HARVARD UNIVERSITY

JOHN F. KENNEDY SCHOOL OF GOVERNMENT

# Framing Vulnerability: Global Environmental Assessments and the African Burden of Disease

Oladele A. Ogunseitan

Global Environment Assessment Project

Environment and Natural Resources Program

Belfer Center for Science
and International Affairs

2000-21

OCTOBER 2000

# Belfer Center for Science & International Affairs

## Framing Vulnerability: Global Environmental Assessments and the African Burden of Disease

**Oladele A. Ogunseitan**

2000-21 October 2000

Global Environmental Assessment Project
Environment and Natural Resources Program

HARVARD UNIVERSITY
JOHN F. KENNEDY SCHOOL OF GOVERNMENT

## CITATION, CONTEXT, AND PROJECT ACKNOWLEDGEMENTS

This paper may be cited as: Ogunseitan, Oladele A. "Framing Vulnerability: Global Environmental Assessments and the African Burden of Disease." Belfer Center for Science and International Affairs (BCSIA) Discussion Paper 2000-21, Environment and Natural Resources Program, Kennedy School of Government, Harvard University, 2000. Available at http://environment.harvard.edu/gea. No further citation is allowed without permission of the author. Comments are welcome and may be directed to the author at the Belfer Center for Science and International Affairs, John F. Kennedy School of Government, Harvard University, 79 John F. Kennedy Street, Cambridge, MA 02138.

The Global Environmental Assessment project is a collaborative team study of global environmental assessment as a link between science and policy. The Team is based at Harvard University. The project has two principal objectives. The first is to develop a more realistic and synoptic model of the actual relationships among science, assessment, and management in social responses to global change, and to use that model to understand, critique, and improve current practice of assessment as a bridge between science and policy making. The second is to elucidate a strategy of adaptive assessment and policy for global environmental problems, along with the methods and institutions to implement such a strategy in the real world.

The Global Environmental Assessment (GEA) Project is supported by a core grant from the National Science Foundation (Award No. BCS-9521910) for the "Global Environmental Assessment Team." Supplemental support to the GEA Team is provided by the National Oceanic and Atmospheric Administration, the Department of Energy, the National Aeronautics and Space Administration, the National Science Foundation, and the National Institute for Global Environmental Change. Additional support has been provided by the Department of Energy (Award No. DE-FG02-95ER62122) for the project, "Assessment Strategies for Global Environmental Change," the National Institute for Global Environmental Change (Awards No. 901214-HAR, LWT 62-123-06518) for the project "Towards Useful Integrated Assessments," the Center for Integrated Study of the Human Dimensions of Global Change at Carnegie Mellon University (NSF Award No. SBR-9521914) for the project "The Use of Global Environmental Assessments," the Belfer Center for Science and International Affairs at Harvard University's Kennedy School of Government, the International Human Dimensions Programme on Global Environmental Change, Harvard's Weatherhead Center for International Affairs, Harvard's Environmental Information Center, the International Institute for Applied Systems Analysis, The Center for International Earth Science Information Network, the German Academic Exchange Service, the Heinrich Boll Foundation in Germany, the Heinz Family Foundation, the Heinz Center for Science, Economics and the Environment, the Massachusetts Institute of Technology's Center for Environmental Initiatives, a National Science Foundation Career Grant to Professor Daniel Schrag, the National Center for Environmental Decisionmaking Research, Yale's Department of Forestry and Environmental Studies, the University of Amsterdam's Department of Science Dynamics, the University of California at Irvine's School of Social Ecology, the University of California at Santa Cruz' Institute for Global Conflict and Cooperation, and the World Health Organization's Global Forum for Health Research. The views expressed in this paper are those of the author and do not imply endorsement by any of the supporting institutions.

Publication abstracts of the GEA Project can be found on the GEA Web Page at http://environment.harvard.edu/gea. Further information on the Global Environmental Assessment project can be obtained from the Project Associate Director, Nancy Dickson, Belfer Center for Science and International Affairs, Kennedy School of Government, Harvard University, 79 JFK Street, Cambridge, MA 02138, telephone (617) 496-9469, telefax (617) 495-8963, Email nancy_dickson@harvard.edu.

© 2000 by Oladele A. Ogunseitan. All rights reserved.

## FOREWORD

This paper was written as part of the Global Environmental Assessment Project, a collaborative, interdisciplinary effort to explore how assessment activities can better link scientific understanding with effective action on issues arising in the context of global environmental change. The Project seeks to understand the special problems, challenges and opportunities that arise in efforts to develop common scientific assessments that are relevant and credible across multiple national circumstances and political cultures. It takes a long-term perspective focused on the interactions of science, assessment and management over periods of a decade or more, rather than concentrating on specific studies or negotiating sessions. Global environmental change is viewed broadly to include not only climate and other atmospheric issues, but also transboundary movements of organisms and chemical toxins. (To learn more about the GEA Project visit the web page at http://environment.harvard.edu/gea/.)

The Project seeks to achieve progress towards three goals: deepening the critical understanding of the relationships among research, assessment and management in the global environmental arena; enhancing the communication among scholars and practitioners of global environmental assessments; and illuminating the contemporary choices facing the designers of global environmental assessments. It pursues these goals through a three-pronged strategy of competitively awarded fellowships that bring advanced doctoral and post-doctoral students to Harvard; an interdisciplinary training and research program involving faculty and fellows; and annual meetings bringing together scholars and practitioners of assessment.

The core of the Project is its Research Fellows. Fellows spend the year working with one another and project faculty as a Research Group exploring histories, processes and effects of global environmental assessment. These papers look across a range of particular assessments to examine variation and changes in what has been assessed, explore assessment as a part of a broader pattern of communication, and focus on the dynamics of assessment. The contributions these papers provide has been fundamental to the development of the GEA venture. I look forward to seeing revised versions published in appropriate journals.

William C. Clark
Harvey Brooks Professor of International Science, Policy and Human Development
Director, Global Environmental Assessment Project
John F. Kennedy School of Government
Harvard University

## ABSTRACT

In many African countries, the reconciliation of national development plans with global priority to mitigate climate change remains an intractable policy controversy. Its resolution requires conviction of vulnerability to new conditions that will exacerbate preexisting environmental stresses on society and public welfare. The impacts of climate on human health are a common concern in Africa, and it is proposed here as a platform for negotiating controversies surrounding participation and the arrogation of global support for local vulnerability assessments. For this purpose, the integration of local valuation of disease burden into global climate impact assessments is essential. However, the communication pathways involved in progressing from issue framing to political action on environmental health issues are not well understood. This paper addresses the limitations of boundary institutions where pertinent communication nodes for framing vulnerability assessments are embedded. These limitations include the perception of intellectual hegemony in the framing of problems associated with global environmental change, and in the financing of regional assessments. The paper provides a conceptual framework for understanding the frequency and mode of participation of African nations in country study programs that were designed to support developing countries in fulfilling their obligations to the United Nations Framework Convention on Climate Change. In certain cases, frame congruence between existent local challenges and available international resources serve to attenuate difficulties in reaching global consensus despite apparent imbalances in regional priorities. The study also found that selective use of metaphorical frames can contribute to sustaining capacity building successes where methodological diversity is accepted, and the integration of local perspectives is possible. The paper concludes by offering an emergent structure where cross-scale problems encountered in translating rhetorical and action frames are approached through open-ended vulnerability assessments that offer opportunities for critical frame reflection. Such progressive assessments are likely to sustain equal engagement of indigenous and imported capacity for adapting to the impacts of global climate change.

## TABLE OF CONTENTS


1. INTRODUCTION ..... 1

2. QUESTIONS POSED FOR THE STUDY ..... 2

3. THE APPROACH AND METHODS OF THE STUDY ..... 3

3.1 CRITERIA FOR SELECTION OF COUNTRY STUDIES PROGRAM FOR THE STUDY ..... 3

4. DEFINING VULNERABILITY ..... 6

5. GLOBAL ASSESSMENT OF HEALTH VULNERABILITY IN AFRICA ..... 7

5.1 AFRICAN PERSPECTIVES ON INITIAL LOCAL CONDITIONS AND THE CONGRUENCE OF ENVIRONMENTAL CHANGE FRAMES ..... 7

6. CROSS-SCALE ISSUES IN FRAMING VULNERABILITY ..... 8

6.1 THE SCALES OF SPACE, TIME AND ECONOMICS ..... 8

7. TRANSLATION OF RHETORICAL FRAMES ..... 9

8. FLEXIBILITY OF ACTION FRAMES ..... 11

9. THE DYNAMIC NATURE OF VULNERABILITY: IMPLICATIONS FOR THE DESIGN OF ASSESSMENTS ..... 15

10. VULNERABILITY ASSESSMENTS AS AVENUES FOR FRAME REFLECTION ON THE ISSUES OF SCALE AND RELEVANCE ..... 15

11. EMERGENT STRUCTURES FOR BUILDING SUSTAINABLE CAPACITY FOR VULNERABILITY ASSESSMENTS ..... 17

12. CONCLUSIONS ..... 19

REFERENCES ..... 21

TABLES ..... 27

FIGURES ..... 31

ENDNOTES ..... 33

APPENDICES ..... 37

## ACRONYM LIST

| | |
|---|---|
| CDC | Center for Disease Control |
| DALY | Disability Adjusted Life Years (lost) |
| DOE | Department of Energy |
| CGIAR | Consultative Group on International Agricultural Research |
| CoP | Conference of Parties (to the UNFCCC) |
| ENSO | El Niño/Southern Oscillation |
| FAO | Food and Agricultural Organization |
| GBD | Global Burden of Disease |
| GCM | General Circulation Model |
| GEF | Global Environment Facility |
| GIS | Geographic Information System |
| HeaLY | Health Life Years (lost) |
| HHS | Health and Human Services |
| IITA | International Institute for Tropical Agriculture |
| IMAGE | Integrated Model to Assess the Greenhouse Effect |
| IPCC | Intergovernmental Panel on Climate Change |
| MARA/ARMA | Mapping Malaria Risk in Africa/Atlas du Risque de la Malaria en Afrique |
| MIASMA | Modeling Framework for the Health Impact Assessment of Man-Induced Atmospheric changes |
| NGO | Non Governmental Organizations |
| TARGETS | Tools to Assess Regional and Global Environmental and Health Targets for Sustainability |
| UN | United Nations |
| UNCED | United Nations Conference on Environment and Development |
| UNDP | United Nations Development Program |
| UNEP | United Nations Environment Program |
| UNFCCC | United Nations Framework Convention on Climate Change |
| RBM | Roll Back Malaria |
| TARGETS | Tools to Assess Regional and Global Environmental and Health Targets for Sustainability |
| TOMS | Total Ozone Monitoring Spectrometer |
| USCSP | United States Country Studies Program |
| USAID | United States Agency for International Development |
| USEPA | United States Environmental Protection Agency |
| WB | World Bank |
| WCIRP | World Climate Impact Assessment and Response Strategies Program |
| WHO | World Health Organization |
| WMO | World Meteorological Organization |

## 1. INTRODUCTION[1]

The ideal outcome of global environmental impact assessments is the adoption of protective policies by vulnerable nations. For reasons that were negotiated at various international summits, assessments of vulnerability to climate change in developing countries are funded through programs based in industrialized countries or through multinational funding regimes (e.g., the United States Country Studies Program and the Global Environment Facility, respectively). The priorities of these funding institutions do not necessarily coincide with development plans of recipient countries.[2] Therefore, debates on the divergence of national and global priorities have permeated the Conference of Parties to the United Nations Framework Convention on Climate Change (UNFCCC) [Apuuli *et al.* 1999].

The objective of funding programs that support UNFCCC is the stabilization of greenhouse gas (GHG) concentrations in the atmosphere at a level that would prevent dangerous anthropogenic interference with the climate system [Article 2 of the UNFCCC, United Nations 1992]. Therefore, national GHG inventories and mitigation plans have priority over vulnerability assessments and adaptation plans in the funding schemes. Furthermore, funding for mitigation activities in developing countries has been justified by the causal history of GHG emissions, which places the burden of remediation on industrialized countries, but the agreement does not cover the financial burden imposed by the impacts of climate change in each country [Shue 1999].

Despite the availability of funds from industrialized countries, certain developing countries, notably India, refused to participate in some comprehensive country study programs because of disputes surrounding issue framing, and equitable allocation of intellectual resources to national priorities [Agarwal 1990; Agarwal & Narain 1991; Kandlikar & Sagar 1997].[3] For developing countries that lack the means to support climate change research, the acceptance of international funding for vulnerability assessments may entail the endorsement of frameworks that do not accommodate national needs. The situation is particularly salient for African countries because of the enormity of cross-sectoral infrastructure problems and the variegation of continental environmental and political systems. Therefore, an evaluation of African participation in externally funded climate change assessments is needed to identify potential shortcomings in the regimented structure of funding for climate change research. The need to integrate local knowledge and value systems into the framing of vulnerability assessments requires critical examination of communication processes that may constrain the transformation of global frameworks into protective policy.

In most of Africa, the communication pathways involved in frame reflection and the engagement of political action for managing environmental quality and health are not well understood [Cooper *et al.* 1998; Dixon et al. 1996; Fairhead & Leach 1996; Herberlein 1977]. This paper focuses on one of the interfaces within which frame reflection and policy advisement occurs in the assessment of Africa's vulnerability to global climate change, namely boundary institutions that stride international and national agendas in the public health sector. Limitations to the influence of these boundary institutions are traced to cross-scale problems in the translation of rhetoric frames and the operational rigidity of institution action frames. These framing issues influence the local perception of vulnerability, and are likely to exacerbate traditional problems associated with uneven development of technical capacity, and gaps in the interest and political connection of local epistemic communities [Benioff *et al.* 1996; Carr & Mpande 1996; Long & Iles 1997; Miller 1998]. The findings suggest that treating vulnerability assessments as long-term dynamic processes that adjust constantly to local baseline conditions can approach problems that arise from cross-scale translation of frames. Such an approach will encourage the maturation of communication pathways necessary for critical frame reflection, and for the full engagement of both indigenous and imported capacity for adapting to climate change impacts in Africa.

## 2. QUESTIONS POSED FOR THE STUDY

The credibility of impact projections used in global environmental assessment depends on how precisely local conditions are captured in predictive models. Hence, there are three opportunities for local scientists to participate in global environmental assessments:

1. Judgments of what globally framed impacts of climate change are relevant to the assessment of vulnerability in local communities.
2. The provision of local primary baseline information useful for modeling projections of impacts that are judged to be relevant.
3. Verification of the output of modeled projections according to alternative policy options.

Therefore, it was postulated that research on the pathways through which information is exchanged among local institutions and between local institutions and international environmental assessment communities will illuminate opportunities for developing capacity to improve the credibility and relevance of climate change information collected locally. The ultimate benefit of investigating these pathways is to increase the effectiveness of global environmental impact assessments in countries where limited resources preclude the establishment of comprehensive national assessments.[4] In such countries, building national capacity to optimize the flow of information between local agencies and global institutions depends on the role of cross-boundary organizations (including United Nations subsidiary agencies, and NGOs) and the funds that they provide.

As the first step towards the understanding of these issues, the present study addressed the following specific questions:

1. How is the global framing of "health impacts of climate change" translated in the research agenda and policy forums of African countries that participate in Country Study Programs supporting the implementation of UNFCCC. This question addresses the inherent hegemony of capacity building programs and how the provision of funds and technical support influence the judgments of what globally framed impacts of climate change are relevant to the assessment of vulnerability in local communities.

2. What roles do cross-boundary institutions that operate in climate-sensitive sectors play in the communication and translation of global frames into technical and political actions at the local level. An understanding the functions of the World Health Organization and its intricate web of local representatives in Africa crucial to answering this question within the framework of "health impacts of climate change." In many African countries, WHO, through the connections that it maintains to local epistemic communities, policy makers, and the public contributes significantly to the collection, analysis, and distribution of baseline information that is essential to the projections used in climate research. At the international level, WHO has also contributed substantially to the global framing of "health impacts of climate change." Therefore, African representatives of WHO are uniquely positioned to reflect critically upon global frames towards the design of assessments that have local relevance. Communication between these agencies and local climate change communities that engage transnational country study programs would be essential for sustaining capacity for independent framing of national vulnerability.

## 3. THE APPROACH AND METHODS OF THE STUDY

The study focused on the translation of global framing of vulnerability in the assessment of climate change impacts on the health sector. The adoption of *"Weather, Climate and Health"* as the theme of the 1999 World Meteorological Day signified the convergence of global frames on the health dimensions of climate change. This event emerged after more than a decade of framing and assessment activities by the World Health Organization (WHO) and the Intergovernmental Panel on Climate Change (IPCC) [World Meteorological Organization 1999]. Forty-six extension offices of WHO in Africa serve as boundary institutions where reflection on the global framework can occur to benefit local vulnerability assessments. The convergence of global frameworks also involves other boundary institutions whose concerns underpin public health security in Africa. The Consultative Group on International Agricultural Research (CGIAR), which focuses on preventing malnutrition, exemplifies such boundary institutions. CGIAR is co-sponsored by The World Bank, The Food and Agricultural Organization, the United Nations Development Program, and the United Nations Environment Program. The International Institute for Tropical Agriculture (IITA) is a CGIAR-sponsored organization with headquarters in Africa. The responsibility of translating the global framing of climate change impacts in Africa is embedded in IITA's agenda for applied research, policy advice, and extension education [IITA 2000].

### 3.1 Criteria for Selection of Country Studies Program for the Study

For reasons outlined in the previous section, the most effective access to information on vulnerability assessments conducted in Africa is through transnational Country Studies Programs (CSP) supported by industrialized countries or multi-institutional conglomerates such as the GEF. Germany, The Netherlands, and the United States have established CSP for supporting climate change research on the implementation of the UNFCCC in developing and transition countries, a category that includes all African nations. However, participation of African counties in different CSP vary because each institution applies specific rules of engagement requests, and to the evaluation of proposals from prospective countries. In addition, there is some variation in the emphasis place by each institution on various topics within the global climate change framework, and the level of technological and infrastructure support provided to funded studies. In some cases, climate change country studies are attached to existing technology transfer initiatives (e.g., the German program), whereas in others such as case the USCSP, a brand new program was designed with funds and staff pulled from various federal agencies interested in climate change, or in technology transfer and sustainable development.[5] In the present study, the criterion for focusing on a particular program is the accommodation of vulnerability assessments in the program framework, and the level of participation of African countries. The following brief review of the different CSP will serve to highlight the differences in institutional frameworks that influence participation.

