interaction of the hazards of place (risk and mitigation) with the social profile of communities" (p. 532).

Simply stated, vulnerability is the openness to adverse impacts. It implies a lack of societal flexibility as well as a lack a variation in response possibilities. Resilience, simply stated, is an ability to return to "normal" after adverse impacts have occurred. But resilience can be more than that. It was suggested that resilience is a rich concept. There are alternative approaches to vulnerability assessment such as the social construction of risk. For example, deforestation and desertification, processes in which human activities are integrally involved, contribute to risk in a given area. The deconstruction of risk involves separating out the societal factors that contribute to a society's level of risk from the non-societal factors.

The ability of a society to adapt to short-term environmental variability and extreme events is a key to sustainable development. A societal capability to identify potential climate-related hazards, such as El Niño events, can go a long way toward its ability to adapt in a pro-active way to such recurrent potentially disruptive climate-related anomalies. Participants said that it was more important to focus on communities as opposed to focusing on events.

Environmental Justice Issues: Using Hurricane Mitch as an Example

An overview was presented of the impacts of Hurricane Mitch in Central America in general and in Honduras in particular. The impacts in Honduras, as an example, were devastating, with well over 10000 deaths and several billions in damage: banana crops lost, large percentage of the infrastructure destroyed, out-migration from the country, etc. Workshop discussion centered for the most part on issues related to inter-generational equity, also referred to as eco-justice and distributive justice. Which generation should be the focus of concern: the present affected generation or future generations? Disaster assistance groups went to Honduras immediately to get things back to "normal." Normal was that Honduras had at the time been the fourth-poorest country in Latin America. Several months later when the development experts went to Honduras, they found that many people had been placed back in similar at-risk locations. This raised concern about how to mesh short-term disaster response to longer-term sustainable development activities. Hurricane Mitch also demonstrated what La Red refers to as "manifest risk," or risk that is waiting to be revealed.

There is considerable argument and support for aiding future generations. In practice, however, there is a bias against it. There are many examples of a bias against investing in future sustainability in favor of getting near-term rewards. The present generation and its needs and wants are real, whereas those of future generations are allegedly unknown. Economic considerations also are biased against the future generations because of the "discount rate." Compounding this is the bias in favor of consumerism. There is also a

feeling (a belief, a hope, or just blind faith) that future generations will be better off than present ones partly because of a pervasive confidence in scientific and engineering ingenuity.

Events such as El Niño could generate opportunities for some people, agencies, organizations or societies. For example, in Nicaragua water pipes were brought in to replace reliance in some locations on well water. Putting a positive spin on a hazard, El Niño could provide a learning experience that could help society to avoid such damages in the future. An optimist would suggest opportunities for everyone; a pessimist would suggest opportunities only for the upper class. Mitch also disrupted regional trade by destroying roads and bridges, destroying crops in the field, prompted considerable cross-border migration, increased the cost of transportation, etc. The Honduran Meteorological Service followed the events of Hurricane Mitch on CNN. Although $11 billion was pledged to reconstruct Central American countries damaged by Mitch, only $5 billion was eventually delivered. Pledges are often made in the immediacy of a disaster, but as time passes, the desire to fulfill the pledge wanes. As reconstruction and development efforts were progressing slowly, the Hondurans remained vulnerable to near-term perturbations in the regional climate system. In sum, responses to Hurricane Mitch, or lack thereof, set up Hondurans to be even more vulnerable to expectable future departures from normal of rainfall.

Regionally, Mitch encouraged Central American countries to work more closely together on some issues. Now there are regional climate outlook forums. This is an example of "Disaster diplomacy" (Kelman, 2003). Knowledge of the impacts of El Niño events within countries and across borders can help decisionmakers to pursue tactics as well as strategies that favor sustainable development.

