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DISASTER VULNERABILITY AND SUSTAINABLE DEVELOPMENT:
A GENERAL FRAMEWORK FOR ASSESSING VULNERABILITY

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I. Introduction

Vulnerability has to do with future jeopardy and potential harm. To be vulnerable is to exist with a likelihood that some kind of crisis event may occur that will cause damage to one's health, life or the property and resources on which health and life depend.

Everyone is, to some degree, vulnerable. Any of us can suffer a catastrophic personal loss that affects our health, life or property. We all could be affected by a nuclear accident that spills across geographical borders or by depletion of essential resources, such as the ozone layer, on which we depend. Many people live in zones that are subject to natural hazards such as earthquakes, wind storms or floods and, increasingly, even remote disasters resulting from these natural phenomena affect those of us who live at a distance through their adverse impacts on the environment, world resources and markets.

Vulnerability is the subject of this paper. Over recent years, even as progress has been made in understanding nature and controlling some of its negative effects, vulnerability appears to be rising. The numbers of disasters have risen, and the numbers of people affected and the value of property destroyed have also

increased.¹ The inauguration of the International Decade for Natural Disaster Reduction (IDNDR) reflects world concern with the suffering and setbacks thus experienced. In its opening session in late 1991, the Special High-Level Council of the IDNDR noted that "reducing vulnerability to natural disasters is a major goal requiring concerted and coordinated efforts of government, UN-system organizations, the world's scientific and technical community, volunteer organizations, schools and educational institutions, the private sector, the media and individuals at risk. Vulnerability assessment...(is) essential."² The Council thus alerted the international community to the fact that, if we are ever to be able to control and limit damage from disasters, we must be able to identify and assess vulnerabilities in different places and times in order to design timely, affordable and effective strategies for reducing negative disaster impacts.

Though essential, assessment of vulnerability has proven complex. As we have gained more and more experience responding to disasters, our understanding of vulnerability has improved. But, we also have been forced to recognize its complexity and to acknowledge that numerous interconnected, mutually reinforcing and dynamic factors are involved. In addition, disagreement about which factors are most important has emerged. Different disciplines have developed indices of vulnerability that incorporate the factors of primary concern within their own fields but overlook or omit factors which other disciplines consider essential for full understanding.

In the pages that follow in Section II below, we shall review the way in which our understanding of vulnerability has shifted and enlarged over time. In Section III, we turn to the interrelationships between economic development efforts of the past, trends in vulnerability, and the current concern with defining and achieving sustainable development. In Section IV, we outline five critical characteristics of vulnerability which emerge from the reviews of the preceding sections and, finally, in Section V we present a framework for vulnerability assessment which reflects the characteristics, factors and relationships discussed previously. The purpose of this effort is to suggest a comprehensive, yet usable, framework for understanding vulnerability that can be used by communities to assess their own risk and to decide on which courses of action to take to reduce their vulnerability, by planners of disaster mitigation and prevention efforts, by educators to improve the public's understanding of disaster proneness and prevention, and by governmental and international bodies to discuss and agree on joint responsibilities and cooperative efforts to reduce vulnerability.

Before we begin, however, it is important that we specify something more about the vulnerability we are attempting to assess. We noted above that everyone is in some ways and to some degree vulnerable. The purpose of assessing vulnerability is to be able to decide upon appropriate actions to reduce it before the potential for damage has become actual. We are, however, interested in understanding more than the simple vulnerability each of us

faces as a part of living. What we are interested in is recognizing and responding to levels of vulnerability where the potential for damage to health, life and/or resources and property is significant--i.e. where it is so large that losses cannot be handled by those who experience them but, rather, that outside assistance is needed to help them sustain life and health and to recover resources and property. We are interested in vulnerability that threatens to put people "over the edge" of self-sufficiency where they become dependent, at least for a while, on outside support. This is, in fact, the working definition of a "disaster," namely a crisis event that surpasses the ability of an individual, community or society to control or survive the consequences.³ We are, then, interested in developing a framework to aid in assessing disaster vulnerability in this sense.

II. An Historical Overview: How Understanding of Vulnerability Has Shifted and Enlarged

There is a large and growing literature on disaster vulnerability and how to assess it. Others have reviewed this literature in useful and interesting ways.⁴ For our purposes here, we shall not repeat their work but, instead, will group the vulnerability literature into three categories which also, to some extent, reflect progress toward the emergence over time of a fuller and more realistic understanding of the concept.

II.1. Nature as Cause: Scientists, Technologists and Engineers Respond

Early disaster studies identified natural hazards as the cause of vulnerability. People who lived in zones of seismic activity,

along coastlines subject to typhoons or tsunamis, on slopes of active volcanoes, in areas prone to extensive drought or flood were, by the fact that they lived in these areas, vulnerable. Where the frequency or magnitude of the hazards was greater, vulnerability was greater. Where such events were infrequent, vulnerability was considered low. By avoiding living or working in these areas, humans could, it was thought, avoid vulnerability. The 1979 working understanding of the Office of the United Nations Disaster Relief Coordinator (UNDRO) that vulnerability represented the relationship between Hazards (natural events, including their strength, magnitude and duration) and Risk (exposure to the events, measured essentially in terms of proximity) reflects this definition.⁵

With this understanding of vulnerability, scientists, technologists and engineers have undertaken efforts to predict natural hazard events and to develop technologies that will enable human structures and systems to withstand their impacts. The assumption has been that such events, as "acts of nature," cannot be prevented. However, vulnerability could be reduced, these researchers believe, if we could more accurately predict where and when and in what magnitude these events will occur and if we could, also, develop adequate controlling technologies to mitigate their negative effects.

The efforts of this group of disaster vulnerability researchers have had significant success over time. Building construction technologies and materials have been developed that can withstand strong winds, storms, flames and seismic activity. Water control

systems have greatly reduced seasonal damage from flooding in many areas, and some communities have invested in elaborate and expensive control systems to limit damage from even the rare and unusual 50 year or 100 year crises.⁶ Systems for predicting and tracking storms which originate at sea have greatly improved so that, in most parts of the world, residents of coastal regions now have hours (or even days) of warning to prepare their property and to evacuate for personal safety. Technologies for mapping hazard-proneness, down to small specific micro-zones, provide precise scientific assessments of the likelihood of disaster vulnerability that can be used by local communities to decide whether and how to respond to reduce their risks.⁷

II.2. Costs as "Cause": Economists Assess How Much Vulnerability Reduction Is Rational

In spite of the many gains in the scientific and technological capacity to limit vulnerability to natural hazards, people continue to be injured and die, and property and resources continue to be destroyed in disasters every year. One reason for this is that many of the prediction and mitigation technologies are costly, and individuals and communities are unwilling or unable to afford them. A second body of literature about disaster vulnerability and mitigation focuses on these costs and attempts to develop economically rational criteria for deciding which vulnerability reduction technologies should be used under what circumstances.