The total amount of funds dispensed annually by the GEF on environmental research in developing and transition countries is approximately US$2.15 billion, out of which US$600 million is focused on climate change. The GEF support of climate change research is organized into five subprograms, with inconsistent participation by African countries [GEF 2000]:

1. *"Removal of barriers to energy efficiency and energy conservation."* This subprogram accounts for 9.9% of total GEF expenditure. African participants include Cote d'Ivoire and Senegal in a regional program to "control greenhouse gas emissions through energy efficient building technology in West Africa." Support is also provided for initiatives on energy conservation in small and medium scale enterprises in Kenya; household energy in Mali; decentralized rural energy in Togo; and photovoltaics for households in Zimbabwe.

2. "*Promoting adaptation of removable energy by removing barriers to reducing implementation.*" This program accounts for 13.4% of GEF budget, and it involves renewable energy research in Cape Verde, Ghana, Mauritius, Mauritania, Mali, Tanzania, Togo, and Uganda.
3. "*Reducing the long-term costs of low greenhouse gas emitting energy technologies*" accounts for 4.7% of GEF budget with no African projects.
4. "*Climate Change Enabling Activities*" accounts for 3.4% of GEF budget, and it includes country studies of greenhouse gas sinks in Morocco, Senegal, Tanzania, and Uganda. Capacity building programs are also being conducted in Ghana, Kenya, Mali, and Zimbabwe. In general, funds for "enabling activities" were distributed over a wide range of countries in Africa, to support investigations within the framework of greenhouse gas sinks.
5. "*Short-term response measures*" costs GEF 5.3% of the annual budget, and it includes reforestation programs for carbon sequestration in the Republic of Benin.

The GEF subprogram on "Ozone depletion", which is now well integrated into the framework on climate change impacts, costs GEF 5.5% of their total expenditure, but has no participants in Africa. In summary, the only GEF-sponsored program that explicitly focuses on vulnerability assessments and adaptation to climate change, as opposed to mitigation and inventories is a pilot program in Cameroon [GEF 2000].

The Deutsche Gesellschaft fur Technische Zusammenarbeit (GTZ) is active in 36 African countries with an annual budget of DM 623.9 million, but only two African countries, Tanzania and Zambia have programs under the agenda of "measures to implement UNFCCC", and neither program entails vulnerability assessments. Tanzania's project under the GTZ is entitled "Technology and other Options for the Mitigation of Greenhouse Gas" whereas Zambia's project is simply entitled "Inventories and Mitigation Analysis" [GTZ 2000].

The Netherlands climate change studies assistance program also supports climate change research in only two African countries, Ghana, and Senegal [Feenstra *et al.* 2000]. The focus of the Ghana study is on impact and adaptation on water resources and coastal zones. The research is also directly linked to the preparation of Ghana's National Communication as required by the UNFCCC. Senegal's study under the Netherlands CSP program primarily covers the impacts of climate change on agriculture and coastal zones. The Senegal study builds upon earlier results of climate change studies conducted under the auspices of GEF.

Of the three programs that have emerged out of single industrialized countries, the USCSP has the broadest participation by African nations. Therefore, the vulnerability assessments conducted under the USCSP became the primary focus of the present study.[6] Fifteen African countries, out of a global coverage of 56 countries, are involved in the USCSP, and at least 10 of the countries have conducted vulnerability and adaptation assessments on a variety of sectors [Figure 1]. The USCSP is a voluntary program inaugurated in 1993 with the primary objective of building institutional and technical capacity for global climate change assessments in developing and transition countries [USCSP 1999]. Eleven of the fifteen countries are in Southeastern Africa and only three are in West Africa. The USCSP staff attributed the skewed geographical representation in Africa to national differences in the interest of scientists and/or their influence on policy makers who must endorse the participation. However, the USCSP operational framework clearly influenced the decision of countries on whether or not, and to what extent, to participate from the moment the program was inaugurated.[7] The following quotation demonstrates the disconnection between the science and policy branches that prevented some African countries from participating in the USCSP:

> *Sandra Guill, USCSP Regional Coordinator For Africa:* "I got a lot of proposals which were not followed up by diplomatic letters from the ministry of foreign affairs, for unknown political reasons. Those proposals were not funded. We got proposals from Cameroon, Togo, and Eritrea, but no diplomatic notes. We could have had additional 15-20 more CSP participants in Africa, if it were not for the lack of ministerial support. This explains the lack of full coverage in West and Central Africa. I begged, contacted, sent faxes, called, and did everything but the diplomatic notes were not forthcoming. I told the Principal Investigators to go back to their countries and push for the diplomatic note. Examples of countries that applied but whose study could not commence are Mali and Niger. We tried to work with Algeria, but their political situation was not conducive."

Sandra Guill also provided the following assessment of African participation in other CSP:

> *Sandra Guill, USCSP Regional Coordinator for Africa:* "One of my jobs is to work very closely with other donors so that we do not duplicate efforts. For example in Tanzania, Zambia, and South Africa, the GTZ funded half, and we funded the other half. We combined our work plans. The Dutch have also funded a few countries. However, the US program is much larger and much better defined than the other country study programs elsewhere- from the perspective of participating countries. For example, what they liked about our program are that: (1) We did true capacity building, we did none of the work for the countries. We gave them models, and computers, we taught them how to analyze their data, but they were the ones who actually went out and did the field work, (2) UNEP and GEF developed a training manual, but they simply gave the countries half a million dollars for the study and let it up to the investigators to select the model to be used. This probably led to a lot of confusion on the part of some investigators in developing countries. They had no idea what to do. The money disappeared, and no results emerged. It also made it difficult to have a cross-sectional comparison of inventories, mitigation, and vulnerability/adaptation events among the countries."

Interviews were conducted with USCSP staff over a period of three days during which access was provided to the program's reports and protocols. Because Nigeria carries a special burden of environmental quality and health in Africa, personal interviews were also conducted with the investigators conducting assessments under the USCSP program there. The Niger delta area of Nigeria emits approximately one-third of the global amount of greenhouse gases from deliberate gas flaring [Adegbulugbe *et al.* 1997]. As the most populous Africa country [half the population of the United States in a land area the size of Texas], a large proportion of the absolute burden of disease in Africa is located within the geographically margins of Nigeria. In order to provide a robust context for the findings on the participation of African countries in the USCSP, a questionnaire was also sent to lead investigators in each of the 56 countries that are participating in the USCSP [Appendix 1]. The questionnaire was structured in a format that could provide information similar to that gathered through personal interviews in Nigeria. Finally, structured interviews were conducted with African representatives of WHO, as well as with representatives of the CGIAR at the headquarters of the IITA. Documents were also reviewed for a workshop on climate change impacts that took place in April 2000 in Nigeria. The Ministry of Environment organized the workshop with financial support from UNEP, UNDP, and GEF.

## 4. DEFINING VULNERABILITY

Webster's collegiate dictionary defines vulnerable systems as "open to attack or damage" [1989]. The implicit assumption in assigning the vulnerability label to a given system is that some other comparable systems are in fact not vulnerable to the events in question. Thus, the pervasive nature of the impact of weather and climate on human affairs makes the demarcation of vulnerability difficult. It is therefore better to refer to degrees of vulnerability.

In order to properly understand what is meant be "global framing", it is important to examine the deliberations of the IPCC, and to consider the factors that contribute to scientific consensus on definitions, concepts, and frameworks. In 1997, the Working Group II of the IPCC published a special report on the assessment of vulnerability in the regional impacts of climate change [Watson *et al.* 1997]. The report was prepared in response to a request from the Subsidiary Body for Scientific and Technological Advise (SBSTA) of the UNFCCC. In turn, the SBSTA request was incited by questions posed by the Conference of the Parties (CoP) to the UNFCCC regarding the degree to which human conditions and the natural environment are vulnerable to the potential effects of climate change [Watson *et al.* 1997]. The report was to assist the CoP in determining justifiable adaptation and mitigation measures based on potential costs and benefits of climate change. The assessment sub-divided the world into ten regions: Africa, Arid Western Asia (including the Middle East), Australasia, Europe, Latin America North America, the Polar Regions (Arctic and Antarctic, Small Island States, Temperate Asia, and Tropical Asia. Consequently, the IPCC confronted a broad range of uncertainties associated with regional projections of climate change. The regional approach revealed wide variation in the vulnerability of different populations and environmental systems. For example, in the health sector, different levels of vulnerability exists under similar climate and pathogen distribution patterns because of local economic, social, and political conditions; and the level of dependence on resources that were sensitive to climate variability. Therefore, instead of producing quantitative predictions of the impacts of climate change for each region, the IPCC took the approach of assessing regional sensitivities and vulnerabilities. A framework for vulnerability assessments was then adopted, in which vulnerability was defined as "the extent to which a natural or social system is susceptible to sustaining damage from climate change." In this context, vulnerability is a function of both *sensitivity* to climate and the ability to *adapt* to new conditions." Sensitivity was further defined as "the degree to which a system will respond to a given change in climate, including both beneficial and harmful effects." The ability to adapt meant "the degree to which adjustments in practices, processes or structures can moderate or offset the potential for damage or take advantage of opportunities created, due to a change in climate." In this frame of vulnerability, a highly vulnerable system has the potential to suffer substantial harmful effects with modest changes in climate while the ability to adapt is severely constrained. There was an early recognition, explicitly stated in the special report, that the approach and regional grouping used needs to be refined in future IPCC assessments [IPCC 1997].

In each of the ten geographical regions, the IPCC's vulnerability assessment focused on the impact of climate on three sectors: ecological systems, socioeconomic sectors and human health. The independent treatment of human health in this assessment is of special interest to investigations of the role of issue framing in the global environmental assessments. The consolidation of epidemic communities working to broaden the scope of traditional environmental health perspectives and the settlement of disputes over methodology contributed to the dominance of certain disease categories in the scientific agenda on climate change and health [Long & Iles 1997]. The IPCC assessment of regional vulnerabilities drew from interim reports compiled by the USCSP [Dixon *et al.* 1996; IPCC 1997]. Although the USCSP mandates the use of specific methods for all participating countries, the IPCC discovered that the diversity of climate scenarios and models used by investigators in the ten regions was so great that it

compounded by different levels of uncertainty. Consequently, a quantitative synthesis assessment was not possible.

## 5. GLOBAL ASSESSMENT OF HEALTH VULNERABILITY IN AFRICA

The IPCC assessment of the vulnerability of human health to climate change emerged from a background of "widespread increase in new and resurgent vector-borne and infectious diseases, such as dengue, malaria, Hantavirus, an cholera" [IPCC 1997]. The only numerical projection included in the IPCC assessment relates to the expansion of the geographical zone of malaria in response to global mean temperature at the upper part of the IPCC-projected range (3-5°C increase in global average temperature by the year 2100). Hence, the proportion of human population affected by malaria is expected to increase from 45% to 60%. This means that an additional 2 billion people, mostly in the temperate Northern Hemisphere could become vulnerable to malaria infection by mid-century (based on the World Health Organization's population projection [Murray & Lopez 1996]. In areas where malaria is currently endemic, mostly in the humid tropical zones of Africa, a 10% increase in the annual number of malaria cases is expected from the current estimate of 500 million cases. The IPCC assessment concludes that, in general, Africa is the continent most vulnerable to the impacts of projected climate change because "wide-spread poverty limits adaptation capabilities" [IPCC 1997]. In the health sector, Africa is expected to be at risk primarily from increases in vector-borne diseases, and because of the huge economic burden of diseases, IPCC suggested that global efforts would be needed to tackle the potential health effects of climate change.

### 5.1 African Perspectives on Initial Local Conditions and the Congruence of Environmental Change Frames

Numerous publications by African authors have articulated national perspectives on vulnerability to drought, disease, and other natural phenomena that are sensitive to climate [for examples, Ominde & Juma, 1991; Ottichilo *et al.*, 1991; Umolu 1994]. The limitations imposed by the peculiar configuration of the science-policy interface on the African scientific community in framing these perspectives have also been explored, notably by Anya and others [Anya 1977; 1986; 1992; 1993; Awe & Anya 1987]. Economic planning in many African countries relied on data on agro-ecological diversity that considered the vulnerability of certain regions or communities as a central variable. For example, in Kenya deliberations on geography and demography were central to national development plans until the 1970s when econometric paradigms became popular [Calestous Juma, personal communication].

In a study on climate change in Kenya, Ottichilo *et al.* [1991] demonstrated that the consequences of long-term climate change (as projected by global models) seemed to correspond with historical data on climatic variability during the previous decades. The correspondence of historical precedence, immediate concerns, and future projections constituted a congruence of frameworks that facilitated dialogue between local and global levels of discussion on environmental change. Frame congruence can also emerge from cross-scale communication of analogous situations and metaphors. In many African studies of environmental systems that predate international negotiations on global environmental change, metaphorical frames supplement rhetorical ones, and have been built largely on local studies of climate change. For example, studies in Tanzania on erosion of coastlines facilitated the discussion of consequences of global warming for sea level rise (Ominde & Juma, 1991). One of the policy implications of metaphorical frames is the need to accept methodological diversity. For example, local environmental assessment in many African studies frequently employ case-study approaches, whereas numerical models are the quintessential tools for projections in global assessments. The disparity of

approaches can hinder the effective participation of local scientists in international assessments (Calestous Juma, personal communication).

## 6. CROSS-SCALE ISSUES IN FRAMING VULNERABILITY

The concept of framing adopted in this study was developed by Schon and Rein [1994] in a constructivist approach towards understanding how scientists and policy makers make the normative leap from findings of fact to policy recommendations, i.e. from the "is" to the "ought". In this view, frames are implicit assumptional structures that spring from generative metaphors. Policy controversies are considered as frame conflicts that may yield to careful frame construction and reflective communication in policy discourse. In extending this concept to transnational policy controversies on environmental issues, the present study tackles the intricately connected dimension of scale that has not been the focus of previous treatments of frame reflection. The problem of scale differentials in international environmental assessments has been confronted by several investigators, but theoretical breakthroughs on how to resolve the policy disputes that they generate have not been forthcoming [Clark 1987; Kates *et al.* 1985; Turner *et al.* 1991]. Practical insights into the resolution of scale problems are particularly relevant to the understanding of frame communication between multinational environmental regimes and policy development in less developed countries [Smith *et al.* 1996; Usher 2000; Watson *et al.* 1997].

### 6.1 The Scales of Space, Time and Economics

The challenge of extrapolating recommendations across spatial and temporal dimensions is the most prominent problem of scale encountered in global environmental assessments. The matrix presented in Table 1 is an attempt to map the nodes of frame communication across the scales of transnational and national boundaries in the assessment of Africa's vulnerability to the impacts of climate change. The major actors in the evolving discourse on vulnerability to climate change are *scientists* who require international collaboration, *policy makers* who expect advise on risk management, and the *public media* where scientific and policy controversies are highlighted in the struggle for legitimacy [Cronon 1992; Kempton 1991; Pittock & Jones 2000; Stern *et al.* 1992]. Strategies for building consensus in global environmental assessments rely on managing the communication pathways within and between the flexible categories of actors, and the structure of transnational communication affects the framing of vulnerability through their influence on the diffusion of knowledge about climate change and the design of "no regrets" adaptation strategies [Apuuli *et al.* 2000].

The IPCC assessment recognized the problem of aggregating several nation-states with extremely diverse environmental and political systems into a single region of vulnerability [IPCC 1997]. The World Health Organization has also confronted the problem of scale in the attempt to produce a quantitative assessment of the global burden of diseases [Murray & Lopez 1996]. The Global Burden of Disease (GBD) was a rigorous and timely compendium of health data presented in an accessible format for large regions of the world. Although the authors took special precautions in carving the world into seven burden-of-disease regions, the existence of intra-regional heterogeneity in the categorical burden of disease is inevitable. In some cases, the national differences within each region are inconsequential for health policy planning because of smoothing effects in cross-boundary migration, health support infrastructure, and efficient technology transfer. In other regions, however, using regional-scale data for local or national health policy can produce long-term devastating effects. The significance of intra-regional differences in the GBD is probably greatest for sub-Saharan Africa (SSA). There are several reasons for this, most salient of which is the paucity of data on local burden of diseases in sub-Saharan Africa. This led to the error-prone assumption that available data and expert opinion from the Republic of South Africa can represent

the burden of disease for the rest of the continent [Cooper *et al.* 1998]. In rare circumstances when local burden of disease data is available, for example through the Ghana Health Assessment Project [1981] there has been little or no systematic follow-up. Therefore, projections for major disease categories through standardized indicators such as disability adjusted life years (DALYs) and healthy life years (HeaLYs) are difficult, if not impossible to achieve [Hyder *et al.*, 1998].

One of the thorny debates associated with the GBD is the policy decision about disproportionate investment of health funds in chronic and heritable diseases as opposed to preventable communicable diseases that are linked to environmental quality [Wilson *et al.* 1994; Cooper *et al.* 1998]. Powerful arguments have been framed on both sides, and it is difficult to understand how different investigators who evaluate the same data used to calculate DALYs reach divergent conclusions. Nevertheless, what is clear is that for countries in sub-Saharan Africa, the burden of diseases associated with environmental conditions will continue to dominate investments on health care [Chukwuma, 1994; Lucas, 1998].

There are two main challenges in the temporal scale of vulnerability assessments. The first is the difficulty of projecting vulnerability to a future event when the baseline information is undergoing continuous and rapid change. Vulnerability assessments must also include consideration for the stochastic nature of the interaction between environmental quality and diseases. The treatment of vulnerability as a dynamic process implies that assessments must be open ended, and this poses special problems for the allocation of resources and for policy formulation. The second challenge concerns the value associated perceived vulnerability to specific impacts. In reframing global problems to fit regional agenda, vulnerability assessments aim to provoke action at the local level, but there are strong differences across the regions in discount rates applied to future events. Present-oriented communities are less likely to act on information concerning vulnerability to where prediction is uncertainty, and the pressures of daily survival can be overwhelming [Poulos & Whittington 2000].

The quantitative expression of human health impacts also poses special problems for the framing of vulnerability and impact assessments. The difficulty inherent in the translation of value systems across national boundaries has led to the increasing use of economic indicators for measuring the burden of human diseases on societies [Murray & Lopez 1996]. Countries vary in the costs expended on the treatment of specific diseases, and unlike other sectors such as agriculture whose products have standardized value in the global economy, valuing morbidity and mortality is notoriously complex even within similar geopolitical boundaries [Aron & Davis 1993].