There are lessons to be learned not only from this disaster in Central America in late October 1998, but also from generalization made after years of dealing with a range of disruptive hazards and disasters. A report of the International Federation of Red Cross and Red Crescent Societies (World Disasters Report, 2003) identified the following set of ethical challenges to capacity building which can interfere with achieving the objective of sustainable development:

- Failure to match external aid supply systems to people's needs
- Unequal partnerships between outsiders and local organizations
- Imposition of outsiders' predetermined aid agendas
- The unintended, sometimes adverse consequences of interventions
- How far can and should agencies go in addressing the root causes of vulnerability to disasters
- Failure to match external aid supply systems to people's needs
- The risk that the presence of international agencies will undermine local organizational capacities
- How to work with government institutions in an effective and politically neutral manner
- The difficulty in measuring success

The topic of "superstorms" was also raised in this session. In the 1990s, the label of superstorm had increasingly been attributed to extreme events: Superstorm 1993 in the United States, SuperTyphoon Orissa in India, SuperTyphoon Maemi in Korea, The 1997-98 El Niño of the Century," among other events. Climate change researchers have proposed that there is likely to be an increase in the frequency and intensity of extreme meteorological events in a warmer global climate regime. Hurricane Mitch was not labeled as a superstorm, but its impacts were similar to those that might be expected of a superstorm.

Since the Galapagos workshop was held in mid-September 2004, four hurricanes made landfall and impacted the state of Florida, and Japan had received a record-setting tenth typhoon to make landfall in a single season. Thus, societies have to learn not only about the single superstorm but also from the likelihood of a season of superstorms, however one chooses to define them. Such blockbuster events can derail development prospects for several years. It is better to anticipate them and their potential impacts in order to strengthen societal resilience and, at the same time, reduce vulnerabilities.

Other similar conflicts between emergency ad-hoc responses and strategic long-term sustainable development prospects were provided by various participants: China (dust storms), India (SuperTyphoon Orissa), and Korea (Typhoons Orissa and Maemi), slow-moving typhoon-related floods and societal responses in the southern Philippines, and Typhoon Waca landfall and impacts in the Pacific nation of Tonga. While the catalysts to disaster were, for the most part, related to atmospheric processes, the extent of death and destruction depended in large measure on socioeconomic factors.

Climate Change & the Pacific Rim and Islands

The literature that relates climate change (e.g., global warming) to adverse impacts on societies, ecosystems and on environment in general in the Pacific Rim countries and island nations is substantial, and it continues to increase on a monthly basis. Some consequences of global warming are well known, such as sea level rise. Sea level rise puts low-lying coastal areas around the Pacific basin at risk and puts many of the Pacific island nations at great risk to inundation. This is of dire concern to the inhabitants and leaders of the island nations, because sea level rise will lead to the forced abandonment of some Pacific island nations.

There is less certainty about how global warming will actually influence typhoon storm tracks, frequencies and intensities. This too is crucially important to island nations, since water supply for many islands comes from rainfall, not ground water. Water in the islands is one of the most important natural resources that sustain settlements. Coral reefs are endangered by warmer atmospheric and sea surface temperatures, because such temperature increases cause coral bleaching.

All of the Pacific Islands are in the region affected by El Niño. During El Niño episodes, many islands suffer from the severe lack of rainfall; drought means little water for agriculture, domestic use, and industrial purposes. Certain vector-borne disease outbreaks also occur on the islands during El Niño. Fish populations shift from their usual habitats, and the needs for port or fish processing capacity decline during an El Niño, thus adversely affecting employment. Tourism tends to decline, as people choose other tourist hotspots to visit out of fear that El Niño would likely disrupt the tropical conditions they seek to enjoy for their vacation. Clearly, the inhabitants and the economies of the Pacific island states are at high risk to El Niño-related adversities. They exist at El Niño's "ground zero."

Eco-justice issues must also be addressed as a result of climate changes in the Pacific region. For example, if islands are overtaken by sea level rise, inhabitants will be forced to move to other countries. Arrangements are already being made if islands like Tuvalu become submerged by the ocean or destroyed by tidal surges; Tuvalu has made such arrangements for re-settlement with New Zealand.

> Earth's climate is in a state of flux. Whether in terms of relatively short-term shifts, called climate variability, or long-term climate change associated with greenhouse gases, consequences of changing climate conditions appear unprecedented. Losses due to weather-related disasters have soared recently ? especially in the Pacific, where island environments, societies, and infrastructures are particularly vulnerable. For generations, human response to climate events has been just that: response after the fact to phenomena that neither residents nor scientists adequately understood. Now, a growing body of information about the causes of climate events is enabling Pacific Islanders and others to anticipate events and move past being victims to become informed planners. This new knowledge can only be successfully applied via dynamic partnerships between science and society. Particularly promising is the emerging field of climate risk management, in which disaster management and climate science communities unite, forming model partnerships to plan for the inevitabilities linked with the planet's variable and changing climate.
>
> Developing countries shoulder the brunt of impacts from such disasters; especially hard hit are small-island developing states of the Pacific, Indian Ocean, and Caribbean. These islands have always been vulnerable to the short-term shifts scientists call climate variability, but until recently not even scientists understood in detail how these phenomena operated or how to predict them. Now, with burgeoning scientific knowledge regarding climate variability and its effects, Pacific Island communities have an opportunity to shape the future. To do so, they must move past being *victims* and embrace the challenge to be *planners* who are preparing for the inevitable consequences of climate variability. This approach is also the most prudent preparation for the effects of climate change which may amplify the effects of climate variability and bring additional environmental hazards, such as sea level rise.
>
> **--Eileen Shea**