These researchers note that while vulnerability has its costs in terms of losses of life, health and property, it is also true

that vulnerability reduction entails costs as well. If the elimination of vulnerability were "free," then societies would reduce all risks to zero. However, when faced with the actual (often high) costs of the vulnerability reducing technologies, individuals and societies must make rational choices between buying these technologies or buying something else instead. The fact that hazards are largely "unpredictable," makes this calculus all the more important and difficult. The choice is whether to invest today to prevent some future, uncertain event or to invest today to produce some certain, needed good.

Economists have developed increasingly sophisticated systems for assessing the value of vulnerability reduction over time. Systems for measuring the cost/benefit ratios of utilization of the various available technologies for vulnerability reduction have developed to include recognition of indirect and secondary costs as well as the direct costs involved in immediate losses.⁸ Probability theory has been merged with economic calculations to arrive at appropriate discount rates for comparing current foregone consumption and future reduced losses. Increasingly, researchers are improving their methods for data collection regarding losses to disasters and their models for incorporating recognition of external and resource-loss costs into their calculations of whether, when, how and where vulnerability reduction is "worth it."

Each of these cost measurement techniques requires for its own accuracy, however, an accurate assessment of vulnerability--i.e. one must be able to know with the highest possible degree of

certainty exactly what vulnerability entails in order to be able to put an accurate "price" on preventing it. If one cannot know this, then pricing has to reflect uncertainty, itself--a much less satisfactory solution to the problem of economic choice. Thus, as economists have contributed to the vulnerability assessment literature, they have recognized that the understanding of vulnerability must be expanded to incorporate an increasing number of variables.

II.3. Humans as Cause: Social Scientists, Policy Reformers, Advocates for the Poor and Environmentalists Enter the Scene⁹

Even as the technological/engineering and economic/accounting approaches to assessing and dealing with vulnerability have been developing, others who are concerned with disaster impacts have criticized these two approaches as too narrow. The critics observe that disasters have differential impacts on peoples who live in hazard-prone areas. They note that vulnerability to loss of life, health and property varies widely among people who experience the same disaster and among people who experience disasters of the same size and scope at different times and in different parts of the world. They conclude that more than just hazard and exposure must be considered in any accurate vulnerability assessment.

Considering the economists' approaches to establishing rational criteria for deciding on vulnerability reduction, these critics also note that different people appraise the danger of hazards differently. Because people acknowledge and interpret their vulnerability--even though they experience the same exposure

to the same hazard--differently, they make different decisions about how much vulnerability reduction is worth to them. That is, the "benefits" side of the cost/benefit ratio varies widely according to factors that go beyond simply avoiding the measurable losses that are captured in the hazard/exposure definition of vulnerability. Thus, this group of critics sees that the price that people are willing to pay, or not willing to pay, to reduce vulnerability to uncertain events incorporates many additional (and some not readily quantifiable) factors.¹⁰

With the growing awareness of the complexity of factors that affect vulnerability assessment came also an awareness of the human role in creating vulnerability. Whereas previous assessments focussed on the "acts of nature" that come from outside human agency, later assessments have acknowledged that it is largely human actions, decisions and choices that result in people's vulnerability to natural events. Choices about where to live (or, in some cases, the lack of any choice due to political, economic or social position); decisions about where to locate a chemical plant; and acts of cutting forests, farming marginal lands or evading building codes are examples of how humans cause a "natural" hazard to become a disaster. Humans make themselves--or, quite often, others--vulnerable.

The third category of literature on vulnerability assessment, therefore, includes the criticisms and expanded definitions of the social scientists, policy reformers, advocates for the poor, environmentalists and others who, having identified the differen-

tial character of vulnerability and the central role of humans in creating vulnerability, have gone on to incorporate many additional variables into their definitions of vulnerability. Included are economic poverty, social and political marginalization, lack of options as well as lack of resources, and other social, political and economic indicators that, in any given setting, cause people to live in circumstances which put them at high risk from any natural, market, political, social or other perturbation.

It is now widely recognized, then, that people are in positions of vulnerability to a natural event not because of proximity per se, but because of proximity coupled with low economic or social status. For example, poor people often live in weaker houses on less desirable and less stable lands, have fewer income or resource reserves and are less healthy than people who are better off. People who are socially or politically marginalized usually have restricted employment opportunities, low access to education, or generally few options that would enable them to withstand or recover from a disaster. The co-incidence of high death and injury rates in disasters with low national income levels reveals how poverty at the national level also makes some nations more vulnerable to disasters than others. It follows that when personal, community or national wealth is inadequate even for basic, daily security, few investments are made in the technologies that can help ensure survival in the face of a hazard event.

However, having acknowledged the important relationship of poverty to vulnerability, it is also apparent that poverty is not

a sufficient proxy for vulnerability. One need only consider the upper-class homes built on the hills of California or on the shores of the eastern seaboard in the U.S. to know that it is not only the poor who reside in risky, hazard-prone places; nor is it only they who lose their homes or lives when hazards strike.

Vulnerability assessment requires far more contextual analysis of complex and multi-faceted factors that cause people to make the decisions and choices and to undertake the actions that increase vulnerability. Increasingly we see that the factors influencing human choices and actions arise from socio-political systems, reflect people's status and position within their economies and societies, and are shaped by habits and expectations related to past experience.

The third body of vulnerability investigation, while complicating the analysis immensely, has made two very important contributions to our understanding of vulnerability that must be noted. First, by lodging responsibility for vulnerability squarely inside human systems, it has removed any justification for the claims that disasters are either unpredictable or unpreventable. While acknowledging that the exact time, place or magnitude of an earthquake (for example) cannot be foretold, this group of writers notes that nonetheless, current scientific knowledge can and has identified zones of seismic activity and this, coupled with awareness of the social and economic factors that cause human habitats to be vulnerable to earthquakes, allows us to predict with

a high degree of certainty where, when seismic activity occurs, disasters will be the result.

Second, this group has noted that, if human agency is involved in creating or increasing vulnerability, then humans can also make different choices which prevent (or reduce) vulnerability. We can decide not to do the things that increase vulnerability and to do things that reduce it. We can not overgraze the lands we now deplete, we can not denude hillsides of their forests, we can not build properties that are below code for predictable wind/earth force, etc. To reverse past risk-increasing mistakes, we can replant unstable hillsides, we can retro-fit old buildings, we can relocate chemical industries to zones of relative safety. While, in the extremes, certain disasters will remain unpredictable and unpreventable, the growing awareness of human responsibility for vulnerability opens up a vast range of choices and actions that can be undertaken for vulnerability reduction.

How, then, does this recognition help us move toward a useful and usable framework for assessing vulnerability? To answer this, we shall next examine in some detail the ways in which vulnerability has risen because of past human actions and the way in which this history influences the future choices to be made.