## 7. TRANSLATION OF RHETORICAL FRAMES

Rhetorical frames are persuasive stories and lines of argument that are used in policy debate [Schon & Rein 1994]. They are commonly found in the discourse on environmental change, where they serve to gain allegiance in the coalition of advocacy groups [Homer-Dixon 1990; Snow & Benford 1992]. For example, the rhetorical frame of equity is prominent in the North-South debate on global climate change, but it has not evolved into dominant action frames that inform policy practice and the content of legal frameworks [Agarwal & Narain 1991; MacLean 1990; Magazda 2000; Shue 1999]. Rhetorical frames have also been used in speculations and projections about the impacts of human-induced climate change [for examples in the health sector, see Appendices 2 and 3]. The stories are based on observations of pervasive effects of natural climate variability on social and ecological systems [Cronon 1992]. Although scientists who participate in global environmental assessments strive to reduce uncertainties in the attribution of causes to the global warming phenomenon, it is far more difficult to ascertain, beyond

rhetoric reframing, that unusual events are in fact due to the actual impacts of human-induced climate change [Bouma, *et al.* 1994; Colwell, 1996; IPCC 1997; McMichael & Martens 1995].

Probably no other frame of climate change impacts commands more attention than putative human health consequences. The emergence of new infectious agents, and the geographic spread of tropical diseases have equally engaged the attention of journalists, novelists, movie producers, and public health officials [McMichael & Sari Kovats 2000; Wilson *et al.* 1994]. With the possible exception of Hanta virus and Lyme disease epidemics in the United States, the usual suspect for the origin of new disease pathogens is the African continent [Kalkstein & Smoyer 1993; Levins et al. 1994]. Indeed, the tumultuous conflict of frames that accompanied the debate on the African origin of the HIV virus has not entirely succumbed to intense scientific research. South African president Thabo Mbeki's recent questioning of the link between HIV and AIDS has rekindled deep-seated controversies among health scientists and policy-makers worldwide [Cohen 2000]. The struggle by many African countries to prioritize multiple issues of environmental quality and health has increased reliance on foreign financial and technical assistance, while discounting the notion that foreign aid is usually accompanied by the requirement to reframe national priorities through the assimilation of foreign values [Watts 1987; Rich 1994].

Rhetorical frames used in generating attention to health impacts of climate change follow the classical model of "fear appeals" [Jayne, 2000]. "Fear appeal" strategies are two-pronged communication tools. The first prong focuses on the magnitude of the threat and on individual or group susceptibility to the defined threat. The second prong identifies recommended responses and the efficacy of adaptive strategies. An example of "fear appeal" framing is the emergence of the "Roll Back Malaria" initiative within the climate change agenda [WHO 1997]. "Roll Back Malaria" (RBM) can be viewed as a generative metaphor in the construction of rhetorical frames pertaining to the health impacts of climate change. Its goal is to expand the geopolitical range of support for malaria research. The RBM initiative was launched, soon after Gro Harlem Brundtland's inauguration as director of WHO, as an extension of the provincial Malaria Control program initiated by the Organization for African Unity in 1995. Global financial support for RBM is crucial, which necessitates the rhetorical framing of malaria as a global problem. The director of RBM, David Nabarro, has effectively constructed a rhetoric frame, based on the fear appeal strategy, of malaria's threat to the Northern Hemisphere as a consequence of climate change impacts on the viability of *Plasmodium* [IPCC 1997]. Nabarro's communications assert that "malaria was once a problem in the US and may return" and that "malaria kills more US troops than bullets" [Nabarro 1999]. Also noteworthy is the statistic that 62,000 indigenous cases of malaria were recorded in central Europe in 1998 [WHO 1997]. At the international summit on RBM held in Nigeria in April 2000, Brundtland reinforced the global framing of malaria in the context of climate change [Appendix 4]. The forgiveness of Africa's debts owed to countries in the Northern Hemisphere was requested to enable African nations in stemming the spread of malaria [Nwaorgu & Johnston 2000; Sachs 2000].

The assessment conducted by WHO on the global burden of diseases that are susceptible to climate change suggests a decline in Africa's malaria burden in the period from 1990 to 2020 (Table 2). The assessment also indicates a more rapid decline in malaria burden outside Africa, because the proportion of global burden of malaria that is associated with Africa is expected to increase, even though the actual burden of malaria in Africa will decrease. This is the case for all climate-sensitive diseases in Africa, except for respiratory ailments, and eye diseases attributable to ultraviolet light exposure (Table 2). Therefore, it is not possible to reconcile the rhetorical framing of RBM with policy recommendations suggested by independent assessments conducted by the IPCC and the WHO [IPCC 1997, and Table 2].

The framing of beneficial impacts of climate change has emerged in the United States [Mendelsohn and Neuman 1999]. Such frames remain controversial, but their publication demonstrates a capacity for frame translation to suit particular local agendas. Entertainment of diverse frames is essential in vulnerability assessments if optimum adaptive strategies are desired. Within the confines of present rhetorical frames, suggestions that certain diseases might benefit from climate change in Africa will likely meet with resistance. Similarly, the idea that AIDS in Africa could be exacerbated by climate change-induced increase in ultraviolet light exposure (which is known to suppress the immune system) is not supported because it disagrees with the dominant global framing of the AIDS epidemic [WHO 2000]. Heat stress has never been discussed in the open literature to describe African vulnerability to climate change impacts [IPCC 1997]. Yet, it seems easy to argue that inhabitants of impoverished urban centers in the humid tropics of Africa with unreliable supply of electricity and acute shortage of air-conditioning units are highly vulnerable to increased ambient temperature. The pervasive nature of projected climate change impacts in Africa suggests the need for a sustainable strategy for coordinating vulnerability assessments through a process that encourages reflection on multiple frames and skepticism in the adoption of global frameworks.

## 8. FLEXIBILITY OF ACTION FRAMES

Three levels of action frames are generally recognized; policy, institutional, and metacultural. Policy frames are used to construct problems in specific policy situations, whereas institutional frames structure broad policy problems in a manner that is characterized by institutions' political mandate and system of beliefs. Institution frames are local expressions of culturally shared systems of belief or metacultural frames, which are organized around generative metaphors such as the oppositional pairing of cause and effect, global and local, disease and cure, developed and developing, and even science and policy [Schon and Rein, 1994].

It is widely believed that Africa is highly vulnerable to climate change [Dixon *et al.* 1996; IPCC 1997; Magazda 2000; WHO 1990]. This view can be traced to the frequency of socio-ecological devastation that results from major climate variations on the continent. The incidence of famines, homelessness, and disease epidemics that require international assistance seems a testimony to the weakness of policy and institution action frames employed in the strategy to cope with climate- and weather-related emergencies. However, the valuation of climate change impacts has a subjective dimension that can only be captured through indigenous experience and an understanding of values associated with life-saving intervention programs.

A recent study of individual time preferences for life-saving programs concluded that the discount rates applied to future life-saving programs by Africans are very different from the rates applied in developed countries, and that the difference ought to be reflected in national development programs and transnational initiatives for capacity building. Clearly, the relationship between time preferences for saving lives and the discount rates applied to intervention programs is not as simple as previously believed [Poulos & Whittington 2000]. In Africa, as in other regions, the perception of climate change and its impacts remains futuristic [Kempton 1991]. Therefore, national differences in time preferences for life-saving programs are expected to affect the adoption of climate change action frames. This is why cross-national assessments of vulnerability and adaptation have posed substantially more challenges than the assessment of GHG inventories and mitigation options [Pitock & Jones 2000].

The current framework for climate change impact assessments is based on probability projections from GCM scenarios and base-line data on coastal resources, agriculture, forests, desertification, fisheries,

biodiversity, and human health. This list of sectors is not exhaustive, and the inclusion of "high-visibility" sectors in impact assessments is a function of institution action frames [Long & Iles 1997]. In applying for funds to conduct vulnerability assessments, developing countries are confined to institution action frames of the contract. In certain cases, methodological constrains are also imposed on the conduct of vulnerability assessments [USCSP 1999; GEF 1999]. Rigid institution action frames may facilitate consensus building and the production of synthesis reports, but they may also adversely affect the ability of African countries to develop frame communication pathways required for dynamic vulnerability assessments that respond to updates in baseline conditions and methods of analysis.

The assessments conducted by the Intergovernmental Panel on Climate Change (IPCC) have become the operational center for the development and dissemination of action frames regarding global climate change impacts. In general, IPCC assessments have endorsed the framing of Africa's extreme vulnerability to climate change, but with particular focus on human health, food security, and water [IPCC 1997]. These three sectors manifest collectively as public health concerns, and they were emphasized among other vulnerable sectors, including biodiversity, dersertification, and coastal settlements and infrastructures. The IPCC action frames also operate within each vulnerable sector. For example, within the human health category, climate-induced changes in the burden of malaria, schistosomiasis and dengue/dengue-hemorrhagic fever are expected to dominate the design of pre-emptive adaptation strategies [IPCC 1997; WMO 1999]. The benefit of a focused action frame is to encourage policy agreements, but in the scarcity of baseline data, there is a danger of uncritical adjustment of national priorities for the benefit of gaining international financial support [Cooper et al. 1998].

In countries such as Nigeria where 90% of the economy depends on petroleum mining in the coastal Niger delta area, vulnerability to sea level rise, and the consequences of reduced market for carbon-based fuels have overshadowed other climate change concerns [Umolu 1994]. The Africa region also includes countries at the extremes of energy utilization and economic efficiency. For example, Gabon operates a highly energy efficient economy (the GDP output/kg oil-equivalent in 1996 was 3.3, compared to 3.4 for the United States), but it exists in the same "IPCC region" as some of the most inefficient economies, such as Nigeria with a GDP/kg oil equivalent of 0.4 in 1996 [UNDP 1999]. Therefore, if national vulnerability and adaptation assessments are independent of institution action frames, the variety of economic and environmental concerns in Africa should be reflected in the record of participation in internationally-funded country study programs, and in the expression of apathy to the UNFCCC [Lopez 1999]. The following analysis of USCSP illustrates the ways in which institution action frames can influence the vulnerability assessments in Africa.

Vulnerability and adaptation assessments conducted by African participants in the USCSP is presented in Table 3. Based on the coverage of sectors by the countries, it is possible to deduce that climate impacts on agriculture, water resources and forests dominate the concerns of African countries, in contrast to the IPCC assessment described above. However, another plausible explanation is that the selection of sectors represented in vulnerability and adaptation assessments is a direct reflection of the institution action frame tacitly imposed by the USCSP program. This latter view is supported by the fact that the first international workshop to include human health vulnerability and adaptation to global climate change occurred in 1995 in Harare, Zimbabwe [Dixon *et al.* 1996]. However, as early as 1990, WHO had issued a report on the potential health impacts of climate change [WHO 1990]. The following quotations provide context for the discussion on the influence of institution action frames on the assessments conducted in Africa:

*Question:* "Could you explain the dynamics of the exchange that goes into how the USCSP

determines what they want to fund and what countries select as relevant, and how the negotiations about proposals and funding agreements are conducted?"

*Jack Fitzgerald, Acting Director of USCSP:* "We imposed some general constraints. We are not a basic science agency. We emphasized the nexus between science and policy-relevant questions within the context of the convention itself. Inventories must be done first. Therefore, we said we would fund inventories. It was not actually a requirement in the first round. In the second round, we did say, if you do not have an inventory study, and no one else is funding it, then your proposal has to include inventories. Mitigation is a big area, and we encouraged proposals to do mitigation assessments. Then came Vulnerability and Adaptation. If a country came and said we need money for tidal gauges, well, that is not what we do. However, in this broad area, we responded to what countries proposed to us. You did not have to do mitigation or vulnerability analysis. The only thing you had to do, at least in the second round was inventory."

*Question*: "Were you surprised by any of the proposals, but that you could not rule out, because they addressed issues relevant to local situations, and still remained within the convention framework?"

***Jack Fitzgerald***: "Surprised? I would say that, *except in the health area, which really did in fact come up from a number of different countries*, nothing else came completely out of the blue because we had a big net. I am sure that in some cases, we were surprised, may be surprise is not the right word, but certain proposals were cutback because they included aspects that did not quite fit into our agenda."

"We funded one regional Study in Central America where the countries came together at a ministerial level and they wanted to study only vulnerability. They did not want to investigate mitigation, because in their opinion, there will be no political support for mitigation unless they believe that vulnerability is an issue. We agreed with them, and they proceeded with their vulnerability assessment."

Similar questions were also posed to Sandra Guill, the USCSP regional director for Africa:

*Question*: "None of the 56 countries did anything about health in the first round?"

***Sandra Guill, USCSP Regional Coordinator for Africa:*** "Right. In round one, we negotiated with countries on what their work plan would be, and what they wanted to do, within budgetary constraints. Health was not an area that was covered in round one. When we did round two, we added several new sectors, including health effects, wildlife and ecotourism, and fisheries."

"There was an early interest in doing health. But because it had not been budgeted for, by the time we developed it in round two, a lot of the countries had already spent their money, and they did not have the funding to do it. In order to do the health component, we did a training workshop in Zimbabwe, based on the model called TARGETS. But there had not been too much work done on the health component in our program, and even now, only

South Africa is doing much of anything on the health impacts."

"I think that we had the one thing that we never did do in the CSP, because of the funding, was that we had a lot of requests from countries to do regional studies, e.g. the Zambezi river basin, or the Nile basin, etc. There was a lot of interest in the countries and among the experts, but we simply did not have sufficient money. But there were definitely several proposals to do health studies on a regional scale."

These responses demonstrate the complexity of communicative interactions that shape the framing of vulnerability assessments across geographical and political scales. The responses also provide a partial qualitative answer to the first question posed in this study: "how is the global framing of "health impacts of climate change" translated in the research agenda and policy forums of African countries that participate in Country Study Programs supporting the implementation of UNFCCC?" Clearly, there are constraints imposed by extramural funding sources on the kinds of vulnerability assessments conducted in Africa. A full answer to the question requires an evaluation of the activities of cross-boundary institutions such as the WHO in framing assessment questions at the local level. Although WHO has representatives in 46 African countries [Figure 1], by 1999 only Zambia had produced an itemized assessment of human health vulnerability to climate change. The Zambia assessment focused on malaria, bilharzia/schistosomiasis, cholera, bubonic plague, and malnutrition [USCSP 1999], but projections of climate change impact on the incidence of these diseases were hampered by the paucity of baseline data on health statistics. Nevertheless, coverage of the health sector in African assessments of vulnerability to global climate is broader than its coverage in other geographical regions involved in the USCSP. Only two other countries (Sri Lanka and Thailand) out of 40 countries in Asia, Latin America, and Central Europe have conducted assessments of vulnerability to the health impacts of climate change under the UNFCCC framework [USCSP 1999].

The mandate of WHO representatives in African countries is to focus on priorities that agree with national goals for health provision and planning. However, three criteria are used to define the agenda of the local WHO office:

*Lola Sadiq, Chief Epidemiologist for WHO-Nigeria:* Our framework is to work in the best interest of host countries, through productive participation in national health plans. We met recently with ministry officials them to make action plans for years 2000 and 2001. We base our decision on WHO's ability to make a change, which is based on (1) regional strategy, (2) global disease control programs such as eradication efforts, and (3) what will make a significant change in the country. These are the criteria that WHO uses to judge participation in a country's health program. If we engage in capacity building through staff training, we expect to have results in terms of apparent changes in the strategy to control specific diseases. We compare disease statistics before and after the training efforts. We also gather baseline data."

Partly based on the application of these criteria, the WHO representative in Nigeria recommended a focus on cerebrospinal meningitis, a climate-sensitive epidemic in the Northern region of the country, as an emergent concern in the framing of health vulnerability to climate change. However, this disease is not generally included in the global framing of climate change impacts [IPCC 1997], and the support for data collection is lacking:

*Lola Sadiq, Chief Epidemiologist for WHO-Nigeria:* "The disease that can be eradicated with better understanding of climate is cerebrospinal meningitis. We want the incidence reported weekly. But the ministry only gives us monthly incidence data. If we have weekly

data, we will have a better model so that we can predict incidence based on climate changes. We need to know whether it will be every year, every three years, etc."

"We wrote a letter to the ministry in November because that is usually the time that meningitis begins, so let us start immunizing people. They now had several vaccine preparations, but they still needed supplements. There is herd immunity from the last outbreak in 1996 and several states now stock their own vaccines. But the credibility of predictions need to be sustained to have this program successful."

## 9. THE DYNAMIC NATURE OF VULNERABILITY: IMPLICATIONS FOR THE DESIGN OF ASSESSMENTS

In the constitution of WHO, health is defined ambitiously as "a state of complete physical, mental and social well-being, and not merely the absence of disease or infirmity" [WHO 1946]. The implication of this broad definition for climate change research is that vulnerability can be framed in a way that covers a wide range of possible impacts. This is reflected in the literature on health impacts of climate change [Balbus *et al.* 1998]. Virtually, all the traditional concerns of the environmental health discipline have been re-framed as potential climate change impacts. This simply reflects the position of human health in the hierarchical view of how ecosystems are organization. Human health is influenced by many other sectors of global climate change impact assessments [Feenstra *et al.* 1998]. Therefore, vulnerability assessments designed around compartmentalized sectors (for example under the USCSP; Table 3) provides an illusion of discretion in assessment of climate impacts.

The dynamic nature of vulnerability in the health sector also affects the selection of time frames used in climate impact assessments. The selection of incremental, short-term time frames has proved to be more useful for health impact assessments than single long-term time frames typically used in climate change research (e.g. 2050 scenarios) [Balbus *et al.* 1998]. Still, the various lengths of incubation periods required for the expression of different diseases can complicate the design of vulnerability assessments. For example, mortality due to heat stress requires daily measurements, infectious vector-borne diseases requires weekly or monthly data in the climate-health axis, and diseases such as shellfish poisoning that are influenced by the slow warming of oceanic waters may require years of monitoring [Balbus *et al.* 1998; Colwell 1996].[8] Recent experience with the AIDS epidemic, cholera outbreaks, and Hantavirus also prove that diseases can appear suddenly in a population, become self-limiting or spread widely. Public health professionals did not predict the emergence of these diseases because of the difficulty of integrating vulnerability assessments into health surveillance programs.