Creeping environmental problems (CEPS) are important to island nations and to Pacific Rim countries. They tend to occur at levels of change that are imperceptible on a daily and on even a monthly basis. After a few years, however, their adverse impacts become quite obvious; for example, mangrove destruction, mining coral for construction

materials, salt water intrusion, the accidental introduction of disease-bearing vectors, increasing levels of water pollution, waste disposal, and so forth.

Climate change will most likely affect the ENSO cycle in ways not yet identified. It will also change the characteristics of El Niño and La Niña events in terms of altering their frequencies, intensities, durations and locations of their distant (teleconnected) impacts. Learning about the impacts of global warming of the Earth's atmosphere on El Niño events in particular and on air-sea interactions in the Pacific in general will enhance society's El Niño knowledge that can be applied to planning for sustainable economic development in future decades. [See Appendix B, *Small Islands Voice*]

Right-sizing El Niño Early Warnings

The original question posed to the participants at the Galapagos workshop was the following: What is the right scope for early warnings related to El Niño in the Pacific Basin? There are several reasons for posing such a question. Today, NOAA in the USA issues El Niño forecasts globally. We have heard from other countries with official forecasting groups that NOAA's forecasts on the likelihood of an El Niño event can generate problems for them and their relations with their own governments: "Why are we funding this activity when we are hearing about the onset of El Niño from the USA?"

This is a concern to national meteorological services worldwide but especially those influenced directly or indirectly, physically or financially, by an El Niño. Local forecasts whose reputations, if not jobs, are on the line locally tend to be more conservative in their forecasts than are agencies outside of their countries. At the first hint of a possible event, scores of forecasts spring up in the media and especially in newsprint and on the Internet. Now the WMO issues a watch for El Niño, possibly to level the playing field in the sense that it may be less conservative that the local forecasters but more conservative than the competing El Niño forecast groups in the industrialized countries.

This is a dilemma for NOAA in the sense that it is doing its job by issuing a forecast of El Niño, based on its models and its experts. It forecasts are newsworthy and are printed in many media outlets around the globe. These articles generate local concern about possible impacts, and the pressure mounts on local forecasts and decision makers in climate-sensitive socioeconomic sectors of society. As noted with the El Niño hotspots maps (first produced by NOAA in the mid-1980s), they lack usable detail for decision makers at the local to national level. How then to downscale in time and space the global warning that an El Niño is likely on the way?

There needs to be a downscaling of the global (general) forecast to the different levels of social and political users (e.g., a spatial cascade of forecast detail) ? regional, national, sub-national regions, local. In some areas an institutionally based ***regional*** downscaling process has already occurred (in sub-Saharan Africa; in Central America; in South America; in the Pacific Islands, among others). There is also a possibility that needs to be pursued, and that is upscaling local forecasts to those issuing the global forecasts,

providing them with the local details and calibration of their data that their global projects lack.

There is an expression that "the devil is in the details," and that is as true for El Niño forecasts and El Niño knowledge as it is for political or economic agreements. Attention needs to be focused more heavily on the problems of downscaling knowledge from global to local and upscaling knowledge from local to global. ***Scale matters*** ? geographical, political, and economic ? when it comes to communicating the right level of detail of El Niño knowledge for sustainable development purposes to the scale of the intended recipients. Policymakers specifically, and decisionmakers generally, do not want to be surprised. Getting the correct level of detail to the appropriate level of decision making is a real challenge to those who produce the science of El Niño and those who translate it for use by the public. Having noted that scale matters, it was stated that the responsibility for getting information to users at all scales rests with the national government.

It was also proposed that El Niño events be de-dramatized, a process that would most likely have to begin ***within*** the scientific community. Scientists have been quite successful in capturing the attention of the media in this recently "discovered" phenomenon. The downside, however, has been the tendency of some scientific organizations and the media to "hype" El Niño and its possible impacts through provocative headlines and scary scenarios.