III. Past Economic Development, Increasing Disaster Vulnerability and Future Sustainable Development

Given the strong linkage described above between poverty and vulnerability, we might assume that economic development is one central strategy for reducing vulnerability. The historical

record, however, presents mixed evidence about this relationship. The processes by which human societies have pursued economic security and wealth have, very often, resulted in increasing vulnerability both for those who have gained and for others as well. Recognition of the negative relationship between development and vulnerability, especially as it is mediated through the environment, has produced a strong and growing concern with defining and pursuing "sustainable" development, i.e. development which meets the needs of the present without compromising the ability of future generations to meet their own needs.¹¹

To plan and work for sustainable development, however, we have to know what has gone wrong in past development efforts. Why have these efforts to improve welfare also, ipso facto, resulted in increasing the vulnerability of large numbers of people?

III.1. Trends Associated with Development that Have Increased Vulnerability

We can identify ten distinct, though related, trends that are associated with the progress of economic development that have led also to increasing vulnerability. Many of these are by now familiar and well-documented. It is not necessary for us to prove, here, that these trends have occurred since others have done so. Rather, this list of development/vulnerability trends serves to focus attention on the realities with which we must deal in future development approaches if we are to reduce vulnerability and achieve sustainable development. The ten trends include:

1. Increasing Resource Transformation

Underlying the dominant development paradigm of Europe and North America in the nineteenth and twentieth centuries (and adopted by many of the counties of the East and South) has been the belief, articulated by Sir Frances Bacon, that nature is to be "understood" in order to be "controlled" and "dominated" by mankind. The possibility for humans to transform natural resources into things which provide increasing levels of security and comfort has provoked immense ingenuity and inventiveness on the part of many people. The outcomes have been impressive, and large numbers of people live healthier and more secure lives as a result of these efforts.

By the late twentieth century, however, we are all aware of the limitations of natural resources and the negative consequences both for the present and the future of their depletion through overuse. Even so, the trends of resource use are up, and the rates of usage are rising.

As non-renewable resources are consumed, three types of vulnerability increase. First, human societies face the possibility of scarcities in the things now considered necessary for the good life and of many things that truly are essential for any life (such as food). Second, as some societies exert their power over remaining limited resources, others suffer shortages and, thus become increasingly vulnerable. This may, in turn, produce political challenges that increase the vulnerability of even those who still have control over scarce resources. And third, the loss

of some resources poses environmental consequences for all of us. For example, depletion of forests has been linked to loss of ozone, possible global warming and rising sea levels with resultant loss of productive land and reduction in food availability, and increasing health dangers. There are many other examples of resources, the loss of which would increase the threat to us all, including nonrenewable energy sources and certain plant and animal species.

Furthermore, production techniques and the good life associated with economic development of the past have resulted in the destruction of "naturally occurring [disaster] mitigation elements in the ecosystems."¹² For example, ocean reefs absorbed wave energy from sea storms and mangrove stands protected coastal lands from winds and waves. Unrecognized as natural preventers of disasters, these have often been destroyed, leaving areas vulnerable now where no vulnerability existed before.

Thus the rates of resource use associated with vast economic progress, as these continue and rise, contribute also to increasing vulnerability.

2. Effluent Production

Production techniques associated with resource use have also resulted in increasingly dangerous levels of effluents being released into the air, waters and soils on which present and future production and welfare depend. The so-called "free" goods of air and water turn out not to be free at all as our levels of effluent production outstrip the capacity of nature to cleanse itself and

replenish its freshness. And, as is true for the use of resources, the rates of effluent production are, for the most part, also rising.¹³

Immediate vulnerability from effluents arises from impacts on the health of humans, animals and plants. Future vulnerability involves also the inability to produce needed things that rely on the resources destroyed through poisons, such as cultivable land or water which are necessary to sustain life.

3. Production of Dangerous Substances/Invention of Dangerous Techniques

Economic development has involved the production of substances and the invention of techniques that both serve human ends and, at the same time, present new dangers. For example, central to develop progress has been the production and usage of a variety of chemicals and chemical processes. The manufacture of these uses some resources and produces waste materials as noted above, but in addition, the substances themselves pose direct dangers to health. Chemical fires, explosions or leakages represent new hazards to which humans are vulnerable. Similarly, gas storage tanks, nuclear reactors, large dam systems and other technologies of modern industrial societies, while contributing to growing wealth, also represent new and immediate hazards. When threatened by the natural hazards of storms and earthquakes, their very existence raises the threat of dangers beyond those produced by the natural events themselves.

4. Growing Population

As development has resulted in improved public health, cleaner water (up to a point), discovery of vaccines, creation of health care systems and technologies, it has resulted in improved life-expectancy and higher fertility for both humans and animals. These gains represent a reduction in vulnerability in the immediate sense.

Yet, an outcome of the cumulative impact of these gains is an increase in population that brings with it increasing demand on the scarce and depleting resource base, adds to the wastes that are returned to the environment, and forces the overuse of land, water and energy. Increasing animal herds have resulted in expanding desertification in some regions with concomitant lowering of the water table and rising drought-proneness. Expanding human and animal populations sometimes increase tensions and the potential for political conflict, another source of human vulnerability.

5. Encouragement to Use Marginal Lands

Improvements in scientific capacity and technological developments, coupled with growing populations, have encouraged societies to move into and rely on lands that, previously, were considered unsafe or unproductive. For example, flood plains have been made "safe" with dams, ditches and dikes or hillsides "stabilized" with reinforcement technologies and, therefore, developed as lands for agriculture, industry and habitation.

As marginal lands are increasingly relied upon for human use, however, the margin of safety of life and production in these areas

is inevitably low. That is, people now are encouraged, by developmental progress, to live in areas which are inevitably more prone to hazards than other lands. The damage caused by the extensive and disastrous flooding in the Midwest of the United States in the summer of 1993 was, to a very large extent, the result of people's decisions to live and work in zones which would never have been settled had "development" not brought the series of technologies that made these areas appear to be safe. With a false sense of security, many people experienced increased vulnerability. In areas where population pressures are also great, this trend toward settlement of un-safe areas--with the aid of technologies associated with development--proceeds apace.

6. Urbanization

Trends toward urbanization have always been associated with economic and social development. Much progress has occurred, in science, industry, the arts and politics, as a result of this trend. Developments of science and technology have also made it possible for more and more people to live in cities. Increases in agricultural productivity enable more people to live off the food grown by fewer people. Communication, transport, sewage, electricity and other complex systems, as well as highly advanced building techniques, enable people to live under conditions of population density which were previously impossible. Population pressures and depletion of rural resources encourage more and more people to move to urban centers in search of employment, security and life styles associated with modernity.