## 10. VULNERABILITY ASSESSMENTS AS AVENUES FOR FRAME REFLECTION ON THE ISSUES OF SCALE AND RELEVANCE

The inability to move beyond hypothetical scenarios is the most challenging weakness of current climate change research. In the health sector, the paucity of spatially geo-referenced disease prevalence data tends to invalidate the output of existing numerical models, (e.g., MIASMA) that are used to project future distribution of disease burden [Feenstra *et al.* 1998]. Consequently, no certain conclusions have been reached about future impacts of climate change because the baseline scenarios are poorly characterized. The dynamic nature of vulnerability affects the design of adaptive strategies in areas where certain diseases are endemic, and may be intensified under new climate conditions. Similarly,

changing environmental conditions and population mobility also affects the vulnerability of regions where a particular disease is currently absent.[9]

Mapping Malaria Risk in Africa/Atlas du Risqué de la Malaria en Afrique (MARA/ARMA) is a continental initiative based in Durban, South Africa that has attempted to confront some of the problems associated with the translation of vulnerability frames across national boundaries. The MARA/ARMA initiative is committed to an open-ended assessment, and its framework is to gather and collate baseline data on the intensity of malaria transmission and geo-referenced climate indices through five regional centers located systematically across African [Le Sueur 1997]. The MARA/ARMA project showed initially that geographical dispersion does not pose an insurmountable barrier against creating databases that could move climate change vulnerability assessments beyond the scenario level. However, preliminary evaluation of the program indicates that cooperation among centers has not been uniform due to shortage of funds, which presently depends on donations from Wellcome Trust, the Canadian International Development and Research Center, and the South African Medical Research Council [Le Sueur 1997]. Nevertheless, the MARA/ARMA model is being proposed as a vehicle for collecting information of importance to other African diseases [Balbus *et al.* 1998]. If this occurs with some guarantee of financial support from Africa countries, MARA/ARMA could emerge as a boundary institution with a focus on regional vulnerability to health impacts of environmental change. The objective would be to have a sufficient bank of information to support critical frame reflection on emergent global health paradigms and the relevance of transnational environmental assessments.

Locally based open ended vulnerability assessment programs can also facilitate the integration of local knowledge and values into the ranking process used to prioritize policy options for adapting to specific impacts. In this regard, the following responses to the framing of Africa's vulnerability to the impacts of climate on nutritional health demonstrates the problems that arise from poor understanding of the communication processes between cross-national institutions and the harbingers of local knowledge, and local policy institutions:

> ***Ken Dashiell, Director of Crop Improvement, IITA, CGIAR:*** "Our climate change agenda is focused on carbon sequestration through increasing the soil biomass, and on the breeding of plant crops that are resistant to drought and insect pests. Cowpea is a good example to illustrate the complex nature of work in this area.":
>
> "About 300 km north of the Nigeria-Niger border, we have cowpea experiments. In 1997, the first year we went to the village with cowpea seeds that has good drought tolerance. We planted the cowpeas and the farmers were laughing at us. We were planting in the spacing that we normally use, 45 cm. The farmers usually plant at 1.5 to 2 meters. That year there was about 300 -350 mm of rain, all fell within 45 days, so there was no extensive drought period, which is very unusual because it is normally so dry that there are no insect pests at all, so the harvest was fantastic and the farmers were extremely elated doing traditional ceremonies to show respect. The next year, the rainfall was barely 100 mm. It was a disaster. There was no crop yield at all. Nothing survived. Normal planting time is June July. By mid July, the farmers saw that there was no hope for a harvest, and they simply packed up and moved. That was their reaction to the disaster. We all have to get used to that lesson. There are some places where agriculture just simply need a break every four years or so. This is something that policy makers grappling with global environmental change have to give some deep thought to."

Building capacity for assessing the vulnerability of human health to climate change must also consider intractable policy controversies that affect progress in adjoining sectors such as agriculture:

> *Christian Fatokun, Breeder and Biosafety Officer, IITA, CGIAR*: "IITA established modalities to assist Nigeria in establishing safety guidelines for biotechnology and genetic engineering through a series of workshops in 1993, published in 1994. It was sponsored by the Stockholm Environment Institute, Australia, Canada, U.S., and Indian scientists were present. After the guidelines were outlined, another workshop was organized to explore alternative approaches for implementation. By that time, IITA had a program in place to push the genetic engineering of cowpea as a major research emphasis."
>
> " Cowpea is particularly susceptible to a number of insect pests that are difficult to control with chemicals or conventional breeding. But somehow, the biosafety guidelines for Nigeria was not implemented, to the best of my knowledge, no other institute outside of IITA is interested, and the guidelines have not been passed as law. The minister of agriculture in 1998 inaugurated a biosafety committee (Nigerian Biosafety Committee, October, 1998). Membership of the committee was problematic because many of the people who attended the original workshop in 1994 were absent. Therefore, another workshop had to be organized to get everyone up to speed. To our surprise, Early in December 1999, we got word that the ministry of environment is having an inter-ministerial conference on biosafety. When in fact the ministry has representatives on the National Biosafety Commission. [Sounds like a turf battle is developing?]. They invited IITA for the meetings on December 9th, but we were not informed until the 8th, so there was no way for us at IITA to participate. We, at IITA, continue to use the guidelines as developed for Nigeria in 1993. Cowpea is a very difficult plant to keep safe because natural cross-fertilization with wild varieties has been documented and the biosafety rules must be rigorously applied."
>
> "Even the international biosafety commission states very clearly, that each country must develop its own biosafety guidelines. The rigor of testing, etc. can only be done locally. For example, through collaborations with some researchers in Belgium, we developed a genetically engineered plantain that is resistant to some fungal pathogens. But we have not been able to test these plants because we can not bring them back to Nigeria as genetically engineered products. The plantain is also useless to Belgians, so this was a wasteful exercise, so far where policy development has not kept pace with research due to political difficulties."

## 11. EMERGENT STRUCTURES FOR BUILDING SUSTAINABLE CAPACITY FOR VULNERABILITY ASSESSMENTS

Vulnerability and adaptation assessments under the USCSP were intended to assist developing and transition countries to understand their potential vulnerabilities to climate change. When many countries became signatories to UNFCCC, there was little or no country-specific information on how they could be affected by climate change [USCSP 1999]. The USCSP was one of the early programs to work directly with African countries in conducting vulnerability assessments. The objective was to build capacity through the provision of training, software, and data needed to assess potential impacts of climate change. The program's goal was to create a foundation upon which future assessments of climate change

can be carried out. Therefore, the program emphasized the training of in-country scientists, who were supported by their governments to conduct the assessments. However, the USCSP action frame applied through the acceptance or rejection of proposals, and through the rigid specification of sectors and methods of the assessment, influenced the mode of participation by different countries. The following quotation provides context for this assertion:

> *Sandra Guill, USCSP Regional Coordinator for Africa*: "What we did was to say, there are several models out there, but we want you to use these specific ones (e.g. COPATH and COMAP for forestry and carbon sinks; and TARGETS for health impacts). By having everyone of our countries use the same model, and we are not saying that they are the best, or most salient, but it allowed us to synthesize the results of the studies into a coherent global picture of climate change assessment and impacts. This book (first report) was a result of that synthesis. This book was the training model."

The USCSP has fulfilled some of its objectives in assisting many developing countries to initiate indigenous environmental assessments, but the test of capacity development is the sustainability of local vulnerability assessments that engage responsive, long-term frame reflection. Relief from the constraints imposed by institution action frames can occur through building flexibility into the translation of global frames endorsed by the parent organizations of boundary institutions. This will require a commitment to frame experimentation and a willingness by transnational funding programs to yield to the outcome of frame reflection in local assessments of the impacts of climate change. The potential benefits are substantial for sustainable capacity development to meet the continuously changing requirement of vulnerability assessments.

In recognizing the limitations of current capacity building programs, a strategic partnership was recently formed between UNDP and GEF to produce a comprehensive approach for developing the capacities needed at country level to meet the challenges of global climate change [UNDP-GEF 1999]. The new partnership distinguishes "capacity development" from "capacity building" in that the former shifts emphasis from a process that is externally driven to one that is self-motivating and takes place gradually from within. In this context, capacity development is defined at three levels: individual, institutional or entity, and the overall system in which individuals and entities interact and operate [UNDP-GEF 1999]. Capacity retention at the systems level is perceived as more critical than development at the individual and entity levels. Consequently, many development agencies have adjusted their strategies towards more programmatic approaches that address the interrelationships between the individual, entity, and system levels. This approach encourages the sense of capacity ownership by developing countries. Based on personal interviews with USCSP participants in Nigeria, and on the responses to questionnaires from USCSP participants in other countries, it is uncertain that the capacity for updating vulnerability assessments is sustainable. This appears to be due in part to limited engagement of communicative processes between the three levels of actors involved, namely the research scientists who conducted the assessments, the resident cross-boundary institutions such as WHO and CGIAR representative, and the federal ministry officials who had to endorse the participation.[10] In a broader view of capacity development, the focus on the ability of individuals and entities is transformed into an enabling environment at the local, national, and regional levels consisting of regulatory frameworks, information, and knowledge technologies that ultimately feed into the improvement of global environmental management [UNDP-GEF 1999]. The "self-interest" appeal of open-ended vulnerability assessments could provide the right incentive for the acceptance of such capacity development initiatives.

## 12. CONCLUSIONS

In ideal circumstances, a country's decision to engage national resources (financial and intellectual) in the assessment of impacts attributable to global climate change must depend on the perception of vulnerability by local scientific and political institutions. However, the perception and assessment of vulnerability are both influenced by factors related to issue framing which has essentially become a transnational phenomenon. In countries with limited capacity to engage in large-scale assessment of every conceivable impact, the persuasiveness of rhetorical frames in vulnerability assessments is of paramount significance. Rhetorical frames are useful for drawing local attention to global issues, and vise-versa. But effective frame translation from global concerns to local relevance can be constrained by institution action frames when financial arrangements require the endorsement of problem definition and methodological approaches. In Africa, boundary institutions that represent global visions while maintaining national visibility occupy a special node in the communication pathways useful for translating global frames into local action. In the public health sector, boundary institutions such as WHO and CGIAR have access to local scientists, policy makers, and the public through their roles in capacity development, policy advice, and extension education. To these functions must be added the responsibility for encouraging critical frame reflection for integrating local knowledge and values into climate change vulnerability assessments.

This research suggests that if the boundary institutions responsible for public health security have not been very effective in resolving the policy controversy surrounding Africa's participation in climate change assessments, it is due in part to limitations imposed by cross-scale issues in framing. Credible projections of health impacts of global climate change are particularly difficult because much of the information required for the exercise are rooted in local circumstances and baseline data that are fraught with uncertainties [McMichael & Martens 1995; McMichael & Sari Kovats 2000]. Moreover, theoretical underpinnings of the relationship between environmental quality and human health have traditionally marginalized the dynamic nature of regional vulnerability, group susceptibility, and social adaptation [Lucas 1998].

Efforts to reduce Africa's dependence on global emergency health response systems will require the development of autonomous capacity to anticipate and adapt to natural disasters. Without appropriate frame reflection at the local level, globally framed assessments tend to marginalize indigenous adaptive experience and value systems [Carr & Mpande 1996]. Theoretical advances in social studies of science suggest that tacit assumptions about motives, public values, social order, and communication pathways influence cross-scale translation of norms and frames in global environmental regimes [Clark 1987; Jasanoff 1996; Turner *et al.* 1991]. Uncritical frame reflection can lead to value conflicts, inadequate policy development, and losses of opportunities for articulating indigenous solutions to global problems that have serious local repercussions. Improvement of the role played by boundary institutions in cross-scale vulnerability assessments will require continuous evaluation of how the framing of climate change impacts is translated across geographical, political and cultural boundaries, particularly under constraints imposed by the structure of funding for global environmental assessments. Finally, the establishment in Africa of indigenous programs that focus on open-ended vulnerability assessments could encourage the maturation of communication pathways that are essential for societal adaptation to the impacts of both local climate variability and global climate change.

For progress to occur in this direction, additional research is needed on various fronts, some of which are suggested by the present study. First, the existing variety of Country Studies Programs provides a unique opportunity for a comparative analysis of different assessment designs and how their outcomes are influenced by the configuration of various science-policy interfaces in localities where the assessments

are being conducted. This line of research has become particularly salient as we approach the synthesis stage of the "national communications" mandated by the UNFCCC, and the attempt is made to apply the same normative judgement and level of credibility to information submitted by various countries. Secondly, this research broached the topic of hegemony in the framing of vulnerability assessments through the influence wielded by industrialized countries over the provision of funds and technical support for studies in developing countries. The question that remains to be answered is whether this form of hegemony has contributed in any way towards the resolution of the controversy surrounding the equity debate in the management of global climate change. Thirdly, as vulnerability, impacts, and adaptation become the focus of activity in research and policy on global climate change, the difficulty in producing a universally acceptable valuation scheme for impacts must be confronted. The valuation of health impacts has been particularly troublesome, but its solution is required for resource allocation for vulnerability assessments and for managed adaptation in the various sectors. The interconnected of human health with practically all other market sectors that are sensitive to climate change might require the development of some "weighting" strategy in vulnerability and impact assessments. Finally, further research on the contribution of framing and frame reflection to the development of sustainable capacity for environmental research in developing countries is warranted. The new UNDP-GEF partnership on capacity development provides a rich opportunity to test the long-term benefits of including the capacity for frame reflection in agenda of international programs engaged in building technical capacity in Africa and in other developing and transition countries.

## REFERENCES


Adegbulugbe, A.O., Ibitoye, I.F., Siyanbola, W.O., Oladosu, G.A., Akinbami, J.F.K., Pelemo, D.A., Adesina, F.A. and Oketola, F.O. (1997) *Greenhouse Gas Emission Mitigation in Nigeria.* In: S. Meyer, Goldberg, B., and Sathaye, J. (Eds). Global Climate Change Mitigation Assessment: Results for 14 Transition and Developing Countries. Pages 221-241. U.S. Country Studies Program, Washington, DC.

Agarwal, A. (1990) The North-South Perspective: Alienation or Interdependence. *AMBIO* 19:94-96.

Agarwal, A, and Narain, S. (1991) *Global Warming in an Unequal World.* Center for Science and the Environment, Delhi, India.

Anya, A. O. (1977) Science policy and the development of Nigeria's geopolitical potential: lecture given at the Nigerian Institute of International Affairs, Victoria Island, Lagos. Series title: The Nigerian Institute of International Affairs lecture series, no. 17, Lecture series Nigerian Institute of International Affairs, Lagos. 32 p.

Anya, A. O. (1986) Scientific research and public policy /, by A.O. Anya. Lagos, Nigeria: Nigerian Institute of International Affairs. Lecture series no. 38. 0331-6262 Nigerian Institute of International Affairs, Lagos, Nigeria. 32 p.

Anya, A. O., editor (1992) Science, leadership and national development: proceedings of a national symposium held at the Nigerian Institute of International Affairs, Victoria Island, Lagos, Nigeria on 3rd & 4th March, 1992.

Anya, A. O. (1993) Science and the crisis in African development. Ida-Ivory Press, Lagos, Nigeria. 285 p.

Apuuli, B., Wright, J., Elias, C. and Burton, I. (2000) Reconciling National and Global Priorities in Adaptation to Climate Change: With an Illustration from Uganda *Environmental Monitoring and Assessment* 61:145-159.

Aron, J.L. and Davis, P. (1993) *A Comparative Review of the Economic Impact of Selected Infectious Diseases in Africa.* Johns Hopkins University, Baltimore, Maryland.

Awe, O. and Anya, O., editors (1987) The role of scientific societies in national development : proceedings of an international conference held on 26-30 April 1987, at Durbar Hotel, Lagos, to mark the 10th anniversary of the Nigerian Academy of Science, xi, 269 p.

Balbus, J.M., Bouma, M., Kovats, S., LeSueur, D., Martens, W.C., and Patz, J. (1998) Human Health. Chapter 10 in Feenstra, J., Burton, I., Smith, J.B., and Richard, S.J.T. (Eds) *Handbook on Methods for Climate Change Impact Assessment and Adaptation Strategies.* Version 2.0. United Nations Environment Program & Institute for Environmental Studies, Vrije Universiteit Amsterdam.

Benioff, R., Guill, S. and Lee, S. (Eds) (1996) *Vulnerability and Adaptation Assessments: An International Handbook.* United States Country Studies Program. Kluwer Academic Publishers, Dordrecht, The Netherlands.

Bouma, M., Sondrop, H.E., and van der Kaay, H.J. (1994) Climate Changes and Periodic Epidemic Malaria. *Lancet* 343:1440.

Carr, S., and Mpande, R. (1996) Does the Definition of the Issue Matter? NGO Influence and the International Convention to Combat Desertification in Africa. *Journal of Commonwealth and Comparative Politics* 34:143-165.

Chukwuma, C. (1994) Health Concepts, Issues, and Experience in the Abakaliki Area, Nigeria. *Environmental Health Perspectives* 102:854-856.

Clark, W.C. (1987) *Scale Relationships in the Interactions of Climate, Ecosystems, and Societies.* In K.C. Land and S.H. Schneider (Eds). Forecasting in the Social and Natural Sciences. Pages 337-378. Reidel, Dordrecht, The Netherlands.

Cohen, J. (2000) AIDS Researchers Decry Mbeki's Views on HIV. *Science* 288:590-591.

Colwell, R.R. 1996. Global Climate Change and Infectious Disease: The Cholera Paradigm. *Science* 274:2025-2031.

Cooper, R.S., Osotimehin, B., Kaufman, J.S. and Forrester, T. (1998) Disease Burden in Sub-Saharan Africa: What should we conclude in the Absence of Data? *Lancet* 351:208-210.

Cronon, W. (1992) A Place for Stories: Nature, History, and Narrative. *Journal of American History*, March:1347-1376.

Dixon, R.K., Guill, S., Mkanda, F.X. and Hlohowskyj, I. (Eds) (1996) *Vulnerability and Adaptation of African Ecosystems to Global Climate Change.* 201 pages. Inter-Research, Oldendorf/Luhe, Germany. Also *Climate Research* 6:1-201.

Fairhead, J. and Leach, M. (1996) *Rethinking the Forest-Savanna Mosaic: Colonial Science and its Relics in West Africa.* In: M. Leach and R. Mearns (Eds). The Lie of the Land: Challenging Received Wisdom on the African Environment. International African Institute, London.