El Niño does provide added forecast skill for forecasting and therefore preparing for likely "downstream impacts." However, it is only one manifestation of variability in the global climate system. Now that we have captured the attention of the public and a wide range of decision makers as to the value of forecasting El Niño (and in general of El Niño knowledge), it is time to put El Niño events in a more realistic light. In other words, as noted earlier, *"put El Niño back into the climate variability box."*

It was pointed out that, when it comes to issuing El Niño forecasts (about the phenomenon and about its likely impacts) and forecast-related products (news releases, warnings, workshops and other meetings, etc.), that right-sizing the institutions involved is crucial. That means right-sizing to the regional level, either geographically or functionally defined. Functional right-sizing refers to coordination of those engaged in similar socioeconomic activities worldwide that could be affected by an El Niño episode (such as specific climate-sensitive commodities; fish, palm oil, coffee, sugar, grains).

One concern is how to evaluate success of the series of El Niño forecasts following its onset and of the cascade of El Niño-related forecasts likely to follow. Some suggested that a change in behavior of decisionmakers is a good indication of forecast use and, therefore, value to society. However, it is important to note that forecasts can also reinforce existing correct behavior and that no change in behavior of decisionmakers occurs. Evaluating the impacts of a forecast (in terms of benefits to society) is a difficult task.

When NOAA issues its forecasts related to an El Niño event, it affects other countries. The national meteorological services are bombarded with requests for information about impacts locally and about the forecast itself. This puts them in a difficult position because the national to local level decision makers have to be more conservative in their immediate reactions to those NOAA projections. They are the ones that are on the proverbial firing line if anything goes wrong that is related to the forecast. They are the ones that have to participate in deliberations to mesh tactical responses to the forecast and likely impacts with the needs of their countries for sustainable futures. To the national meteorological services it is much more important to be correct than to be first with the forecast, in the absence of the NOAA global forecast about El Niño.

Yet again, the idea was raised to put El Niño in the context of another aspect of climate variability in the context of right-sizing El Niño knowledge for early warning. Month to month and year to year, people at the local to national levels are coping with variability and its extremes. Coping with El Niño may be a special case of having to cope but it is clearly not the only case of variability. In this discussion, phrases were used such as "de-dramatize" and de-hype" the El Niño phenomenon. This will not be an easy task, though it is one worthy of serious consideration.

The Pacific Rim countries and islands represent considerable diversity in terms of information needs and in terms of capabilities to respond to El Niño events and to forecasts of them. There are countries with considerable expertise, scientific and applied, that would be willing to share with others in the region. There are also sub-regional groupings as well, such as East Asia, Southeast Asia, the Pacific Island nations, the countries in Central America, and those in CPPS in South America. A network of such networks could be developed virtually, at the least with the active and innovative use of the Internet and satellite-based radio waves, e.g., RANET.

Prospects of Linking across the Pacific

The participants were asked to discuss in plenary session the strengths, weaknesses, opportunities and constraints (a SWOC assessment) of networking across the Pacific Basin for the purpose of sharing and using El Niño knowledge for sustainable development.

Strengths and opportunities

Linking activities related to El Niño across the basin can bring together people, groups, and institutions with a diversity of experiences in coping with El Niño events as well as with coping strategies and tactics for dealing with climate variability and its climate-related impacts (e.g., droughts, floods, forest and bush fires, vector-borne disease outbreaks, heat waves, etc.). Some countries around the basin have had more experience in dealing with El Niño forecasts and impacts than others. Those ahead of the El Niño learning curve can help to build human capacity among those below them on that curve.

It provides a serious reason for attempts to gather climate-related knowledge at the local levels around the Pacific region. There is considerable local and traditional knowledge that could be exposed and shared. Enhancing cooperation across the basin would encourage collaborations about the science of El Niño and its societal aspects (impacts and response tactics and strategies).

It would right-size, i.e., regionalize, the El Niño forecast system, as those in and around the Pacific are likely to suffer similar adverse impacts of El Niño. For example, some countries will suffer from drought and other countries from floods. Some may share the loss in productivity of their fisheries, while others may benefit from an influx of commercially valuable fish populations. Lessons can be learned from the experience of other countries. Regionalizing El Niño early warning and response strategies would spark a more effective way to share in the exploitation of migrating living marine resources. Coral bleaching and human impacts on coral are often transboundary, as well as national, problems. There are regional guidelines set forth by the WMO that foster the virtual operation of regional climate interactions. In this regard, through virtual arrangements, a sharing of climate-related data would take place around the Pacific.