As cities¹⁴ become mega-cities, with populations over 20 million people, however, they become highly vulnerable to any of a number of hazards and failures. These include those that arise from inadequate available resources to sustain the number of people and over-production of harmful wastes that cannot be absorbed in the given space, with resultant potential for hunger and disease. They also include hazards from accidents such as explosions of fuel stocks (located for convenience near the population that needs them), leakages of chemical and other toxic wastes used in industrial production, or fire. Systems failures and break-downs can also bring extraordinary dangers. When vast numbers of people are linked through telecommunications systems on which they depend for their work, health or information, a loss of such a system can threaten survival. Urban dwellers are vulnerable to a whole new set of hazards that accompany the very processes that make city-life attractive and possible. This vulnerability seems to rise in correlation to the numbers of people accommodated within fixed geographic space.

Three of the ten trends that are associated with economic and social development are trends in attitudes. These represent changes in the ways that people think, and they exacerbate the vulnerabilities we have just discussed. They are:

7. Rising Expectations

Worldwide, aspirants to development identify it with increasing access to consumer goods. The Western model of consumer-oriented economics has come to be, by the vast majority of people, synonymous with "development." So long as no alternative model of development is equally compelling and appealing, the rising expectations among those who are now poor put strong pressure on all of the above trends.

8. Everything Can be Done/All Problems Solved

Historically, progress in achieving economic surplus through the Industrial Revolution in Western Europe and North America was linked to (and, in part an outcome of) the Scientific Revolution which had occurred one century earlier. The way of knowing of the Scientific Revolution--empirical, pragmatic, experimental--drove and reinforced the technological discoveries on which abundance was gained. Steady apparent progress was made in the economic sphere by drawing on the expanding knowledge available from science and technology for three consecutive centuries.

With the experience of such apparent success, people came to believe that all problems that have to do with the material of science--specifically, nature and matter--are solvable. All that is necessary is further scientific/technological discovery. Every problem is viewed as a challenge or a frontier to be conquered, as all the past ones have been, by the application of increasing knowledge.

In fact, as we come to the twenty-first century, more and more problems are not susceptible to the scientific solutions we have come to expect. We can, indeed, analyze and understand some of the new problems we face--such as depletion of non-renewable resources--but the easy discovery of ways to re-produce these resources, or of alternatives that can substitute for what has been lost, eludes us. Believing that such solutions are "out there" and with sufficient effort they can be found has, however, seduced human societies into pursuing costly, irreversible patterns of resource use and effluent production. Unless solutions are found, these patterns, as we know, increase vulnerability on a broad scale.¹

9. Rationality through Pricing

Concomitant with the attitude that all problems can be solved, another attitude--that rationing of scarce resources can be rationally handled through the pricing mechanism of the free market system--has also been widely accepted through the experience of the past two to three centuries. This belief supports the view that, even though we cannot always replace over-used resources, we can apply a price to their use which accurately reflects not only their use but also the loss of their future availability. Thus, even though it is a fact of life that some things get used up, we can make rational (hence, good) decisions about when, how and where to

¹ In fact, we believe that solutions do exist, but they are not to be sought only in the scientific or technological spheres. Solutions will come, if they come at all and in time to reverse vulnerability, also from the spheres of social science--politics, communication, education, negotiation--that support effective decision-making and policy reform.

use them, that safeguard us from wasting, or in a fundamental sense, misusing scarce resources.

Increasingly, this belief is under attack. Many now note that systems of pricing and application of discount rates do not adequately incorporate the loss of resources. Criticisms center on the impossibility of putting a reasonable price on irreversible losses, on the fact that future generations are not present to negotiate the price that they pay for current misuse of resources, and on the fact that, even in the present, those who pay for resource mis-use are often not those who benefit from its use.¹⁵

So long as decision-makers can appeal to the idea that all things can be accurately priced as a way of making rational choices among alternatives, however, the pace of resource usage and of effluent discharges will not fundamentally alter. Thus, this attitude reinforces the other trends that are now leading to increasing disaster vulnerability.

Finally, a tenth trend and an attendant coda to all the trends remain to be discussed.

10. The Gap between Rich and Poor

Worldwide, and within countries as well, a significant gap between those who are well off and those who remain (or are becoming) poor persists. Previously it was believed that development would inevitably produce an enlarged middle class and that gains at the top would "trickle down" finally benefitting everyone,

so that the rich-poor gap would be reduced. This did, in fact, occur in some places over some decades. However, not only do we now see the income/welfare gap persisting, there appears even to be a trend toward a widening of the gap as an adjunct to the patterns of development currently being pursued.

For example, consumption of resources is extremely unevenly distributed across the world. While the 16 percent of the world's population that lives in India has less than two percent of the world's income, the fewer than 5 percent of the world's population that lives in the USA has about 36 percent of the income. Almost one billion people or almost one-fifth of all humans live in absolute poverty and hunger today.¹⁶

Given the trends noted above of resource depletion, environmental degradation, population growth with more humans concentrated into less space in cities, the tendency is for the gap between rich and poor to grow and for the absolute numbers of those who are counted among the poor to grow. Vulnerability for some people is increasing and, because more people are vulnerable, their vulnerability will have greater worldwide impacts. These may show up in the form of costs of humanitarian assistance to those who are unable to sustain their own lives or in the form of social/political tensions erupting in localized violence or expanding conflicts.

Coda:

Attendant to the trends toward increasing vulnerability that have arisen from and been furthered by the very processes of development is another tendency related to people's capacities to

recover from crises. This is: even as people have moved from their traditional life patterns toward modern life-styles, through which they have been exposed to new and greater hazards, they have at the same time left behind a number of the social, familial, economic production and moral/ethical structures and modes which helped them cope with crises in the past. Their exposure to hazard has been increased and their capacity for resistance and recovery has been eroded by the processes of development which they have sought and continue to pursue.

If these ten trends and one coda toward increasing vulnerability have accompanied the very processes of development--previously viewed by human societies as central to any strategy for reducing vulnerability--then what does this tell us about assessing vulnerability? And how does this relate to current efforts to find a new approach to development which corrects these trends and is sustainable over the long run?

III.2. Vulnerability Assessment and Sustainable Development

Recognition of the trends discussed above has prompted the current focus of attention on sustainable development. In particular, growing awareness of the negative and irreversible impacts of past development gains on the world's ecosystems has raised the specter of spiraling and expanding vulnerability that can neither be controlled nor contained. As a recent publication of the World Bank put it, "...accelerated changes in demographic and economic trends have disturbed the balance between ecosystems, increasing the risk of human suffering, death and destruction."¹⁷

The report goes on to note that not only have the number of disasters risen over recent decades (i.e. events with negative consequences on humans), but even more striking is the fact that the number of extreme weather events (whether or not they have had an impact on human societies) has also been rising by "about 50 percent on average each decade between 1900 and 1990, accelerating significantly since 1950."¹⁸

The evidence of perturbations in the environment and ecosystems is strong. While debates continue within the scientific community regarding the actual changes that have occurred or are occurring in nature, most who study these issues agree that human-caused environmental degradation probably has had significant long-term impacts. As the leadership of the Scientific and Technical Committee of the IDNDR notes, "...the increasingly realistic mathematical models of global climate tend to suggest a more hazardous world in the future."¹⁹ And, the point is widely (universally?) accepted that sustainable development strategies must directly address the ways in which economic progress affects vulnerability.