Feenstra, J., Burton, I., Smith, J.B., and Richard, S.J.T. (Eds) (1998) Handbook on Methods for Climate Change Impact Assessment and Adaptation Strategies. Version 2.0. United Nations Environment Program & Institute for Environmental Studies, Vrije Universiteit Amsterdam.

Ghana Health Assessment Project Team. (1981) A quantitative method of assessing the health impact of different diseases in less developed countries. *International Journal of Epidemiology* 10:73-80.

Global Environment Facility. (2000) *The GEF Programmatic Approach: Criteria and Processes for its Implementation.* Global Environment Facility, Washington, DC.

GTZ (2000) German Co-operation with Developing Countries on Climate Policies. http://www.gtz.de/climate/fccc/e_coop.html.

Herberlein, T.A. (1977) Norm Activation and Environmental Action. *Journal of Social Issues* 33:207-211.

Homer-Dixon, T.F. (1990) *Environmental Change and Violent Conflict.* Occasional Paper No. 4, International Security Program, American Academy of Arts and Sciences, Cambridge, MA.

Hyder, A.A., Rotlland, G. and Morrow, R.H. (1998) Measuring the Burden of Disease: Healthy Life-years. *American Journal of Public Health* 88:196-202.

International Institute for Tropical Agriculture (2000) Institute Information. http://www.cgar.org/iita/.

IVM (2000) Netherlands Climate Change Studies Assistance Program. http://www.vu.nl/english/o_o/instituten/IM/research/climatechange/fb_info.htm.

Jasanoff, S. (1996) *Science and Norms in Global Environmental Regimes.* Pages 173-197 In: Hampson, F.O. and Reppy, J. (Eds). Earthly Goods, Environmental Change and Social Justice. Cornell University Press, Ithaca.

Jaeger, J., van Eijndhoven, J. and Clark W.C. (2000) *Knowledge and Action: An Analysis of Linkages among Management Functions for Global Environmental Risks* Chapter 21 In Clark, W.C., Jaeger, J., van Eijndhoven, J., and Dickson, N.M. Learning to Manage Global Environmental Risks: A Comparative History of Social Responses to Climate Change, Ozone Depletion and Acid Rain. MIT Press, Cambridge.

Kalkstein, L.S. and Smoyer, K.E. (1991) The Impact of Climate on Human Health: Some International Implications. *Experiencia* 49:469-479.

Kandlika, M. and Sagar, A (1997) *Climate Change Science and Policy: Lessons from India.* Environment and Natural Resources Program Discussion Paper E-97-08, Kennedy School of Government, Harvard University, and International Institute for System Analysis Interim Report IR-97-035/August.

Kates, R.W., Ausubel, J.H. and Berberian, M. (Eds) (1985) *Climate Impact Assessment: Studies of the Interaction of Climate and Society.* ICSU/SCOPE Report No. 27. John Wiley, Chichester.
Kempton, W. (1991) Lay Perspectives on Global Environmental Change. *Global Environmental Change* 1:183-208.

Le Sueur, D. (1997) Annual Report of the Mapping Malaria Risk in Africa (MARA) / Atlas du Risqué de la Malaria en Afrique (ARMA) Project. Durban, South Africa.

Levins, R., Awerbuch, T. and Brinkman, U. 194. The Emergence of New Diseases. *American Scientist* 82:52-60.

Long, M. and Iles, A. (1997) *Assessing Climate Change Impacts: Co-evolution of Knowledge, Communities, and Methodologies.* ENRP Discussion Paper E-97-09. Kennedy School of Government, Harvard University, Cambridge.

Lopez, R. (1999) *Incorporating Developing Countries into Global Efforts for Greenhouse Gas Reduction.* Resources for the Future, Climate Issue Brief Number 16. Resources for the Future, Washington, DC.

Lucas, A. (1998) WHO at Country Level. *Lancet* 351:743-747.

MacLean, D.E. (1990) *Comparing Values in Environmental Policies: Moral Issues and Moral Arguments.* In P.B. Hammond and R. Coppock (Eds). Valuing Health Risks, Costs, and Benefits for Environmental Decision-Making. National Academy Press, Washington, DC.

Magazda, C.H.D. (2000) Climate Change Impacts and Human Settlements in Africa: Prospects for Adaptation. *Environmental Monitoring and Assessment* 61:193-205.

Martens, P. and Hall, L. (2000) Malaria on the Move: Human Population Movement and Its Impact on Malaria Transmission. *Emerging Infectious Diseases* 6:103-109.

Masood, E. (2000) Biting back. *New Scientist* 167:41

McMichael, A.J. and Martens, W.J.M. (1995) The Health Impacts of Global Climate Change: Grappling with Scenarios, Predictive Models, and Multiple Uncertainties. Ecosystem Health. 1:23-33.

McMichael, A.J. and Sari Kovats, R. (2000) Climate Change and Climate Variability: Adaptations to Reduce Adverse Health Impacts. *Environmental Monitoring and Assessment* 61:49-64.

Mendelsohn, R. and Neumann, R.E. (Eds) (1999) *The Impact of Climate Change on the United States Economy.* 344 Pages, Cambridge University Press, New York.

Miller, C. (1998) Extending Assessment Communities to Developing Countries. ENRP Discussion Paper E-98-15. Kennedy School of Government, Harvard University.

Murray, C.J.L. and Lopez, A.D. (Eds) (1996) *The Global Burden of Disease: A Comprehensive Assessment of Mortality and Disability from Diseases, Injuries, and Risk Factors in 1990 and Projected to 2020.* Cambridge, MA: Harvard University Press.

Nabarro, D. (1999) *Roll Back Malaria.* Presentation to the United States Congress. November. http://www.who.ch/rbm/.

Nwaorgu, O. and Johnston, N. (2000) The Roll Back Malaria Summit. *MalSum News* 1:1-2. Abuja, Nigeria.

Ominde, S.H. and Juma, C. (eds) (1991) A change in the weather: African perspectives on climatic change. African Center for Technology Studies. 210 p. African Center for Technology Studies (ACTS) environmental policy series; Number 1., African Center for Technology Studies. ACTS Press, Nairobi, Kenya.

Ottichilo, W. K., Kinuthia, J.H., Ratego, P.O., and Nasubo, G. W. (1991) Weathering the storm: climate change and investment in Kenya. Series title: African Center for Technology Studies (ACTS) environmental policy series; no. 3, African Center for Technology Studies ACTS Press, Nairobi, Kenya. 90 p.

Pittock, A.B. and Jones, R.N. (2000) Adaptation to What and Why? *Environmental Monitoring and Assessment* 61:9-35.

Poulos, C. and Whittington, D. (2000) Time Preference for Life-saving Programs: Evidence From Six Less Developed Countries. *Environmental Science and Technology* 34:1445-1455.

Rich, B. (1994) *Mortgaging the Earth: The World Bank, Environmental Impoverishment, and the Crisis of Development.* Beacon Press, Boston, MA.

Sachs, J.D. (2000) What $8 a Year Could Do for Africa. Washington Post, May 23. Washington, DC.

Schon, D.A. and Rein, M. (1994) *Frame Reflection.* Pages 3 – 58. Basic Books, New York.

Shue, H. (1999) Global Environment and International Inequality. International Affairs 75:531-545.

Smith, J.B., Huq, S., Lenhart, S., Mata, L.J., Nemesova, I., and Toure, S. (Eds) (1996) *Vulnerability and Adaptation to Climate Change: Interim Results from the U.S. Country Studies Program.* 367 Pages. Kluwer, Dordrecht, The Netherlands.

Snow, D.A. and Benford, R.D. (1992) *Master Frames and the Cycles of Protest.* In Morris, A.D. and C.M. Mueller (Eds). Frontiers in Social Movement Theory. Yale University Press, New Haven.

Stern, P.C., Young, O.R. and Druckman, D. (Eds) (1992) *Global Environmental Change: Understanding the Human Dimensions.* 308 Pages. National Research Council, National Academy Press, Washington, DC.

Turner, B.L., II, Kasperson, R.E., Meyer, W.B., Dow, K., Golding, D. Kasperson, J.S., Mitchell, R.C. and Ratick, S.J. (1991) Two Types of Global Environmental Change: Definitional and Spatial Scale Issues in Their Human Dimensions. *Global Environmental Change* 1:14-22.

Umolu, J.E. (Ed) (1994) *Global Climate Change: Impact on Energy Development.* Proceedings of the International Workshop on Impact of Climate Change on Energy Development, March 28-30, Lagos, Nigeria. ASEA Brown Boveri, Zurich.

United States Country Studies Program (1999) *Climate Change: Mitigation, Vulnerability, and Adaptation in Developing and Transition Countries.* The United States Country Studies Management Team, Washington, DC.

United Nations (1992) *Framework Convention on Climate Change.* United Nations, New York.

United Nations Development Program (1999) *The Human Development Report.* United Nations Publications, New York.

United Nations Development Program and the Global Environment Facility (1999) Capacity Development Initiative. UNDP-GEF Strategic Partnership. Terms of Reference. Global Environment Facility, Washington, DC.

Usher, P. (2000) Integrating Impacts into Adaptation Measures. *Environmental Monitoring and Assessment* 61:37-48.

Watson, R.T., Zinyowera, M.C., Moss, R.H. and Dokken, D.J. (Eds) (1997) *The Regional Impacts of Climate Change: An Assessment of Vulnerability.* Summary for Policymakers. Intergovernmental Panel on Climate Change. World Meteorological Organization and the United Nations Environment Program.

Watts, M. (1987) *Silent Violence: Food, Famine, and Peasantry in Northern Nigeria.* University of California Press, Berkeley.

Wilson, M.E., Levins, R. and Spielman, A. (Eds) (1994) Disease in Evolution: Global changes and Emergence of Infectious Diseases. *Annals of the New York Academy of Sciences* 740: 1-503.

World Health Organization (1946) Constitution of the World Health Organization. Final Acts of the International Health Conference, New York. http://www.who/

World Health Organization (1990) *Potential Health Effects of Climatic Change.* World Health Organization, Geneva.

World Health Organization (1997) *The Roll Back Malaria Initiative.* World Health Organization, Geneva.

World Meteorological Organization (1999) *Weather, Climate and Health.* Message From Prof. G.O.P. Obasi, Secretary General of WMO. World Meteorological Day 1999. WMO, Geneva.

## TABLES

**Table 1: Summary of Communication Nodes and Objectives in Transnational Framing of Vulnerability Assessments.**

NATIONAL (LOCAL) SCALE (AFRICA)

TRANS-NATIONAL (GLOBAL) SCALE

| | SCIENTISTS | POLICY MAKERS | PUBLIC/MEDIA NGOs |
|---|---|---|---|
| SCIENTISTS | Predictive Models<br>Baseline Data<br><br>Primary Frame Communication and Reflection | Credibility, Validation<br>Risk Communication | Access to Indigenous Knowledge |
| BOUNDARY INSTITUTIONS | Secondary Frame Communication and Reflection<br><br>Capacity Development Constrained within Action Frames | Implementation of Action Frames<br><br>Incidental Reframing and Frame Negotiation | Emergency Intervention<br><br>Extension Education And Frame Recognition |
| PUBLIC MEDIA NGOs | Tertiary Frame Communication and Reflection | Translation of Rhetoric Frames<br><br>Support for Advocacy Coalitions | Shared Values<br><br>Socialization<br><br>Metacultural Frame Network |

**Table 2: Summary of Africa's Share of the Global Burden of Diseases Impacted by Climate**

| Disease Category | 1990 DALYs[a] | | 2000 DALYs | | 2010 DALYs | | 2020 DALYs | |
|---|---|---|---|---|---|---|---|---|
| | % of Total African Burden | **Africa's Share of Global Burden Within Category (%)** | % of Total African Burden | **Africa's Share of Global Burden Within Category (%)** | % of Total African Burden | **Africa's Share of Global Burden Within Category (%)** | % of Total African Burden | **Africa's Share of Global Burden Within Category (%)** |
| Malaria | 9 | **85** | 8 | **91** | 6 | **93** | 4 | **94** |
| Diarrhea | 11 | **32** | 9 | **41** | 7 | **46** | 5 | **49** |
| Dengue | < 0.1 | **3** | < 0.1 | **5** | < 0.1 | **6** | < 0.1 | **6** |
| Tropical[b] | 2 | **52** | 1 | **58** | 1 | **64** | 0.5 | **73** |
| Malnutrition[c] | 3 | **18** | 3 | **24** | 2 | **28** | 2 | **30** |
| Respiratory[d] | 3 | **13** | 3 | **13** | 4 | **14** | 5 | **15** |
| Eyes[e] | 1 | **19** | 1 | **19** | 1 | **19** | 1 | **20** |
| HIV[f] | 3 | **75** | 6 | **51** | 6 | **42** | 4 | **33** |

[a] Disability Adjusted Life Years Lost (Murray and Lopez, 1996)
[b] Insect-vector borne tropical-cluster diseases includes Trypanosomiasis, Schistosomiasis, Leishmaniasis, Lymphatic Filariasis, and Onchocerciasis.
[c] Nutritional deficiencies include: Protein energy malnutrition, Iodine deficiency, Vitamin A deficiency, and Iron deficiency anemia.
[d] Chronic Obstructive Pulmonary Disease (COPD) and Asthma
[e] Cataracts and Glaucoma
[f] HIV is included primarily for comparison, but the impact of climate change-induced population destabilization on the HIV epidemic should be taken seriously. Also, the impact of ultraviolet light exposure on the immune system is a concern for the prognosis of AIDS.

Data extracted from Murray and Lopez 1996 (baseline scenarios).

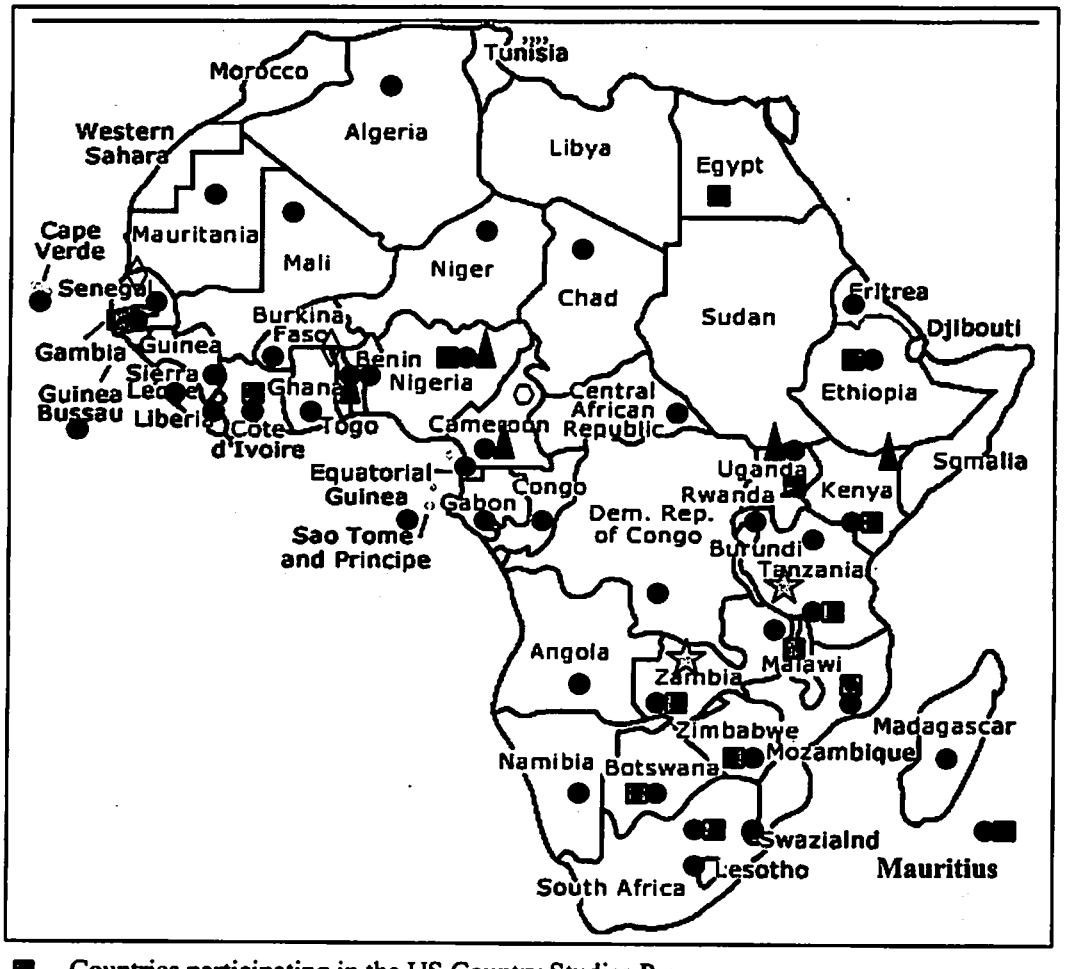
**Table 3: Summary of Sectors Covered in Vulnerability and Adaptation Assessments by African Countries participating in the United States Country Studies Program**

| Country | Coastal Resource | Agriculture | Grassland And Livestock | Water Resource | Forests | Fishery | Wildlife | Human Health |
|---|---|---|---|---|---|---|---|---|
| Botswana | | | * | *# | * | * | | |
| Cote d'Ivoire | | | | * | * | | | |
| Egypt | *# | *# | | * | | | | * |
| Ethiopia | | * | * | * | * | | | |
| The Gambia | *# | * | * | * | * | * | | |
| Kenya | | * | | * | * | * | | |
| Malawi | | | | * | * | | * | |
| Mauritius | * | * | | * | | * | | |
| Mozambique | * | * | * | * | * | | | * |
| Nigeria[a] | * | | | | * | | | |
| South Africa | | * | * | * | * | * | * | * |
| Tanzania | * | * | * | * | * | | | |
| Uganda | | * | * | * | * | | | |
| Zambia | | * | * | * | * | | * | * |
| Zimbabwe | | * | | | * | | | |

* Vulnerability Assessment
\# Adaptation Assessment
[a] Completed under the Global Environment Facility Program.

U.S. Country Studies Program 1999.