Weaknesses and constraints

There are political constraints to the sharing of data. Some countries are willing to do while others are not. There are sub-regional functional and geographic institutions that might feel that their jurisdictions are being violated. Long time series for El Niño and other climate-related phenomena and their impacts on ecosystems and society do not exist in many local communities. Language barriers do exist, which could require greater expenditures for the translation of shared information; there is no *lingua franca* for the Pacific region. The cost of bringing participants from around the basin to a specific venue for face-to-face meetings, as opposed to using teleconferencing and other forms of workshop interaction, can be quite costly and time-consuming. There is a lack of shared knowledge about the Pacific region's institutes and organizations that are wholly or partly involved in El Niño-related, and even climate-related, activities.

Putting together this workshop exposed some of the problems that could arise from linking on a more permanent basis physical, biological, and social science researchers, disaster managers, and policymakers from around the Pacific Rim and the islands. The cost and time required to bring people together in the same location are quite high, when compared to the resources available. If such a linking cannot be shown to provide positive advances in forecasting and responses to the impacts of ENSO forecasts, then perhaps it would be better to let the two sides of the Pacific focus their interactions with others in their respective hemispheres. In such a case, once again the islands would be left to fend for themselves. In this regard, a popular belief holds true: the whole is greater than the sum of its parts. Link when you can and when it makes sense to do so for the parties seeking to link.

The Grand Challenge: Dynamics of Humanity on Earth

The term "Grand Challenge" was coined by Ken Wilson, Nobel Prize-winning physicist. In the early 1990s, the term was used to connote a fundamental problem in science whose solution is dependent on more computer power than is currently available. It has taken on a wider meaning in subsequent years and now is frequently used in connection with extremely complex problems, the solution to which will benefit society. Recently the National Science and Technology Council (NSTC) Sub-committee on Social, Behavioral, and Economic Sciences Working Group on Portfolio and Priorities has tasked each of its members (which includes the National Science Foundation) to identify grand challenge questions for the social, behavioral and economic sciences. Although not the focus of this workshop, the richness of discussion lead to the framing of a Grand Challenge problem.

Sustainable development encompasses many different aspects, but the notion of a "triple bottom line" of economic impacts, social impacts, and environmental impacts suggests that sustainable development is a negotiated tradeoff among these three elements.

Understanding the Dynamics of Humanity on Earth. Humans are most influential species in the history of the planet. There are three powerful forces driving humankind today, i.e. The Triple Bottom Line (TBL): **society, the economy and the environment.** Society depends on the economy - and the economy depends on the global ecosystem, whose health represents the ultimate bottom line. Each TBL factor is shaped by complex and dynamic interactions at the interfaces of technology, a new world economy, societal latency and responsiveness, political agendas, public health, the uneven and changing application of justice and ethics, and environmental changes. These factors collide in unpredictable ways and with frequent unintended consequences. *The grand challenge is to understand the complex interaction of these factors on the human condition on the planet.*

A participant set the pace for the discussion of notion of the Grand Challenge Problem by proposing that one could fame the problem in terms of the 3 Cs: community, climate and conservation. He proposed looking at the problems societies face wit hclimate and conservation of resources from a community perspective. That is why community was posed as the first "C". Another outcome from this workshop was to put El Nino back in the climate variability box and also to put climate variability back in an even larger context. The challenge to this participant was how to get communities to develop a different underlying relationship with climate as opposed to their reactions to climate-related extreme events and other anomalous behavior of the atmosphere.

Another participant suggested that the climate be broadened to the concept of climate risk. Society needs to know better how the climate system works and interacts with human and ecological systems in order to better identify more correctly the vulnerable populations in a given society. He suggested that the real challenge was how to reduce risk through applied science and a variety of effective approaches to risk reduction.

Yet another participant suggested that a fourth “C” be added to the original suggestion --- communication. Throughout the workshop it was strongly noted in a variety of contexts that communication was ***the*** major problem with regard to issuing forecasts and with using El Nino knowledge for proactive development purposes. She noted that the lack of effective communication to, from and with the local level by those at higher political levels puts the local communities at greater risk to climate-related impacts.