Important, also, of course, are the effects of vulnerability on economic progress and, particularly, on the sustainability of that progress. One point of interaction has been discussed above. We have seen that human actions have undermined and continue to undermine the environment. Significant among these damaging actions are those undertaken by vulnerable populations who see no options for survival except to continue their (harmful to the

environment) practices. Patterns of marginal living--in agriculture, in herding, in fishing, in forestry, i.e. in that range of human activities undertaken to derive a livelihood directly from nature--often "use up" the resources on which survival depends. This is increasingly true as population pressures mount.

Two additional points about the impact of vulnerability on the prospects for sustainable development should be made. Cumulatively, environmental degradation has produced a group of environmental refugees who comprise "...the single largest class of displaced persons in the world."²⁰ These trends are "likely to worsen over the next few decades" and will, themselves, add to the pressures on the environment of the regions to which they flee and undermine chances of achieving sustainable development in those regions. Finally, current government-sponsored development efforts in many countries reinforce the tendencies toward future environmental depletion in an attempt to meet citizens' immediate needs for food, jobs, housing sites, etc. Short-term strategies undertaken in the name of "development" contribute to long-term hazards and reinforce the negative impact of vulnerability on prospects for sustainable development.

However, as it is true that high and increasing vulnerability undermines the pursuit of sustainable economic strategies, reduction of vulnerability and progress in sustainable development are also mutually reinforcing. The linkage of the two may work either positively or negatively. Sustainable development is not possible without an explicit component of vulnerability reduction

and vulnerability will never truly be reduced until approaches to development are altered to meet the sustainability criteria now under discussion.

IV. The Characteristics of Vulnerability

Above, we have reviewed the growing understanding of disaster vulnerability gained through decades of experience with disaster response, and we have discussed and identified the ways in which efforts to improve human life through development have been linked with trends toward increasing vulnerability. We have, further, noted the interaction and mutual reinforcement of vulnerability reduction and sustainable development. With this background, we can identify five characteristics of vulnerability that must be understood and reflected in any vulnerability assessment framework. These characteristics are at the heart of the past development/increasing vulnerability/future sustainable development nexus. Specifically, vulnerability is:

1. Complex. It is not necessary to reiterate the myriad of factors that together constitute and shape vulnerability. We have referred to these above. However, the starting point for assessing vulnerability must be the acknowledgment that it is complex and affected by multiple factors. While always complex, however, vulnerability will be shaped by different factors in different settings. That is, vulnerability is location/group/circumstance specific.

2. Dynamic. Because vulnerability is the product of interactions between natural and environmental forces and human, social

and political constructs, and because these are always changing in and of themselves and forcing corresponding changes through their interrelatedness, it is never static. Vulnerability assessments must, therefore, contain some system for noting and recording the direction and magnitude of change that is occurring.

3. Compounding/Cumulative. Vulnerability is a self-compounding and cumulative phenomenon. Quite often, when people are vulnerable to and experience one disaster, they are left more vulnerable to subsequent hazards. If their resources are destroyed, if the assistance they receive promotes dependency²¹, if their families or other social systems are undermined, they have less resilience for facing future hazards. (Of course, the reverse is to be hoped for by disaster educators. That is, if people suffer once from their vulnerability, it is hoped that they will be motivated to undertake hazard preparedness and mitigation efforts that will reduce their future vulnerability. Too often, however, especially among poor and marginalized groups, what actually happens is that vulnerability accumulates and compounds.)

In addition to the undermining of economic reserves and of personal confidence that one disaster can bring, vulnerability is additionally self-compounding in that one type of vulnerability--such as poverty--is often related to other types--such as poor health or lack of education. In this sense, too, people who are vulnerable in one aspect of their lives tend toward vulnerability in others.

4. Sometimes Irreversible. As depletion or extinction of the elements in the natural resource base lie at the heart of current vulnerabilities, sometimes these losses pose all the more serious threats because they are irreversible. That is, as resource usage or effluent production approaches irreversibility in nature, vulnerability from these causes increases.²²

5. Frequently Borderless/Non-containable. Increasingly, also, environmentally-based hazards (and vulnerability to them) are without borders or containment. Loss of the ozone layer, nuclear exposure due to accident, chemical poisoning, etc. move with the winds and waters and atmosphere, so that the exposure to them (and resultant vulnerability) is separated from causation and is random and encompassing rather than controlled and limited.

It remains, now, to join these five characteristics of vulnerability to previously developed aspects of vulnerability assessment in a framework that can be used by communities and nations to enable them to analyze the sources of their vulnerability, to assess its seriousness and to devise appropriate programmatic responses to reduce or eliminate it.

V. A Vulnerability Assessment Framework

A vulnerability assessment framework must be simple enough to be useful but complex enough to capture reality. No framework can supplant thought or substitute for intelligence. As a tool, a framework can provide a schema for 1) ensuring that all factors, considered critical for understanding, are included in an assessment and 2) "picturing" (and, thus, reminding us of the importance

of) the relationships among these factors. It cannot, itself, make judgments or structure actions to be undertaken. It can be used, by skilled, knowledgeable and thoughtful people, to help them do so.

Our framework has four steps. There is nothing surprising about these as they reflect precisely the learning which has been catalogued above. They are:

Step I: What? Identifying Hazards

The contributions of science and technology which provide information about the likelihood or probability of the occurrence, magnitude, frequency, scope and duration of hazards should be incorporated into this step. However, two categories of hazard must be considered. In addition to the so-called "natural" hazards of wind, water, earth and fire, technical and systems-based hazards must also be included. These include: fuel, chemical and nuclear accidents; breakdowns and disruptions in information, communication and transport systems on which societies depend; and other dangerous perturbations that grow out of the production and distribution techniques of human societies.

This step can be pictured in a simple matrix shown below.

WHAT?	Probability	Magnitude	Frequency	Scope	Duration
Natural Hazards					
Human Systems Based Hazards					

Step II: Who? Identifying Exposure

Following the early vulnerability assessments, we acknowledge the importance of identifying the individuals/groups/communities that are most "exposed" to any given hazard. This aspect of the assessment must take into account more than mere proximity, however. It must include any of the physical, geographical, economic, social, political, or psychological factors that cause some people to be more exposed to the dangers of any given hazard while others are, because of any of these factors, relatively "protected." In some cases, because of the inter-connectedness of societies through environment, markets, and political systems, exposure will be comprehensive and borderless as we noted above. On the other hand, even though everyone has the potential to suffer from a borderless hazard, factors of wealth, reserve resources, options and the like will mean that there is an identifiable

differential risk for different groups. This step should consider all of these factors.