## FIGURES




■ Countries participating in the US Country Studies Program

▲ CGIAR Centers: International Institute for Tropical Agriculture

● World Health Organization Representatives (Africa Region)

☆ German GTZ Country Studies Program

◊ Netherlands Country Studies Program

○ GEF/UNEP Country Studies Program

**Figure 1: Distribution of Boundary Institutions and Epistemic Communities Engaged in Framing Vulnerability Assessments in Africa.**

## ENDNOTES

[1] This research was supported in part by a research grant from the Global Forum for Health Research in Switzerland, and by a Global Environmental Assessment (GEA) Fellowship awarded by the Environment and Natural Resources Program, Belfer Center for Science and International Affairs at Harvard University. The research benefited from discussions with GEA faculty William Clark, Sheila Jasanoff, James McCarthy, Jill Jaeger, and Nancy Dickson, as well as with present and alumni fellows of the GEA project at Harvard. Finally, sabbatical support from the University of California, Irvine is gratefully acknowledged, as well as discussions with the focused research group on International Environmental Issues, School of Social Ecology at UC-Irvine.

[2] This information was obtained through an interview with Joseph Huang, the regional coordinator for Asia and Island Countries under the USCSP. He attributed India's absence from the USCSP to the influence of a small cadre of top policy makers who essentially vetoed proposals from research institutes and independent researchers. Several Indian investigators were approached to develop proposals for funding under the USCSP, but the minister of external affairs refused to transmit letters of support and commitment to the program. Jack Fitzgerald, the USCSP regional coordinator for Latin America also observed similar events in Brazil. Argentina participated in training workshops organized by USCSP, but preferred to accept the terms and conditions of a climate change country study under the GEF rather than to continue participation in the USCSP, presumably because they would have access to more funds and more freedom in designing their study.

[3] Climate Change Country Studies Programs are divided into four related activities, (1) Greenhouse gas emission inventories, (2) Mitigation studies, meaning reduction of greenhouse gas emission, (3) Impact assessment and adaptation studies, and (4) Preparation of National Communications in agreement with the UNFCC [Feenstra *et al.*, 1998]. Based on an interview with the staff of the USCSP, proposals from countries to participate in the USCSP must include studies of GHG inventory or Mitigation, and preferably both. There was no requirement for Impact assessments and adaptation studies, and no such study was funded in the first round of funding. The second phase of funding for USCSP participants included the preparation of National Action Plans, in which only three African countries have participated: Egypt, Tanzania, and South Africa. To illustrate the difficulty in reconciling national or regional priorities with the global climate agenda, Jack Fitzgerald of the USCSP cited the case of a coalition of central Latin American countries who agreed to participate in the USCSP only if vulnerability assessments were funded first. This was because they believed that there would be no political (ministerial level) support for participation if evidence of vulnerability cannot be demonstrated. Why conduct inventories and mitigation when there is no vulnerability? Ultimately the USCSP agreed to this exceptional proposal from Latin America, but perhaps only because this was a single proposal backed by several countries. It is doubtful that the proposal would have succeeded if it were from a single country, say in Africa.

[4] For example, the United States National Assessment of is an extensive (and expensive) project. However, the effort improved the understanding of how climate change may exacerbate existing stresses on local environments and communities. Thus, a reframing of the climate change impacts was encouraged at the local level. The disadvantage of such location-specific framing is the difficulty of producing synthesis assessment, but the standardization of techniques provides a way around the problem. The design of the US assessment also benefited from the collective experience of several American participants, a privilege that is not extended to developing countries [personal communication with Robert Corell, director of the US National Assessment).

[5] I interviewed Jack Fitzgerald, the current acting director of the USCSP on April 6, 2000. The USCSP was established by executive order in 1993 during the regime of George Bush, with John Sununu as the major overseer. The initial operating budget for the program (US$20 million) was extracted from the budget of 10 Federal agencies: The Departments of Agriculture, Energy, Health and Human Services, Interior, State, Agency for International Development, Environmental Protection Agency, National Aeronautics and Space Administration, National Oceanic and Atmospheric Administration, and the National Science Foundation. The program was expected to last 2 years, and now, in its seventh year, support has dwindled, and only three core agencies who have maintained their supports through provision of funds, staff, and space: The USEPA, DOE, and NOAA. The USCSP has supported 56 developing and transition countries in climate change research, many of which include vulnerability and adaptation assessments.

[6] According to Sandy Guill, the USCSP regional coordinator for Africa and the Middle East, a substantial portion of her time and effort goes to comparing the USCSP topics covered in Africa with the agenda of other programs such as GEF, GTZ, and the Netherlands Programs. The reason is to avoid duplication of efforts. The institution action frames of the four programs are quite different. USCSP staff believes that their program is true capacity building because indigenous scientists actually carry out the assessments, but they have to follow very specific procedures and methods communicated through various workshops conducted before and during the assessments. Presumably, facilitates the production of synthesis reports by USCSP and the cross-comparison of assessments during program evaluation. According to USCSP staff, this approach contrasts sharply with GEF sponsored programs where funds are provided without a regimented structure of how to proceed, i.e., indigenous scientists are expected to select their own protocols, models, and participants.

[7] The process of participation also differs among the four programs. Participation in the USCSP requires commitment (letter of support) from the national ministries of foreign affairs, even if the proposal was written entirely by indigenous scientists not affiliated with the policy process. Nigeria is a good example of where participation was initiated by independent scientists and the letter of support by he ministry was a matter of formality. The assessment was conducted entirely by independent scientists. On the other hand, In Egypt, the ministry of the environment was very actively involved in the proposal writing, the assessment, and the report writing. According to Sandy Guill, participation by many countries in West Africa was hindered because federal ministries did not offer letters of support although there were credible proposals from indigenous scientists. This was the case for Liberia, Sierra Leone, and Niger.

[8] According to Dr. Lola Sadiq, chief epidemiologist at the WHO representative office in Nigeria, one of the most challenging disconnection between global frameworks on health and the operation of national infrastructure for health statistic is the coordination of monitoring time frames for diseases known to be influenced by climate factors. For example, vector-borne encephalitis is one of the fastest growing environmental diseases in northern Nigeria. There is credible evidence that it is linked to weather patterns that recur periodically, but weekly estimates of prevalence is required to ascertain whether otherwise sporadic cases will develop into large scale epidemics. For some technical reasons, the Ministry of Health has difficulty balancing the various time frames required for acquiring data on a host of reportable diseases.

[9] In an unpublished article, "Malaria on the Move: Human Population Movement and its Impact on Malaria Transmission", Pim Martens & Lisbeth Hall, showed that the ratio of *faciparum* to *vivax* malaria doubled in Europe between 1984 and 1993. The ratio was taken is an indicator of the spread of malaria from Africa.

[10] According to Tony Adegbulugbe, director of the Nigerian Center for Energy and Development the lead investigator of the USCSP assessment program in Nigeria, only one follow-up assessment has being conducted since the publication of the first GHG inventory conducted in Nigeria under the USCSP, which used baseline data from 1990. For the National Communication obligation under UNFCCC, Nigerian Ministry of Environment is supporting an update of the inventory to include data up to 1994. There are no plans to update vulnerability assessments. Based on responses to questionnaire, this situation is common in African countries.

An interesting finding based on responses from Eastern European countries (e.g., Czech Republic, Estonia, Ukraine, and Hungary) that participated in the USCSP, there was a sense that global environmental scheme do not adequately represent issues of pressing national concerns. Therefore, considerable effort is being dedicated to establishment of "Focal Point Institutes" to disseminate capacity for environmental assessments.

## APPENDICES

**APPENDIX 1.** Text of questionnaire used to survey the coordinators of vulnerability assessments in each of 45 countries participating in the USCSP.

**(1)** Name
**(2)** Occupation
**(3)**Academic Specialization and Degrees
**(4)** When and how did you get involved in Global Environmental Change issues?
**(5)** When and how did you become involved in the U.S. Country Studies Program?
**(6)** In order of importance (Number 1 being most vulnerable) list up to ten (10) infrastructures, tangible services and public welfare programs in your country that are vulnerable global climate change.
**(7)** What sources of information did you use to make the rankings above? For examples, (a) your own research, (b) international assessments or recommendations, (c) national agencies, (d) regional assessments, or (e) other (please describe).
**(8)** What is your assessment of the level of concern for your country's special needs by international agencies coordinating the assessment of global environmental change?
**(9)** What opportunities are available for environmental scientists and policy makers in your country to participate in international global environmental assessments (such as the Intergovernmental Panel of Climate Change)?
**(10)** Has participation in international vulnerability assessments (such as the United States CSP) contributed to the design or adjustment of national environmental policy or the restructuring of in priorities in your country? (Explain your answer).
**(11)** In your country, how vulnerable is public health to global environmental change?
**(12)** If your answer to question 11 above is a, b, c, or d, what three most important diseases will be affected most drastically by global environmental change?
**(13)** Where (what institutions) in your country is research and planning for public health impacts of environmental change being conducted? Please give specific names of researchers or agencies if known.
**(14)** What are the sources of funds for the research or policy planning described in your response to question 13 above?
**(15)** In your assessment of the current capacity for research, technology transfer and policy development in your country, what are the specific needs for effective participation in global environmental assessments? Please list as many as possible.
**(16)** Use the following space comment on this questionnaire, other issues of importance to global environmental change, or issues that are unique to your country's situation.

**APPENDIX 2.** Speech on WMO Day, March 23, 1999. WEATHER, CLIMATE, AND HEALTH (*emphasis added in italics*).

Office of the Director-General World Health Organization
Dr. Gro Harlem Brundtland
Director-General
World Health Organization
Geneva,
23 March 1999

Secretary-General Professor Obasi,
Excellencies,
Ladies and Gentlemen,

It gives me great pleasure on behalf of WHO to share the platform with Professor Obasi, Secretary-General of the World Meteorological Organization, on World Meteorological Day. In WHO we have put a new emphasis on reaching out to our external partners - to other agencies in the UN family, to the research community, to partners in civil society and to the private sector. We do so because we believe we can achieve more by pulling together and looking for solutions to health and development across traditional borders.

Working closely with WMO has been ongoing for many years. For good reason. We are brought together on the broad agenda of sustainable development.

Our area of common interest can be described sharply and briefly:
We have evidence to state that climate change - by altering weather patterns and by disturbing life-supporting natural systems and processes - affects the health of human populations. There are many effects of these changes. And there is still discussion on the exact causality between human behaviour and climate change. But we know enough to take this very seriously and we have every reason to be concerned about adverse consequences for human health. The world's climate is warming and we know that human behaviour has a role in that phenomenon through the sharply increasing emission of greenhouse gases. We must expect that this trend, if continued, will have profound consequences for life on Earth and for the health of human beings.

The purpose of my address here today is to focus on the health implications and to reiterate WHO's commitment to continue its work on environment and health, and in doing so to work closely with WMO. We need to bring our findings together. Sustainable development cuts across sectors and calls for action by all parts of society. This was the message of the World Commission on Environment and Development. Environment is where we all live. Development is what we all do to improve our lot within that abode. The two are inseparable.

It takes little effort to point to some obvious health consequences of recent climatic drama. Disasters like Hurricane Mitch and Hurricane George are ruining entire health systems and the economies needed to support them. Honduras and neighbouring Nicaragua are now rife with cholera, malaria, dengue fever, respiratory diseases and rodent-borne leptospirosis.

Floods in China and Bangladesh have had devastating effects on the health of millions and millions. I saw with my own eyes the extensive burden put on China in protecting against emerging diseases and epidemics following the floods - weeks after the water had receded. Such dramatic events

place a particular burden on the poor. Some question that - clinging on to the belief that the weather is the only thing that treats all people equally. As the saying goes: no matter whether you are rich or poor, everybody gets wet when it rains.

But that gives a false picture. Even when it comes to weather, the poor are worse off. Much worse. When a storm hits, the poor are most likely to live near the waterfront and in low-lying areas. Their sheds are made of flimsy material which easily get smashed to bits by wind and water. And when the storm has passed, leaving destruction and disease in its path, the poor have no insurance to pay for damage and treatment. Their water supply is more likely to be contaminated, and the risks of them falling victim to epidemics is much greater than for the better off.

This we all know. But what is becoming increasingly clear is that the poor are also bearing the main burden of the long-term climatic changes to our environment. Recent assessments by health scientists working within the Intergovernmental Panel on Climate Change have confirmed that poor populations tend to be the most vulnerable to the health impacts of climatic variation and climate change. This is a serious cause for concern. Social inequality and environmental issues are intimately connected.

Just as it is the poor who bear the brunt of the HIV/AIDS epidemic, malaria and tuberculosis, it is they who would be the most vulnerable to heatwaves, floods, temperature extremes, sea-level rise and, of course, El Niño. About 60% of today's carbon dioxide emissions come from industrialized countries - and even more have done so historically. Yet the anticipated impact of climate change will fall largely on developing countries, where nearly 80% of the world's population live. Global models project a 1 to 3.5 degrees Celsius rise in global temperatures by the end of the next century. This would be the fastest rate of warming over the past 10,000 years. Health scientists estimate that it would increase the relative size of the population at risk of malaria, dengue, yellow fever, cholera, Rift Valley Fever, and various other infectious diseases.

*Let us talk for a minute about malaria - a special concern for WHO. Malaria is on the increase in the world at large, but particularly in Africa. More than 300 million new cases of malaria - perhaps as many as 500 million - occur every year, and one million people die annually. Children are, as always, the most vulnerable, with most of these deaths occurring in sub-Saharan Africa. WHO has launched Roll Back Malaria to rally forces against a disease which not only causes serious human suffering but also represents a real roadblock to social and economic development. Roll Back Malaria is driven by WHO in partnership with UNICEF, UNDP and the World Bank and a broad alliance of public and private partners.*

*The link to the environment is striking. We need only to follow the breeding environment for mosquitoes. They enjoy floods, unsafe water and a warming climate. A mosquito can happily breed in a footprint. During periods of extreme temperature or altered rainfall, many areas of the world have been shown to experience a marked increase in malaria cases. Quantitative leaps in malaria incidence have been recorded in recent decades in Colombia, Ecuador and Venezuela in South America, in Rwanda in Africa, and in Pakistan and Sri Lanka in South Asia.*

*In several locations around the world, malaria is now reported at higher altitudes than in preceding decades, such as on the mountain plateaus in Kenya. We cannot yet be sure of the reason - and there are probably several. One possibility that we have to take seriously, if the trends continue, is that climate change is contributing to the spread of this major disease. Health scientists, including some at the Copenhagen and Rome offices of WHO, are beginning to address this as a serious research issue.*

The impact of climatic variation goes beyond malaria. The drought-related forest fires in Indonesia, parched by an El Niño event, resulted in a dramatic increase in cases of respiratory diseases in cities in Malaysia. There is circumstantial evidence of a close connection between El Niño-caused changes in coastal water temperature, weather and outbreaks of cholera. More generally, cholera can be linked to floods which contaminate water supply, or to droughts which make hygiene difficult and also contaminate the water that remains.

*Let me give you a specific example. In Tanzania in September and October 1997, heavy rainfall and flooding led to 40,000 cases of cholera, a huge increase beyond the 1,460 cases the previous year. About 2,200 people died in 1997, compared to 35 deaths in 1996. An unforeseen consequence of the East African cholera epidemic was its economic cost. Europe refused to accept fish imports from the region because of the marine reservoir for the cholera bacteria. It is a vicious circle. Extreme weather and outbreaks of diseases cause human suffering and retard economic development.*

Beyond the diseases there are other health consequences of climatic variations. There will be increased impact, particularly on urban populations, of hotter summers and especially heatwaves. It can be argued that a warming climate may open up new areas for agricultural production. That may gradually become true, but it is hard to believe that this will outweigh the negative implications of an increasingly unstable climate. Let me take but one example: climate change may impair agricultural production in some regions - particularly in various poorer countries where food insecurity already exists. Food and water shortages, due to a combination of increasing demand and climate-induced downturns in supply, may heighten tensions between populations and countries in some of those regions. The implications for public health are as sad as they are obvious.

Let us also include the consequences of rising sea-levels. If coastal protection systems are not strengthened, a 50 centimetre rise in sea-level by 2100 would place 80 million people in danger of being flooded more than once a year, compared to 46 million people under present climate and sea-level conditions.

The displacement of so many people to already densely-populated delta areas and on populous island states would be bound to result in outbreaks of diseases like diphtheria and diarrhoea, just to mention the most obvious ones. The rising water table along the coast could also encourage the release of pathogens into septic systems and waterways. There would also be nutritional, physical and psychological health impacts.

Again - and as always - the poor, the elderly and children will be the most vulnerable. It also goes without saying that the consequences of sea-level rise will be much more serious for developing countries and their people than for industrialized societies and their peoples. Developing nations are less able to respond to food and water shortages and to deal with epidemics.

Closely associated with climate change is ultraviolet radiation due to depletion of the stratospheric ozone. This environmental change, now well documented, results from an essentially separate process from that of greenhouse gas accumulation in the lower atmosphere. Nevertheless, the two processes influence one another. Exposure to ultraviolet radiation would result in an increase of non-melanoma skin cancer, particularly in light-skinned people. It is also a near-certain cause of cataracts. Less certain, but potentially important, is the suppressive effect of ultraviolet radiation on the human immune system.

We recognise the possibility - and that is all there is at this stage - that this effect could reduce the effectiveness of vaccine programmes. One of WHO's most successful programmes over recent decades has been the massive immunization of children. We therefore must remain alert to this possible consequence of ozone depletion.

What can be done to meet these profound challenges?

At the outset we need to revert to the broader agenda of sustainable development. The message of Our Common Future - reiterated at Rio - was the link between environment and development. We called for a new era of economic growth - growth that is forceful and at the same time socially and environmentally sustainable.

In that process the developed countries must show their share of solidarity. Poverty is in itself the prime polluter. Populations have a right to lift themselves out of poverty. The developed world cannot pull up the ladder and say: sorry - we filled the waste baskets - there is no room left for you. *We need to continue the work to take the Climate convention further - step by step - based on evidence, and new mechanisms of burden sharing.*

Health is a yardstick for how we succeed. In the health field, concerted action over the past 50 years has led to significant progress. Half a century ago, the majority of the world's population died before the age of 50. Today average life expectancy in developing countries is 64 years and is projected to reach 71 years by 2020.

But as we pride ourselves on the positive trends in the traditional macro-indicators of health status - life expectancy and infant and child mortality - poverty has been eating away at many of the health gains. Reversing this trend - in fact aiming at halving the number of people living in poverty by 2015 - will call for commitment and action. The work may be even harder if the changing climate creates new obstacles for us.