The Australian participant underscored the often neglected theme of interacting as equal partners with industries. They need the knowledge of the climate community and the climate community needs their knowledge as potential users of their products. Along these lines fisheries were also proposed as a grand challenge problem. The sustained health of fish populations is subjected to many intervening variables, environmental, societal and variables intrinsic to fish population dynamics.

The addition to the workshop of the notion of a grand challenge problem in the context of climate generated interesting discussion and comment and served to challenge participants to think outside of their traditional problems areas of concern.

References

Cutter, S., 1996: Vulnerability to environmental hazards. *Progress in Human Geography*, **20**(4), 529–35.

EEA (European Environment Agency), 2001: *Late Lessons from Early Warnings: The Precautionary Principle 1896–2000.* Report No. 22. Copenhagen: On line at http://reports.eea.eu.int/environmental_issue_report_2001_22/en

Glantz, M.H. (ed.), 2001: *Once Burned, Twice Shy? Lessons Learned from the 1997–98 El Niño*. Tokyo: United Nations University.

Guayaquil Workshop, 1975: *Report on the Phenomenon Known as El Niño*. Rome: UN Food and Agriculture Organization.

Haddon, M., 2003: *The Curious Incident of the Dog in the Night-Time*. New York: Doubleday.

ISDR (International Strategy for Disaster Reduction), 1994: Yokohama Strategy and Plan of Action for a Safer World: Guidelines for Natural Disaster Prevention, Preparedness and Mitigation, Yokohama, Japan, 23–27 May 1994. www.unisdr.org/eng/about_isdr/bd-yokohama-strat-eng.htm

Kelman, I. 2003: Beyond disaster, beyond diplomacy. Chapter 7 in Pelling, Mark (ed.), *Natural Disasters and Development in a Globalizing World*, Routledge, U.K. Also see www.disasterdiplomacy.org

Kovats RS, Bouma MJ, Hajat S, Worrall E, Haines A., 2004: El Niño and health. *Lancet*, Jan 17; **363**(9404), 247-8.

Lowe, I., 2001: Australia, 27 June, "Science in the News." www.earthethics.com/Sustainability%20Science.htm

Murphy, R.C., 1954: The guano and the anchoveta fishery. Official report of the Compañia Administradora del Guano to the National Government in Lima, Peru. Reprinted in M.H. Glantz and J.D. Thompson (eds.), *Resource Management and Environmental Uncertainty: Lessons from Coastal Upwelling Fisheries.* New York: Wiley Interscience, 81–106.

Ropelewski, C.F., and M.S. Halpert, 1987: Global and regional scale precip itation patterns associated with the El Niño-Southern Oscillation. *Nature*, **356**, 476-7.

Scott, G.H. 1954. The economic theory of a common property resource: The fishery. *Journal of the Political Economy* **62**(April), 124-42.

Sears, A.F., 1895: The coastal desert of Peru. *Bulletin of the American Geographical Society*, **28**, 256–71.

Streets, D.G. and M.H. Glantz, 2000: Exploring the concept of climate surprise. *Global Environmental Change*, **10**, 97–107.

WCED (World Commission on Environment and Development), 1987: *Our Common Future*. London: Oxford University Press.

World Disasters Report, 2003: Focus on Ethics in Aid. Bloomfield, CT: Kumarian Press.

Appendix A

Shanghai Early Warning Systems (EWS) Highlights

- While warning systems look great on paper as organization charts or as input-output diagrams, they run into difficulties (bottlenecks) at various locations (nodes and arrows) in the flow of warning preparation to communication to action.
- Several honest scientific disagreements exist about what an EWS should do for a government or a society.
- One officially designated early warning system cannot meet all societal needs.
- At every stage in the early warning process, there will be ethical and equity issues that must be addressed.
- Hazards and threats can change over time not only in intensity, frequency, and in location and duration, but also in importance and interest.
- Those affected by hazards can be far removed from the disaster site and not just in the disaster zone.
- It is necessary to keep the definition of an EWS broad to allow for a wide range of interpretations and flexible to accommodate for the likely recognition of new hazards and development of new EWS technologies.
- Scenarios can help to uncover potential impacts of hazards that might otherwise have caught decision makers by surprise.
- Many early warnings knowingly and unknowingly activate other early warnings, as the time gap between a warning and the onset of a hazardous event shortens. This process can be referred to as a cascade of early warnings.
- However large or complex the formal early warning system, there exists an even larger early warning network which encompasses many more elements of society than one might realize.
- Creeping environmental changes are in need of early warning systems because the impacts of incremental but cumulative changes on society in the long run may be more costly and disruptive than the quick onset hazardous events.
- EWSs should also report on advances in hazards research, advances in the development of early warning systems, and in new technologies and techniques that can improve the effectiveness of existing EWSs.
- Each stage in the warning process from monitoring to responding must be interactive in such a way as to keep the warning timely, understood, and providing enough lead-time for responses.
- As new earlier warning technologies and techniques have been developed or new monitoring methods devised, EWSs have had the opportunity to become more effective in their spatial coverage and in the lead timing of the warning.