The matrix below depicts this step.

WHO? Individual <-----> Community <-----> World		
Factors:	Exposure	Capacities to Withstand
Proximity Economic class Social status Political status Psychological condition		

Step III: Why? Identifying the Complex Sources of the Hazard

This step incorporates the complexity and inter-relatedness of natural/social/developmental factors discussed above. Essential to assessing impacts of hazards--to getting a complete picture of vulnerability--is an analysis of why it is that a particular hazard exists, why it is that certain groups are more exposed to this hazard than other groups, and whose actions, choices or decisions have been involved in creating this hazard and why. Vulnerability will be greater when answers to these questions show that the causes of hazards are deeply embedded in social/political or economic structures that are difficult to alter or reverse; when exposure to the hazard arises from deep-seated social and political structures for which we have no ready remedies; or when the decision-makers and action-takers who help "create" the hazard are powerful, removed from its consequences and have little motivation

to change their behavior or when they are powerless, poor and have few options other than to contribute to and exacerbate the hazard.

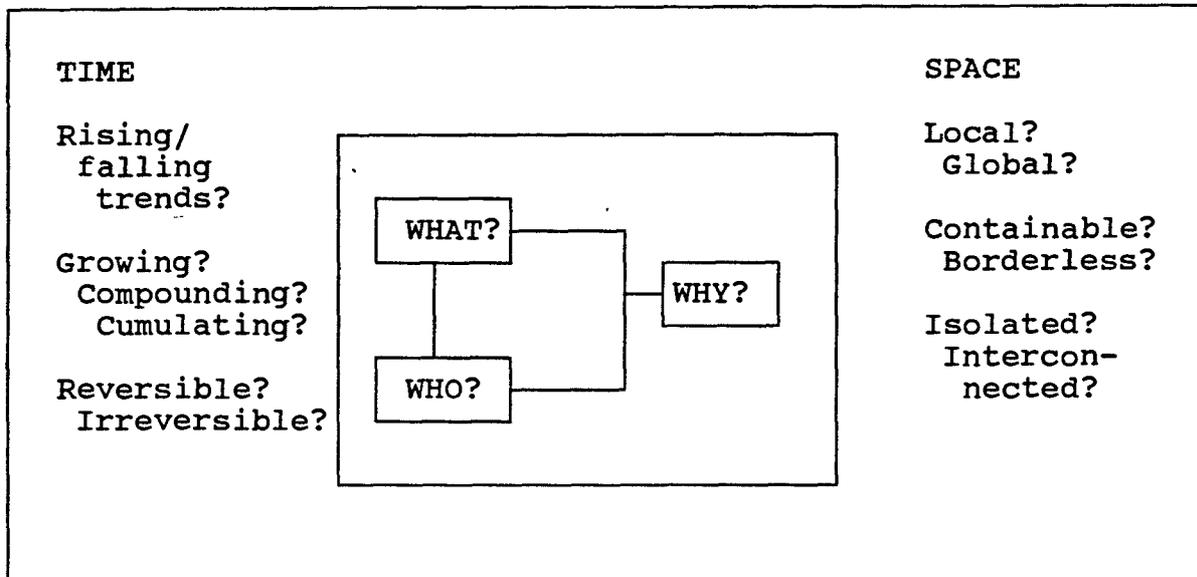
The diagram below depicts the major factors to be considered.

WHY? (Why this hazard?? Why this group exposed??)				
(1)	(2)	(3)	(4)	(5)
History: What happened to make vulnerability high?	Who was involved in the decisions and choices?	What are their characteristics? economic? social? political? psychological?	Who is most affected by the decisions and choices?	What are their characteristics? economic? social? political? psychological?

Step IV: Time and Space Dimensions

Finally, the fourth step of vulnerability assessment takes account of the dynamic change and interrelatedness of factors that affect vulnerability. Included here are considerations of trends over time (increasing or decreasing? simple growth or compounding, cumulative growth? reversible or irreversible?) and over space (local or global? containable or borderless? isolated or interconnected?). It is clear that vulnerabilities that are growing, cumulating, tending toward irreversibility and expanding through their interconnectedness without being containable within borders pose far more serious problems and demand more immediate attention than those that exhibit the opposite characteristics. Assessment of vulnerability is incomplete without this step.

The fact that this step sets the broad context for the other three steps is illustrated in the diagram below.



As successive steps of the assessment framework incorporate the more immeasurable factors that require judgments based on values and the weighing of competing social/political/economic "goods," some people may become increasingly uncomfortable with the tool. Nonetheless, we would argue that the evidence of the importance of all of these factors is compelling. Their incorporation is neither utopian nor frivolous. They are essential aspects of the disaster vulnerability equation.

Additionally, while imprecise in the quantitative sense, all of these factors are increasingly evident and indisputable to researchers and policy-makers alike. A broad review of the literature on vulnerability (as the one undertaken in the writing

END NOTES

1. Many authors assemble data to show these trends. One notable publication which provides an overview of disaster trends is the World Disaster Report of the International Federation of Red Cross and Red Crescent Societies, Geneva, 1993, pp.33ff.
2. Quoted from Stop Disasters, The Newsletter of the United Nations International Decades for Natural Disaster Reduction, No. 8, July/August 1992, Geneva.
3. Kreimer, Alcira and Mohan Munasinghe, "Managing environmental degradation and natural disasters: an overview," from Kreimer, A. and M. Munasinghe, Managing Natural Disasters and the Environment, The Environmental Policy and Research Division, Environment Department, The World Bank, Washington, D.C., 1990, p.3.
4. For a recent, excellent review, see: Winchester, Peter, Power, Choice and Vulnerability: A Case Study in Disaster Mismanagement in South India, 1977-1988, James and James Science Publishers Ltd., London, 1992, especially Chapter Two entitled "A Conceptual Model of Vulnerability."
5. See, for example, Report of the Expert Group Meeting, "Natural Disasters and Vulnerability Analysis," Office of the United Nations Disaster Relief Coordinator (UNDRO), July 1979.
6. An example of this is the massive flood control system built to protect London and its surrounds from floods that are estimated to occur every 2000 years at a cost of 730 million British pounds, referred to in Anderson, Mary B., "Analyzing the Costs and Benefits of Natural Disaster Responses in the Context of Development," Environment Working Paper No.29, Environment Department, The World Bank, May 1990, p.10 cited from an article in The Financial Times of London (December 16, 1982).
7. See, for example, "Earthquakes and Geological Hazard Prediction," Colloquium 06, Reports, Vol. 6, 27th International Geological Congress, Moscow, August 1984; "Welcome to the Future," lead article in Hazard Technology, Vol.1, No.1, Nov./Dec. 1993, published by Emergency Information System, Inc., publications of RADARSAT, an "Advanced Earth observation satellite project" developed by the Minister of Supply and Services, Canada, Ottawa, to name only a few of the sources of scientific and technological approaches to vulnerability assessment.
8. Anderson, May 1990, op. cit.; also Kramer, Randall A. and Anna Lea Florey, "Use of Natural Hazard Information in the Economic Analysis of Agricultural Sector Projects," from Course Manual for the Course on the Use of Natural Hazards Information in the

Preparation of Investment Projects, Department of Regional Development, Organization of American States, n.d.