*But we can also apply another perspective and look at health policy in itself as a means to reduce the impact of extreme weather patterns. Equitable, cost-effective health systems that improve the health conditions among poor, that assist in reducing poverty, free resources that can be used to improve preparedness.*

Health systems which reach and treat all people will ensure that those who are most exposed to the vagaries of weather will, at the least, not have to suffer unduly in the aftermath. Working to raise the living standards of all people will ensure that everyone is less likely to be, literally, swept up or aside by the next extreme weather event. Increased living standards will mean better health systems, better living conditions, more resources to prepare for the next extreme weather event -and as a bottom line - new opportunities to foster human, social and economic development.

There are a number of specific actions that can be taken to increase preparedness for extreme weather patterns and improve the assistance in the wake of these events. As a member of the "climate agenda" inter-agency programme, WHO's task is to help link the monitoring of health impacts with the monitoring of climate and associated impacts. For example: improvements in predicting and monitoring unusual weather occurrences, such as El Niño, will allow us to take pre-emptive measures to reduce the public health impact of such events.

We have recently compiled a comprehensive report on the health impacts of El Niño events. We need to develop our ability to respond to an increasingly diverse set of humanitarian crises -particularly in the disaster preparedness phase, but also in follow-up support to populations after the event.

This brings me back to where I started - to much needed partnerships. We in the health sector are very dependent on working with WMO. We are grateful to you, Professor Obasi, for your Organization's data inputs to our work.

There are numerous current health impacts of climatic variation in today's world and many potential impacts of the anticipated future changes in world climate. These health impacts weaken our ability to counter various disease problems - from rolling back malaria, to maintaining good nutrition, to sustaining our highly effective immunization programme.

The task is complex; the scale is often unfamiliar; and there is a clear need to take coordinated intersectoral action. But that is what we intend to do. At WHO we will set up a Task Force on the health dimension of the global climate agenda, including climate change. This Task Force will ensure that issues related to climate variation and climate change are adequately addressed, future health impacts are anticipated, and our preparedness for disasters is enhanced.

WHO is ready to work with WMO and other partners to undertake this major task. Thank you.

**APPENDIX 3.** WMO Day, March 23, 1999. Professor Obasi, Director General's Message.

World Meteorological Day commemorates the coming into force, on 23 March 1950, of the Convention of the World Meteorological Organization. Each year, WMO celebrates the day by focusing on a theme of topical or current interest. The choice of "Weather, climate and health" is particularly appropriate at a time when communities around the globe, struggling to recover from the impacts of recent natural disasters, are asking why these disasters occurred and what can be done to cope with the economic and health impacts in the future.

Throughout the ages, human beings have adapted to weather and climate by arranging shelter, food production, energy provision and lifestyles in harmony with climate and environmental conditions in general. Every other species on the planet is also adapted to its local climate as part of its environment. However, the recent prediction of significant changes in climate over the next 100 years, combined with some of the major natural disasters experienced in recent years, have focused new attention on the consequences of climate and weather on the environment and on socio-economic development, including health aspects.

Human beings respond physiologically to a number of atmospheric conditions, including temperature, humidity, wind, solar radiation and air pollution. Although humans have a great capacity to adapt to varied climates and environments, they are still vulnerable when surrounding meteorological conditions change considerably. For example, exposure to extreme temperatures may lead to heat stroke or frost bite. In most countries, people can live comfortably in the temperature range of 17°C–31°C. However, when the temperature of the surrounding air raises the body's core temperature to above 40.6°C, death from heat stroke can result. Scientists have also found that many more people die from causes such as heart attacks during heat waves—albeit less severe—than during cooler periods. In addition, the human response to weather as viewed from the point of view of "comfort" depends on temperature, as well as humidity and wind. Urban populations are typically more vulnerable than their rural counterparts.

The air around us is full of particles and gases such as pollen, fungal spores and toxic emissions, which have implications for health. In addition, "acid rain" and dry toxic deposits, which contaminate farmlands, forests, water sources and fish stocks, can adversely affect huge areas, depending on meteorological conditions. Thus, the health of populations in distant areas can be affected by pollutants transported by atmospheric circulations from a small number of factories in urban areas. This has been a major problem in Europe, for example, where acid rain is said to have damaged remote areas of Scandinavia. Local effects from pollution, such as smog and low-level ozone concentrations, as well as the presence in the air of certain pollens, have been linked to acute attacks of asthma and other respiratory diseases. The number of people potentially affected varies, depending on the prevailing winds and humidity, that can encourage either the dispersal or concentration of the pollutants and pollens.

In other cases, the link between weather, climate and health is not direct, but is none the less important. For example, stratospheric ozone shields the Earth's surface from incoming solar ultraviolet (UV) radiation that is harmful to all animals and plants. Depletion of the ozone layer can therefore have serious health implications. Many epidemiological studies have implicated UV-B radiation as a cause of skin cancer in fair-skinned humans, and have concluded that depletion of the ozone layer could result in an increased incidence of cases. In areas of high exposure to sunshine rich in ultraviolet radiation, cataracts, as well as other damage to the eyes, such as snow blindness, are also more prevalent. Moreover, there is evidence that UV-B causes the immune system to be suppressed in humans and animals, though the wider significance of this for patterns of disease is difficult to assess.

In addition to these factors, weather-related natural disasters, such as tropical cyclones, droughts, severe floods and abnormal monsoons also have implications for health. For instance, food supplies are destroyed, resulting in malnutrition, and water supplies deteriorate. Secondary effects include an increased risk of infectious diseases due to a breakdown in sanitation, a lack of clean freshwater, and over-crowding, as well as damage to local health care infrastructure.

An example of the impacts of the year-to-year changes in the weather on health can be seen from recent episodes of the El Niño phenomenon. Droughts are more frequent and intense during and immediately following El Niño in some areas of the world. In other areas, rainfall extremes associated with El Niño can adversely affect human societies by triggering food shortages, floods and landslides. Indeed, the aggregate effect of El Niño is so great that the global burden of natural disasters is greater in the year after the onset of El Niño, compared to the year before, with associated consequences on the health of the affected populations.

Recent studies have also shown that El Niño is linked to epidemics of certain diseases, such as malaria, Rift Valley Fever and viral and other vector-borne diseases, which are more prevalent after heavy rain. Following the heavy rainfall caused by the 1997/1998 El Niño in north-eastern Kenya and southern Somalia, the associated outbreak of Rift Valley Fever, which had been effectively eradicated, killed large numbers of cattle, and even spread to humans. Much work remains to be done on how to control and reduce the effects of such El-Niño-linked diseases.

Human societies over the years have been depleting a number of natural resources and degrading the environment, particularly through pollution from heavy industry, transportation and certain land-use practices. Populations have also modified their local climates by cutting down trees or building dams. Today, the aggregate human impact has attained an unprecedented global scale. The WMO/UNEP Intergovernmental Panel on Climate Change has concluded that "the balance of evidence suggests a discernible human influence on the global climate". Recognition has now grown that climate change to a warmer world is likely to affect the health of human populations. Increasing our understanding of the linkages between climate, weather and health will help us to forecast the impacts and take appropriate precautionary measures.

The assessment of potential health impacts of climate change is a complex exercise. It draws initially on the assessment by climatologists of when, where and to what extent the ongoing accumulation of greenhouse gases, particularly carbon dioxide, will translate into changes in climate. It must then take account of the assessment by other scientific disciplines of how those climate changes would affect health.

A few potential impacts of climate change on health are, however, fairly well understood. For example, it is known that certain species of mosquito transmit malaria, the tsetse fly transmits sleeping sickness and the black fly transmits river blindness. Because climate can play a dominant role in determining their distribution and abundance, climate change could have an effect on the geographical range of many of these insects. As a result of a warmer climate, for example, the southern USA and parts of Europe could be threatened with malaria. It is now possible to identify habitats that favor high survival rates for tsetse flies and mosquitoes, and subsequent analyses, using geographic information systems in combination with other data, can establish where human populations are at risk.

Long-term changes in climate could also influence the two foundations of public health systems: sufficient food, and safe and adequate drinking water. Because all plant and animal species are sensitive

to climate change, agriculture and ecosystems would be affected. Some assessments suggest that one-third to one-half of the world's vegetation types would change, and many plant and animal species would become extinct. Climate change would also have an impact on the availability of freshwater for domestic, agricultural and industrial consumption and on water quality. A rise in sea-level would cause salt contamination of underground aquifers near the coasts and some river systems. A warmer world is expected to produce more severe flooding in some places and more severe droughts in others. Greater flooding can lead to increased contamination of water by human and animal waste and agricultural chemicals. Reduced water levels in other places can concentrate pollutants and pathogens in surface water. As well as affecting food supply, reduced water availability has health implications; it has been shown that, in times of water shortage, cooking takes precedence over hygiene.

So what can be done to address further the threats to health caused by weather, climate variations and predicted climate change? In the first instance, national Meteorological and Hydrological Services (NMHSs) and public health authorities should, as appropriate, initiate or strengthen activities related to the provision of relevant information, such as comfort indices, pollution warnings and pollen and dust counts, and issue, among others, UV and sunburn forecasts and bioclimatic maps.

Secondly, NMHSs and public health services should strengthen their cooperation as they prepare to deal with the potential health hazards caused by natural disasters. Such cooperation could benefit from improved skill in weather forecasts achieved over the last decade and now available in many countries. Improved early warnings have saved millions of lives from tropical cyclones, floods and other severe weather events. Member countries of WMO routinely exchange meteorological information under the World Weather Watch system and use that information to improve prediction capabilities and provide warnings of weather-related disasters.

Thirdly, NMHSs could provide seasonal forecasts to health authorities on a regular basis for use in advance planning. Considerable progress has also been made towards seasonal predictions, as a result of work being carried out under the WMO World Climate Programme. New services based on seasonal predictions are likely to become established during the next decade. In particular, the ability to forecast El Niño/Southern Oscillation events and other anomalous climate conditions a year or more in advance will help mitigate many of the associated adverse health impacts.

Fourthly, NMHSs could contribute further to the efficient use of scarce water resources in semi-arid and drought-prone lands and to the assessment of water quality and quantity. In particular, meteorological and hydrological information contributes to an improvement of agricultural production and a decrease in pollution by agricultural chemicals or other agents that lead to ill health and the degradation of the environment. In this regard, WMO supports a number of activities aimed at mitigating the adverse impacts of climate variability and change, thereby reducing the risk to health for hundreds of millions of vulnerable persons in all parts of the world.

Fifthly, at the local or community level, climate and weather information must be expressed in terms that complement local knowledge and perceptions. In this regard, efforts are continuously being made by WMO to ensure that NMHSs have the capability to provide relevant guidance to decision-makers and health officials. In particular, WMO's Climate Information and Prediction Service (CLIPS) project, which aims to ensure the provision of climate information and near-future predictions, is a useful mechanism to support cooperation with health officials.

Finally, while the impacts of climate change and variability on human health are increasingly highlighted on the environment and health agenda, many information gaps need to be filled through local

studies of the health impacts of short-term variations in weather and climate. In this context, health scientists should further involve meteorologists, as well as climatologists, hydrologists and scientists from other disciplines, to undertake more collaborative research.

The focus of World Meteorological Day celebrations this year on "Weather, climate and health" provides an opportunity for governments, the general public and the media to fully appreciate this linkage. It encourages them to reflect upon the important contributions being made by WMO and the NMHSs to the health sector. It should be realized that the success in the application of climate and weather information and knowledge for the improvement of human health can be achieved through strengthened cooperation between NMHSs, health professionals and other decision-makers responsible for human health and welfare. WMO will continue to enhance its collaboration with Member countries through the NMHSs and the health communities at regional and international levels in improving our understanding of the role of weather and climate system on human and animal health for the benefit of future generations of humankind.

For more information, please contact:
Information and Public Affairs Office, World Meteorological Organization
41, avenue Giuseppe-Motta, CH 1211 Geneva 2
Switzerland
Tel.+(41 22) 730 8315
Fax.+(41 22) 733 2829
E-mail:ipa@gateway.wmo.ch
Internet website: http://www.wmo.ch

**APPENDIX 4:** WHO Director Brundtland's Statement at the Summit on Roll Back Malaria in Africa. Abuja, Nigeria, 25 April 2000 (*emphasis added in italics*).

Office of the Director-General
World Health Organization
Organization mondiale de la Santé

Honorable Mr. President and heads of governments,
Excellencies,
Ladies and Gentlemen,

Thank you, your Excellency, for this extra-ordinary initiative - for bringing us together, to focus on health and development. Before I became Director General of WHO in 1998 Africa's leaders told me that malaria undermines the development of their people. I was asked, several times, why the suffering and poverty caused by malaria was so often overlooked in development dialogue. I resolved that WHO should do much more to support Africa's efforts to control malaria.

Mr President, Professor Jeffrey Sachs has just presented to us his report on the economic effects of malaria. As I listened to him, *I was struck by the enormity of the damage caused by this ancient disease.* A loss of economic growth of more than one percentage point per year. A 20% reduction in GNP after 15 years. Short term benefits from malaria control of up to $12 billion each year. These are staggering numbers.

I conclude that Malaria is taking a big bite out of Africa's economic growth. For every year that malaria is left unchecked, it will cause African nations to fall further behind the rest of the world. But malaria is not just an African issue. Malaria and its economic impact threaten our stability as a global community and threaten the future of our increasingly global economy.

I do not accept a future with ever widening differences in the growth of nations. Together we must fight for a future free from the burdens of malaria.

If we can control malaria, we will see an acceleration of Africa's development
If malarious areas are free of the disease, family incomes will rise
If there is less malaria in homes, school attendance will increase - sometimes dramatically.

At yesterday's technical meeting, Africa's scientists told us of the tools needed to roll back this cause of suffering and poverty, to banish this obstacle to economic growth.

Insecticide treated nets in the home reduce transmission and prevent infection. Indoor spraying with safe insecticides prevents infection.
Treatment during pregnancy protects the mother's health and improves birth weight.
Rapid diagnosis and early treatment of someone with malaria shorten the illness and reduce death rates.

These interventions appear simple. Ensuring their success is not. To be effective they must reach all at risk. In many countries malaria has been a fact of life and death for so long that individuals,

families, communities and institutions tolerate its burden. Outspoken commitment, vision and energy are essential to overcome this sense of fatalism and resignation surrounding malaria.

Your excellencies:

I am delighted that you have come here today to turn the tide.

Over the last two years, your Governments have joined forces with the WHO, UNICEF, UNDP, the World Bank, the African Development Bank, with development agencies, research groups, non-governmental organisations and private corporations in starting to build a powerful movement. This is the movement to Roll Back Malaria. The spearhead for this movement is in Africa.

In more than 20 countries, malaria is now being tackled through all branches of government and with increasing involvement of the private sector. However, much more remains to be done.

*Malaria needs a high profile throughout African society.* Everyone needs to realise the full impact of this disease, to agree on the goals, and to know how they can be realised in different settings.

We - the partners supporting the Roll Back Malaria Movement - must continue to support applied research to identify and apply the best anti-malaria therapies. This will help to counter the development of drug resistance. We need to find better ways to improve access to drugs, and to prevent counterfeiting. We need to work together to review taxes and tariffs on mosquito nets and other commodities. We need to coordinate the many contributions –financial and technical— of the Roll Back Malaria partners at country level. And, most importantly, we need to monitor achievements.

We need to involve the parts of the private sector that can help get goods and services to people. It has the distribution networks, the communications skill and the marketing resources. We would like private entities to be true partners in the movement. Several are already involved in the Medicines for Malaria venture.

In all this work, we count on you, the Heads of State and Governments, to lead us, so that we work together effectively in Rolling Back Malaria.

Mr. President,

The turn of the century coincides with a remarkable shift in thinking about human development. I sense a growing realisation among decision-makers that to reduce poverty we must improve health. Illness - particularly malaria - keeps Africa's people and their nations poor. Bad health locks people into poverty. Healthy populations have better school attendance, higher incomes and more rapid economic development.

I anticipate that today we will agree an approach on rolling back malaria that also applies whether we are tackling tuberculosis, HIV/AIDS, maternal ill-health, tobacco-related ill-health or other priority problems. It means:

Information campaigns, to increase knowledge and understanding and empower people to act to improve their health

Access to essential drugs, vaccines, and other commodities;

Effective health services - close to the home; and

A healthy environment - with clean water and sanitation

It certainly includes actions within communities, responsive to the needs of poor people, supported by all sectors of society.

We partners are working together to mobilise large increases in resources for health, to reduce the prices of drugs and commodities, to minimise tariffs and taxes on these goods, to support the discovery and development of effective drugs and vaccines, and to back-up effective action at country level. These are all concrete and target-oriented actions. They bring results.

Mr President:

Your vision has brought us here today, to focus on malaria. But I am sure you would agree that poverty is our real enemy. We now have an extraordinary window of opportunity. We have Governments, international organizations, NGOs and the private sector ready to work together to achieve agreed health goals, and so contribute to prosperity. We have a potential for dramatic increases in resources for health. That means, the number of malaria deaths can be halved within ten years. There will be further health gains. This summit will help us move forward. The impact will be extraordinary. Africa will have stronger health systems, healthier populations and faster-growing economies.

Thank you.

# BELFER CENTER FOR SCIENCE AND INTERNATIONAL AFFAIRS

BCSIA is a vibrant and productive research community at Harvard's John F. Kennedy School of Government. Emphasizing the role of science and technology in the analysis of international affairs and in the shaping of foreign policy, it is the axis of work on international relations at Harvard University's John F. Kennedy School of Government. BCSIA has three fundamental issues: to anticipate emerging international problems, to identify practical solutions, and to galvanize policy-makers into action. These goals animate the work of all the Center's major programs.

The Center's Director is Graham Allison, former Dean of the Kennedy School. Stephen Nicoloro is Director of Finance and Operations.

BCSIA's International Security Program (ISP) is the home of the Center's core concern with security issues. It is directed by Steven E. Miller, who is also Editor-in-Chief of the journal, *International Security*.

The Strengthening Democratic Institutions (SDI) project works to catalyze international support for political and economic transformation in the former Soviet Union. SDI's Director is Graham Allison.

The Science, Technology, and Public Policy (STPP) program emphasizes public policy issues in which understanding of science, technology and systems of innovation is crucial. John Holdren, the STPP Director, is an expert in plasma physics, fusion energy technology, energy and resource options, global environmental problems, impacts of population growth, and international security and arms control.