- Because of limited resources (human and financial) in many countries, it is important to distinguish between what is desirable for an effective EWS and what is essential.
- EWSs need to be treated as subsystems embedded and integrated into larger socioeconomic and political systems. Stakeholders need to be involved in the development of new EWSs or redesigning existing ones.
- Stakeholders can provide important insights into how warnings might best be prepared and delivered to the public, the media, and even to the governments at different levels.
- Transparency is important for building up credibility in the outputs of EWSs.
- Early warning systems for food security, for example, need to use all kinds of information as inputs, even rumors, to assure that the earliest warning possible can be made for potential food-related problems.
- The selection of indicators is very important, because monitoring will center on them. The wrong indicators can lead to wasted time, effort, and resources.
- There will be surprises with respect to hazards with regard to timing of onset, intensity, location and duration and even impact.
- Early warning system operators face a dilemma: they are often criticized for a missed or erroneous warning, but are infrequently praised for having been correct.
- The psychological aspects surrounding EWSs are more important than generally realized. The way that people view early warning systems will affect how effective the EWS might prove to be.
- Discounting the value of information has a negative effect on the many lessons identified from the impacts of previous hazards and disasters.
- While perceptions of reality may not accurately reflect reality, the actions taken based on those perceptions will have real consequences.
- The impacts of hazards need not be surprising, if the appropriate warning mechanisms are in place.
- It is essential to identify societal processes that can affect the impacts of hazards (quick onset and creeping), so that governments and individuals can better warn about and prepare for likely impacts.
- Each government has the responsibility to identify what it is that makes societies more or less vulnerable and more or less resilient.
- Early warning of hazards combined with the early warnings of underlying societal problems and processes can lead to a strengthening of resilience and a reduction in vulnerability.
- How well prepared a society is in order to be proactive in the face of early warning of a looming hazard determines how well people might respond to the hazard.

- Climate change will have impacts that add to the list of yet-unknown underlying processes that can affect hazards and societal vulnerability to them.
- It seems that EWSs are more likely to receive blame for missed or erroneous warnings than praise for successful ones. Memories of successes are short-lived and easily overshadowed by the next disaster.
- There should be multiple expressions of a warning. Foreseeability can be viewed as yet another way to express an early warning of potential harm, even if it is not used in an operational way.
- It would be useful to collect lessons of the past for evaluation by present and future EWSs. It is important to identify and then apply lessons so that the victims in previous disasters do not become victims without a legacy.
- Disasters get the lion's share of attention from the media when compared with "ordinary" adverse impacts resulting from seasonal climate variability. As far as early warnings are concerned, it is useful to talk about the "seasons of disaster."
- The seasonality of such hazards already provides policymakers with a clear warning for regions potentially at risk. However, a significant increase in global warming of the atmosphere is expected to alter the characteristics of the seasons in ways that are yet to be determined.
- Disaster priorities in a given location will likely vary over time as new hazards appear, as old forgotten hazards reappear, and as existing hazards known to inhabitants of one region appear in new unsuspecting areas.
- While the public might not understand quantitative probabilities, they do understand what it means to "take a chance" or to "take risks".
- Early warning systems have an important contribution to make by "warning" that normal conditions are likely to prevail.
- An early warning system is an important tool in a government's program to achieve sustainable development. In fact sustainable development prospects are very dependent on the effectiveness of the many early warning systems.
- Early warning systems must partner with the media in a mutually beneficial way. A key problem is that disasters are media-friendly; creeping changes are not.
- There is a need for an intermediary to act as a translator of the warning's technical contents and background to the media.
- Not every warning is meant for public consumption and may be only for the eyes and ears of specific target audiences, such as relevant government agencies.
- The early warning system must take full responsibility for the warning when it presents its messages to the public, the media and the government.
- Human capacity exists in just about every country. What is needed is a desire and a mechanism to bring people together and to support them as they enhance their existing early warning capabilities.