9. See, for example: Schramm, Gunter and Jeremy J. Warford, eds., Environmental Management and Economic Development., A World Bank Publication, Johns Hopkins University Press, Baltimore and London, 1989; Bruce, James P., "Challenges of the Decade: Natural Disasters and Global Change," in AIP Conference Proceedings 277: The World at Risk: Natural Hazards and Climate Change, edited by Rafael Bras, MIT, Cambridge, MA, 1992, pp.3-11; Suhrke, Astri, "Pressure Points: Environmental Degradation, Migration and Conflict," in Environmental Change and Acute Conflict, Occasional Paper Series, A Joint Project of the University of Toronto and the American Academy of Arts and Sciences, No.3, March, 1993; Maloney, Clarence, "Environmental and Project Displacement of Population in South Asia, Part II: Land and Water," Field Staff Reports, Universities Field Staff International and the Natural Heritage Institute, 1990-91, No. 19.; and many others.

10. Notable for starting the inclusion of these issues in his analysis is Gilbert A. White, referred to in the review chapter of Winchester, op. cit.

11. This definition is the one put forth by the World Commission on Environment and Development, created by Resolution 38/161 of the General Assembly of the United Nations in 1983.

12. Bender, Stephen, "The Green Accounting of Natural Hazards: An Integral Part of Sustainability and Environmental Management," unpublished paper, June 1993, Organization of American States, Washington, D.C.

13. See: Quarantelli, E.L., "Urban Vulnerability and Technological Hazards in Developing Societies," in Kreimer, Alcira and Mohan Munasinghe, eds., Environmental Management and Urban Vulnerability, World Bank Discussion Papers, No. 168, The World Bank, Washington, D.C., 1992. Also, in the same volume: Anderson, Mary B., "Metropolitan Areas and Disaster Vulnerability: A Consideration for Developing Countries," and Parker, Ronald Steven, "Vulnerability and Resiliency: Environmental Degradation in Major Metropolitan Areas of Developing Countries."

14. See Kreimer and Munasinghe, 1992, cited above; also "Study on Megacities Underway," in Disasters: Preparedness and Mitigation in the Americas, Issue No. 56, October 1993, p.2.

15. For a brilliant brief essay on what the economists' pricing models leave out, as well as what they can handle, see Herman E. Daly, "Filters Against Folly in Environmental Economics: The Impossible, the Undesirable, and the Uneconomic," reprint, n.d., referenced from Pillet, G. and T. Murota, eds., Environmental

Economics: The Analysis of a Major Interface, (no further information).

16. Report to the Storting No. 46, Environment and Development, Programme for Norway's Follow-Up of the Report of the World Commission on Environment and Development, The Ministry of Environment, Oslo, 1988-89, p.18.

17. Kreimer, Alcira and Mohan Munasinghe, 1990, op. cit. , p.3.

18. Kreimer and Munasinghe, 1990, also p. 3 with reference to an OFDA report of 1990.

19. Bruce, James P., Chairman of the Scientific and Technical Committee of the IDNDR, in "Natural Disasters and Global Change," an Editorial in STOP Disasters, No. 15, Sept./Oct. 1993, p. 3.

20. Jacobson, Jodi L., "Environmental Refugees: A Yardstick of Habitability," in Worldwatch Paper 86, November 1988, p.37.

21. Anderson, Mary B. and Peter J. Woodrow, Rising From the Ashes: Development Strategies at Times of Disaster, Westview and UNESCO Presses, Boulder and Paris, 1989.

22. Schramm and Warford, pp.11-12.

BIBLIOGRAPHY

Abbot, Stan, "Disasters: Tracing the Roots of Human Vulnerability," in Geographical, The Monthly Magazine of the Royal Geographical Society, London, August 1991.

Anderson, Mary B., "Analyzing the Costs and Benefits of Natural Disaster Responses in the Context of Development," Environment Working Paper No. 29, The Environment Department, Policy Planning and Research Staff, The World Bank, Washington, D.C., May 1990.

Anderson, Mary B. and Peter J. Woodrow, Rising From the Ashes: Development Strategies in Times of Disaster, Westview and UNESCO Presses, Boulder and Paris, 1989.

Aysan, Yasemin and Ian Davis, eds., Disasters and the Small Dwelling: Perspectives for the UN IDNDR, James and James Science Publishers, Ltd., London, 1992.

Bolt, B.A., W.L. Horn, G.A. Macdonald and R.F. Scott, Geological Hazards: Earthquakes, Tsunamis, Volcanoes, Avalanches, Landslides, Floods, Springer-Verlag, New York, Heidelberg, Berlin, 1975.

Brammer, Hugh, "Floods in Bangladesh: Vulnerability and Mitigation Related to Human Settlement," in Aysan, Y. and I. Davis, eds., Disasters and the Small Dwelling: Perspectives for the UN IDNDR, James and James Science Publishers, Ltd., London, 1992.

Bras, Rafael, ed. The World at Risk: Natural Hazards and Climate Change, AIP Conference Proceedings 277, American Institute of Physics, New York, 1992.

Canadian Council for International Cooperation, "Focus on Environment" A 'Capacities and Vulnerabilities' Approach," Booklets on "Modern and Ecological Agriculture," "Irrigation," and "Women, Trees and Forest Resources," R and R Reports, Ottawa, November 1989 through May 1991.

Coburn, A.W., R.J.S. Spense and A. Pomonis, Vulnerability and Risk Assessment, First Edition, Disaster Management Training Programme, UNDP, UNDRO, 1991.

Colby, Michael E., Environmental Management in Development: The Evolution of Paradigms, World Bank Discussion Papers, The World Bank, Washington, D.C., 1990.

Conable, Barber B., "Remarks," Conference on Global Environment and Human Response Toward Sustainable Development," Tokyo, Japan, September 11, 1989.

Chorley, Richard J., ed., Directions in Geography, Methuen and Co., Ltd., 1973.

CRED Bulletin, "Disaster Ranking over 25 Years," Centre for Research on the Epidemiology of Disasters, Brussels, January 1993.

Daly, Herman E., "Filters Against Folly in Environmental Economics: The Impossible, the Undesirable, and the Uneconomic," undated offset reprint, referenced from G. Pillet and T. Murota, eds., Environmental Economics: The Analysis of a Major Interface, (no further information).

de Freitas, C.R., "The Hazard Potential of Drought for the Population of the Sahel," from Clarke, John I., Peter Curson, S.L. Kayastha and Prithvish Nag, Population and Disaster, Basil Blackwell in association with International Geographical Union Commission on Population Geography, 1989.

"DHA News," Department of Humanitarian Affairs, United Nations, New York, multiple editions.

Field Staff Reports, No. 14, Asia, 1990-91, Published cooperatively by Universities Field Staff International and the Natural Heritage Institute.

Gauchat, Urs. P. and Daniel L. Schodek, "Housing in Disaster-Prone Countries: A Codification and Vulnerability Analysis of Housing Types," Department of Architecture Graduate School of Design, Harvard University, Cambridge, Massachusetts, 1977.

Hewitt, K., ed., Interpretations of Calamity: From the Viewpoint of Human Ecology, Allen and Unwin, Inc., Boston, London and Sydney, 1983.

International Conference on Preparedness and Mitigation for Natural Disasters '92, Natural Disasters '92, Conference Proceedings, Reykjavik, Iceland, May 1992.

27th International Geological Congress, Earthquakes and Geological Hazard Prediction, Colloquium 06, Reports, Volume 6, Moscow, August 4-14, 1984.

International Federation of Red Cross and Red Crescent Societies, Development and Disaster Preparedness, 1993: Targeting the Vulnerable, Geneva, 1993.

International Federation of Red Cross and Red Crescent Societies, World Disasters Report 1993, Geneva, 1993.

Jacobson, Jodi L., Environmental Refugees: A Yardstick of Habitability, Worldwatch Paper 86, November 1988

Jones, Barclay Gibbs, "Disasters and Urban Systems," in "Disaster" Journal of Architectural Education, Vol. XXXIII, No. 4, Summer 1980.

Kates, Robert W. and Ian Burton, eds., Geography, Resources, and Environment: Volume II Themes from the Work of Gilbert F. White, The University of Chicago Press, Chicago and London, 1986.

Kerr, Richard A., "Upgrade of Storm Warnings Paying Off," Research News, Science, Vol. 262, October 15, 1993.

Kreimer, Alcira and Mohan Munasinghe, eds., Environmental Management and Urban Vulnerability, World Bank Discussion Papers, The World Bank, Washington, D.C., 1992.

Kreimer, Alcira and Michele Zador, eds. "Colloquium on Disasters, Sustainability and Development: A Look to the 1990s," Environment Working Paper No.23, Environment Department, Policy Planning and Research Staff, The World Bank, Washington, D.C., December 1989.

Kreimer, Alcira and Mohan Munasinghe, eds., Managing Natural Disasters and the Environment, The Environment Department, Environmental Policy and Research Division, The World Bank, Washington, D.C., June 27-28, 1990.

Lagorio, Henry, "Urban Design and Hazards," in "Disaster" Journal of Architectural Education, Vol. XXXIII, No. 4, Summer 1980.

Lavell, Allan, "Risk Zoning, Research and Planning for Disasters in Central America: An Agenda for Needed Change," Paper presented to the UCLA International Conference on the Impact of Natural Disasters, Agenda for Future Action, July 10-12, 1991.

Ministry of Environment, Government of Norway, "Report to the Storting No. 46, "Environment and Development, Programme for Norway's Follow-Up of the Report of the World Commission on Environment and Development," Oslo, 1988-89.

Office of the United Nations Disaster Relief Coordinator, Disaster Prevention and Mitigation: A Compendium of Current Knowledge, Vol. 5, "Land Use Aspects" United Nations, New York, 1978.

Office of the United Nations Disaster Relief Coordinator, Natural Disasters and Vulnerability Analysis, Report of the Expert Group Meeting, July 9-12, 1979, Geneva.

Organization of American States, Primer on Natural Hazard Management in Integrated Regional Development Planning, Washington, D.C., 1991.

Palm, Risa I., Natural Hazards: An Integrative Framework for Research and Planning, The Johns Hopkins University Press, Baltimore and London, 1990.

Pan American Health Organization, Disasters: Preparedness and Mitigation in the Americas, Issue No. 56, October 1993, Washington, D.C.

Parker, Ronald Steven, "Vulnerability and Resiliency: Environmental Degradation in Major Metropolitan Areas of Developing Countries," a Paper Prepared for the Environment Department, Environment Policy and Research Division, The World Bank, Washington, D.C., May 1991.

"Puncak Pass Declaration on People's Participation and Sustainable Development," from Lokniti, The Journal of the Asian NGO Coalition, Vol. 7, No. 1, March 1991.

Repetto, Robert, "Economic Policy Reform for Natural Resource Conservation," Environment Department Working Paper No. 4, Environment Department, Policy Planning and Research Staff, The World Bank, Washington, D.C., May 1988.

Rogge, John R., "A Research Agenda for Disaster and Emergency Management," Prepared for the United Nations Development Programme and the United Nations Disaster Relief Coordinator, May 14, 1992.

Schramm, Gunter and Jeremy J. Warford, eds., Environmental Management and Economic Development, A World Bank Publication, The Johns Hopkins Press, Baltimore and London, 1989.

Sheets, Payson D. and Donald K. Grayson, eds., Volcanic Activity and Human Ecology, Academic Press, New York, London, Toronto, Sydney, San Francisco, 1979.

Smith, Keith, Environmental Hazards: Assessing Risk and Reducing Disaster, Routledge, London and New York, 1992.

Stop Disasters, Newsletter of the International Decade for Natural Disaster Reduction, United Nations, Geneva, multiple editions.

Suhrke, Astri, "Pressure Points: Environmental Degradation, Migration and Conflict," Occasional Paper Series of the Project on Environmental Change and Acute Conflict, A Joint Project of the University of Toronto and the American Academy of Arts and Sciences, No. 3, March 1993.

White, Gilbert, "Natural Hazards Research," in Chorley, Richard J., ed., Directions in Geography, Methuen and Co., Ltd., 1973.

Wiggins, John H., "Balanced Risk Analysis," in "Disaster" Journal of Architectural Education, Vol. XXXIII, No. 4, Summer 1980.

Winchester, Peter, Power, Choice and Vulnerability: A Case Study in Disaster Mismanagement in South India, 1977-1988, James and James Science Publishers, Ltd., London, 1992.

The World Bank, The World Bank and the Environment: Fiscal 1993, Washington, D.C., 1993.

The World Bank, World Development Report 1992, "Development and the Environment," Oxford University Press, 1992.