Appendix B

Subject: [SIV Global:] Climate is changing: what can we do?
Date: Wed, 25 Aug 2004 15:26:00 +0100
From: smallislandsvoice@sivglobal.org
Reply-To: notify@sivglobal.org
To: notify@sivglobal.org

SMALL ISLANDS VOICE

Do you live in a small island?
Tell us what you think.

****

The rising sea is eating at the shores of low-lying Funafuti, a small mound of coral and coconut palms in the remote Pacific, midway between Hawaii and Australia. Nervous islanders watch as fingers of ocean travel beneath the sands, resurfacing inland in startling places. 'It used to be puddles. Now it's like lakes' said Hilia Vavae, local meteorologist.

People were especially worried when the runway flooded. 'That's new' Margaret Bita told a visiting reporter after Sunday church services. The church and the little airport lie on the broadest part – 600 yards across – of slender, steamy 7-mile long Funafuti, home to about half the 11,000 people of Tuvalu, an impoverished nation getting by on fees from foreign fishing fleets, international aid and money sent home by Tuvaluan merchant seamen.

The main island narrows elsewhere to a mere 50 yards of sand, with swaying palms and a roadway between the lagoon and the sea. Its elevation is seldom more than a few feet. When February's high tides washed out a small causeway, children swam to school.

As recently as the 1980s, Vavae said, the peak high tides came only in January and February, now she said they crash ashore from September to May. But it is the quiet seepage from below that most alarms Tuvaluans. Because of intruding salt water, many have abandoned their gardens and crops. On the nearby islet of Vasafua, the coconut trees are dying. Another small, uninhabited island has vanished beneath the waves. 'It went underwater in the cyclone of 1997' Vavae said.

Similar events are taking place in the Marshall Islands, 1,250 miles away, and in Kiribati to the north of Tuvalu. And it is not only the low-lying atolls that are being affected. On Kosrae, a high island of volcanic peaks in the Federated States of Micronesia, the people have always lived along a flat coastal strip, but some are now dismantling their simple homes and heading for the hills as recommended by the government. People across the Pacific feel sure that something unusual is happening. 'I don't know' said a government worker in Kosrae 'but I think it is because of green something'.

Like the glass of a greenhouse, carbon dioxide, methane, nitrous oxide and other gases in the atmosphere let sunlight in but tend to warm the earth by trapping the heat inside the earth's atmosphere.
Concentrations of carbon dioxide, a by-product of fossil fuels burned

in everything from cars to electricity plants, reached record levels in the atmosphere this past winter, a Hawaii observatory reported in March 2004. This global warming is expected to change regional climates in powerful ways such as melting ice caps, intensifying storms and raising ocean levels.

The 'greenhouse effect' and climate change have languished on the world's agenda since the 1970s, a seemingly distant threat. But year by year, inch by inch, it is rising to the top – as ocean islets flood, glaciers retreat, Arctic permafrost melts, and leading voices raise new alarms. The long-stalled 1997 Kyoto Protocol, that aims to reduce the world's greenhouse gas emissions, is opposed in Washington where US government and industry object that emission controls would handicap the US economy. Meanwhile signs of global warming mount.

And Pacific islanders aren't alone. Rising seas are a growing threat from Alaska, where Eskimos are relocating a coastal village further inland, to New Orleans in the USA and Shanghai in China – coastal cities already below sea level, sinking on their own and further endangered by expanding oceans.

Back in Tuvalu, devoutly Christian since missionary days, many talk not of greenhouses, but of Genesis, reminding each other of God's promise to Noah: As long as rainbows cross the sky there will be no more great floods. 'God will protect us' one woman churchgoer assured a visitor. Saufatu Sopoanga, as Tuvalu's prime minister, must look into the future, not the Bible. He is talking to New Zealand about a kind of 21st century Noah's Ark – a standby plan for a mass migration there. 'In 50 or 100 years, the islands are expected to go under water. What can we do?' Tuvalu's leader asked, on a day when a tropical morning downpour soon gave way to a rainbow in a blue, very warm sky.

Adapted from 'Mercury and tides climb, as climate change rises on global agenda' by Charles J. Hanley in San Juan Star newspaper, Puerto Rico, Caribbean, 23 May 2004

Title: Climate is changing: what can we do?
Author: Charles J. Hanley
Date: Wednesday, 25 August 2004