The Environment and Natural Resources Program (ENRP) is the locus of interdisciplinary research on environmental policy issues. It is directed by Henry Lee, expert in energy and environment. Robert Stavins, expert in economics and environmental and resource policy issues, serves as ENRP's faculty chair.

The heart of the Center is its resident research staff: scholars and public policy practitioners, Kennedy School faculty members, and a multi-national and inter-disciplinary group of some two dozen pre-doctoral and post-doctoral research fellows. Their work is enriched by frequent seminars, workshops, conferences, speeches by international leaders and experts, and discussions with their colleagues from other Boston-area universities and research institutions and the Center's Harvard faculty affiliates. Alumni include many past and current government policy-makers

The Center has an active publication program including the quarterly journal *International Security*, book and monograph series, and Discussion Papers. Members of the research staff also contribute frequently to other leading publications, advise the government, participate in special commissions, brief journalists, and share research results with both specialists and the public in a wide variety of ways.

The Center's web address, through which all its research programs web sites can be reached, is: http://ksgnotes1.harvard.edu/bcsia/bcsia.nsf/www/Home. The Kennedy School web address is: www.ksg.harvard.edu.

BELFER CENTER FOR SCIENCE AND INTERNATIONAL AFFAIRS
JOHN F. KENNEDY SCHOOL OF GOVERNMENT
HARVARD UNIVERSITY

**Discussion Paper Series**

2000-25 Jaffe, Adam B., Richard G. Newell, and Robert N. Stavins. "Technological Change and The Environment."

2000-24 Gupta, Aarti. "Governing Biosafety in India: The Relevance of The Cartagena Protocol."

2000-23 Eckley, Noelle. "From Regional to Global Assessment: Learning from Persistent Organic Pollutants."

2000-22 Keykhah, Modjeh. "Global Hazards and Catastrophic Risk: Assessments, Practitioners and Decision Making in Reinsurance."

2000-21 Ogunseitan, Oladele. "Framing Vulnerability: Global Environmental Assessments and the African Burden of Disease."

2000-20 Betsill, Michele M. "Localizing Global Climate Change: Controlling Greenhouse Gas Emissions in U.S. Cities."

2000-19 Patt, Anthony. "Communicating Probabilistic Forecasts to Decision Makers: A Case Study Of Zimbabwe."

2000-18 Lund, David C. "Regional Abrupt Climate Change Assessment in the U.S.: Comparing the Colorado and Columbia River Basins."

2000-17 Biermann, Frank. "Science as Power in International Environmental Negotiations: Global Environmental Assessments Between North and South."

2000-16 Krueger, Jonathan. "Information in International Environmental Governance: The Prior Informed Consent Procedure for Trade in Hazardous Chemicals and Pesticides."

2000-15 Stavins, Robert N. "Economic Analysis of Global Climate Change Policy: A Primer."

2000-14 Weeks, Jennifer. "Advice – and Consent? The Department of Energy's Site-Specific Advisory Boards."

2000-13 Yereskovsky, Alexander. "The Global Security Environment and U.S.-Russian Strategic Relations in the 21st Century: Partners or Rivals?"

2000-12 Clark, William et. Al. "Assessing Vulnerability to Global Environmental Risk."

2000-11 Foster, Charles, H.W. and William B. Meyer, "The Harvard Environmental Regionalism Project."

2000-10 Cash, David. "'In Order to Aid in Diffusing Useful and Practical Information': Cross-scale Boundary Organizations and Agricultural Extension."

2000-09 Foster, Charles, H.W. et al., "Colloquium on Environmental Regionalism."

*The Belfer Center for Science and International Affairs (BCSIA) Discussion Papers, established in 1991, will be issued on an irregular basis with three programmatic subseries: International Security; Science, Technology, and Public Policy; and Environment and Natural Resources. Inquiries and orders may be directed to: Belfer Center for Science and International Affairs, Publications, Harvard University, 79 JFK Street, Cambridge, MA, 02138.*

BELFER CENTER FOR SCIENCE AND INTERNATIONAL AFFAIRS
JOHN F. KENNEDY SCHOOL OF GOVERNMENT
HARVARD UNIVERSITY

**Discussion Paper Series**

| | |
|---|---|
| 2000-08 | Lee, Henry and Shashi Kant Verma, "Coal or Gas: The Cost of Cleaner Power in the Midwest." |
| 2000-07 | Fischer, Markus, "The Liberal Peace: Ethical, Historical and Philosophical Aspects." |
| 2000-06 | Cash, David, "Distributed Assessment Systems: An Emerging Paradigm of Research, Assessment and Decision-making for Environmental Change." |
| 2000-05 | Donohue, Laura K., "Civil Liberties, Terrorism, and Liberal Democracy: Lessons from the United Kingdom." |
| 2000-04 | Golub, Alexander, "Russian Forests for Climate Change Mitigation: An Economic Analysis." |
| 2000-03 | Coglianese, Cary, "Policy Implications of Environmental Management Systems." |
| 2000-02 | Meyer, William B. and Charles H.W. Foster, "New Deal Regionalism: A Critical Review." |
| 2000-01 | Newell, Richard and Robert Stavins, "Abatement-Cost Heterogeneity and Anticipated Savings from Market-Based Environmental Policies." |
| R-99-01 | Rapporteur's Report. "Workshop on Research and Policy Directions for Carbon Management." |
| 99-20 | Rufin, Carlos, "Institutional Change in the Electricity Industry: A Comparison of Four Latin American Cases." |
| 99-19 | Rothenberg, Sandra and David Levy, "Corporate Responses to Climate Change: The Institutional Dynamics of the Automobile Industry and Climate Change." |
| 99-18 | Stavins, Robert, "Experience with Market-Based Environmental Policy Instruments." |
| 99-17 | Jaffe, Adam, Richard Newell and Robert Stavins, "Energy-Efficient Technologies and Climate Change Policies: Issues and Evidence." |
| 99-14 | Jung, Wolfgang. "Expert Advice in Global Environmental Decision Making: How Close Should Science and Policy Get?" |
| 99-13 | Levy, David L. and Sandra Rothenberg, "Corporate Strategy and Climate Change: Heterogeneity and Change in the Global Automobile Industry." |
| 99-12 | Biermann, Frank, "Big Science, Small Impacts -- in the South? The Influence of International Environmental Information Institutions on Policy-Making in India." |
| 99-11 | Eckley, Noelle, "Drawing Lessons About Science-Policy Instruments: Persistent Organic Pollutants (POPs) under the LRTAP Convention." |
| 99-10 | Gupta, Aarti. "Framing 'Biosafety' in an International Context: The Biosafety Protocol Negotiations." |

*The Belfer Center for Science and International Affairs (BCSIA) Discussion Papers, established in 1991, will be issued on an irregular basis with three programmatic subseries: International Security; Science, Technology, and Public Policy; and Environment and Natural Resources. Inquiries and orders may be directed to: Belfer Center for Science and International Affairs, Publications, Harvard University, 79 JFK Street, Cambridge, MA, 02138.*

BELFER CENTER FOR SCIENCE AND INTERNATIONAL AFFAIRS
JOHN F. KENNEDY SCHOOL OF GOVERNMENT
HARVARD UNIVERSITY

**Discussion Paper Series**

| | |
|---|---|
| 99-09 | Seng, Jordan. "If Iraq Gets the Bomb: Zealous Rogues, Old-Fashioned Tyrants, and Nuclear Deterrence." |
| 99-08 | Konoplyov, Sergei. "Analytical Centers in Ukraine." |
| 99-07 | Foster, Charles, H.W. and David Foster. "Thinking in Forest Time: A Strategy for the Massachusetts Forest." |
| 99-06 | Pfaff, Alexander S. and Stavins, Robert N. "Readings in the Field of Natural Resource & Environmental Economics." |
| 99-05 | Johnsen, Tor Arnt, Shashi Kant Verma and Catherine Wolfram. "Zonal Pricing and Demand-Side Bidding in the Norwegian Electricity Market." |
| 99-04 | Dietrich, William F. "Guide to Research Databases of Acid Rain Assessment and Policy Literatures." |
| 99-03 | Grant, Richard. "Power and Prosperity: Challenges and Opportunities for Small States." |
| 99-02 | Hahn, Robert W. and Robert N. Stavins. "What has Kyoto Wrought? The Real Architecture of International Tradeable Permit Markets." |
| 99-01 | Hahn, Robert W. "The Impact of Economics on Environmental Policy." |
| 98-27 | Parris, Thomas and Charles Zracket and William Clark. "Usable Knowledge for Managing Responses to Global Climate Change: Recommendations to promote collaborative assessments and information systems." |
| 98-26 | Fisher-Vanden, Karen. "Technological Diffusion in China's Iron and Steel Industry." |
| 98-25 | Bunn, Matthew, Neil J. Numark and Tatsujiro Suzuki. "A Japanese-Russian Agreement to Establish a Nuclear Facility for MOX Fabrication and Spent Fuel Storage in the Russian Far East." |
| 98-24 | Holdren, John P. "Getting to Zero: Is Pursuing a Nuclear-Weapon-Free World Too Difficult? Too Dangerous? Too Distracting?" |
| 98-23 | Stavins, Robert N. and Richard Newell. "Climate Change and Forest Sinks: Factors Affecting the Costs of Carbon Sequestration." |
| 98-22 | O'Neill, Kate. "(Not) Getting to 'Go': Recent Experience in International Cooperation over the Management of Spent Nuclear Reactor Fuel." |
| 98-21 | Lee, Henry. "Designing Domestic Carbon Trading Systems: Key Considerations." |
| 98-20 | Patt, Anthony. "Analytic Frameworks and Politics: The Case of Acid Rain in Europe." |

*The Belfer Center for Science and International Affairs (BCSIA) Discussion Papers, established in 1991, will be issued on an irregular basis with three programmatic subseries: International Security; Science, Technology, and Public Policy; and Environment and Natural Resources. Inquiries and orders may be directed to: Belfer Center for Science and International Affairs, Publications, Harvard University, 79 JFK Street, Cambridge, MA, 02138.*

BELFER CENTER FOR SCIENCE AND INTERNATIONAL AFFAIRS
JOHN F. KENNEDY SCHOOL OF GOVERNMENT
HARVARD UNIVERSITY

**Discussion Paper Series**

98-19 Iles, Alastair. "The Evolution of Acidification Impact Frames in Europe: Interactions Between Regional and National Assessment of Forest Conditions."

98-18 Franz, Wendy E. "Science, Skeptics and Non-State Actors in the Greenhouse."

98-17 Cash, David. "Assessing and Addressing Cross-Scale Environmental Risks: Information and Decision Systems for the Management of the High Plains Aquifer."

98-16 Moser, Susanne. "Talk Globally, Walk Locally: The Cross-Scale Influence of Global Change Information on Coastal Zone Management in Maine and Hawai'i."

98-15 Miller, Clark. "Extending Assessment Communities to Developing Countries."

98-14 Bader, Pascal. "Targets and Strategies: The Role of Economic Assessments in European Climate Policy."

98-13 Botcheva, Liliana. "Doing is Believing: Participation and Use of Economic Assessments in the Approximation of EU Environmental Legislation in Eastern Europe."

98-12 Farrell, Alex and Terry J. Keating. "Multi-Jurisdictional Air Pollution Assessment: A Comparison of the Eastern United States and Western Europe."

98-11 Keating, Terry J. and Alex Farrell. "Problem Framing and Model Formulation: The Regionality of Tropospheric Ozone in the U.S. and Europe."

98-10 Samson, Paul. "Non-State Actors and Environmental Assessment: A Look at Acid Rain and Global Climate Change."

98-09 VanDeveer, Stacy D. "European Politics with a Scientific Face: Transition Countries, International Environmental Assessment, and Long Range Transboundary Air Pollution."

98-08 Chayes, Abram. "A Suggested Model for Implementing the Clean Development Mechanism."

98-07 Lynn-Jones, Sean M. "Why the United States Should Spread Democracy."

98-06 Mitchell, Ronald and Ted Parson. "Implementing Joint Implementation: Developing a Management and Performance System for the Kyoto Protocol's 'Clean Development Mechanism.'"

98-05 Hahn, Robert. "An Analysis of the First Government Report on the Benefits and Costs of Regulation."

98-04 Stavins, Robert N. "How do Economists Really Think about the Environment?"

98-03 Coglianese, Cary. "Getting the Message Out: Regulatory Policy and the Press."

98-02 Stavins, Robert. "Market-Based Environmental Policies."

98-01 Newell, Richard, Adam Jaffe and Robert Stavins. "The Induced Innovation Hypothesis and Energy-Saving Technological Change."

*The Belfer Center for Science and International Affairs (BCSIA) Discussion Papers, established in 1991, will be issued on an irregular basis with three programmatic subseries: International Security; Science, Technology, and Public Policy; and Environment and Natural Resources. Inquiries and orders may be directed to: Belfer Center for Science and International Affairs, Publications, Harvard University, 79 JFK Street, Cambridge, MA, 02138.*

BELFER CENTER FOR SCIENCE AND INTERNATIONAL AFFAIRS
JOHN F. KENNEDY SCHOOL OF GOVERNMENT
HARVARD UNIVERSITY

**Discussion Paper Series**

97-15 Foster, Charles, H.W. "Managing Resources as Whole Systems: A Primer for Managers."

97-14 Anderson, Steven. "U.S. Electricity Restructuring and Environmental Policy: A Survey of Opinions in the Environmental Community."

97-13 Verma, Shashi. "Getting Privatization Right: Establishing a Competitive Market for Electricity Generation in Brazil."

97-12 Hahn, Robert. "Climate Change: Economics, Politics, and Policy."

97-11 Keohane, Nathaniel, Richard Revesz and Robert Stavins. "The Positive Political Economy of Instrument Choice in Environmental Policy."

97-10 Patt, Anthony. "Assessing Extreme Outcomes: The Strategic Treatment of Low Probability Impacts of Climate Change."

97-09 Long, Marybeth and Alastair Iles. "Assessing Climate Change Impacts: Co-Evolution of Knowledge, Communities and Methodologies."

97-08 Kandlikar, Milind and Ambuj Sagar. "Climate Science and Policy in India: Learning Some Lessons."

97-07 Franz, Wendy E. "The Development of an International Agenda for Climate Change."

97-06 Fisher-Vanden, Karen. "International Policy Instrument Prominence in the Climate Change Debate: A Case Study of the United States."

97-05 Agrawala, Shardul. "Explaining the Evolution of the IPCC Structure and Process."

97-04 Wright, Jan C. "'Bright Lines' and the Value of Life: Resolving the Dispute over the Regulation of Carcinogens."

97-03 Parson, Edward A. and Karen Fisher-Vanden. "Joint Implementation and its Alternatives."

97-02 Stavins, Robert N. "Economic Incentives for Environmental Regulation."

97-01 Arbatov, Alexei G. "Military Reform in Russia: Dilemmas, Obstacles, and Prospects."

96-03 de Nevers, Renee. "Sustaining the Transition? Western Efforts to Support Democracy and Prevent Conflict in Russia."

96-02 Rogers, Elizabeth S. "Using Economic Sanctions to Prevent Deadly Conflict."

96-01 Meade, Andre and Sydney Rosen. "The Mixed-Grass Prairie Reserve: Managing the Greater Badlands Region as a Whole System."

95-14 Schatzki, Todd. "The Effects of Uncertainty on Landowner Conversion Decisions."

95-13 Lee, Henry and Negeen Darani. "Electricity Restructuring and the Environment."

*The Belfer Center for Science and International Affairs (BCSIA) Discussion Papers, established in 1991, will be issued on an irregular basis with three programmatic subseries: International Security; Science, Technology, and Public Policy; and Environment and Natural Resources. Inquiries and orders may be directed to: Belfer Center for Science and International Affairs, Publications, Harvard University, 79 JFK Street, Cambridge, MA, 02138.*

BELFER CENTER FOR SCIENCE AND INTERNATIONAL AFFAIRS
JOHN F. KENNEDY SCHOOL OF GOVERNMENT
HARVARD UNIVERSITY

**Discussion Paper Series**

| | |
|---|---|
| 95-12 | Clark, William C. and Nancy M. Dickson eds. "The Press and Global Environmental Change: An International Comparison of Elite Newspaper Reporting on the Acid Rain Issue from 1972 to 1992." |
| 95-11 | Zaborsky, Victor. "Crimea and the Black Sea Fleet in Russian-Ukrainian Relations." |
| 95-10 | Stavins, Robert, Adam Jaffe, Steve Peterson, and Paul Portney. "Environment Regulation and the Competitiveness of U.S. Manufacturing: What does the Evidence Tell Us?" |
| 95-09 | Haran, Olexity. "Disintegration of the Soviet Union and the US Position on the Independence of Ukraine." |
| 95-08 | Allison, Graham T., Owen R. Coté, Jr., Richard A. Falkenrath and Steven E. Miller. "Avoiding Nuclear Anarchy: Containing the Threat of Loose Russian Nuclear Weapons and Fissile Material." |
| 95-07 | Falkenrath, Richard A. "The U.S.-Russian HEU Purchase Agreement: Achievements, Problems, Prospects." |
| 95-06 | Stavins, Robert N. "The Costs of Carbon Sequestrian: A Revealed Preference Approach." |
| 95-05 | Dietrich, William. "The Challenge of Selecting Goals: Case Studies Regarding the Use of Critical Levels." |
| 95-04 | Ferenz, Michele N. and Stephan D. Sylvan. "The Design of a Palestinian-Israeli Water Commission: A Best Practices Approach." |
| 95-03 | Stavins, Robert N. and Tomasz Zylicz. "Environmental Policy in a Transition Economy: Designing Tradable Permits for Poland." |
| 95-02 | Not available. |
| 95-01 | Perlman, Brett A. "Pricing the Internet: How to Pay the Toll for the Electronic SuperHighway." |
| 94-10 | Stavins, Robert N. "Correlated Environmental Uncertainty and Policy Instrument Choice." |
| 94-09 | Falkenrath, Richard A. "The United States and Ballistic Missile Defense after the Cold War." |
| 94-08 | Falkenrath, Richard A. "The United States, the Former Soviet Republics, and Nuclear Weapons: Problems and Policies of Denuclearization." |
| 94-07 | Stavins, Robert N. and Adam Jaffee. "Environmental Regulation and Technology Diffusion: The Effects of Alternative Policy Instruments." |
| 94-06 | Not Available. |
| 94-05 | Zaborsky, Victor. "Nuclear Disarmament and Nonproliferation: The Evolution of the Ukrainian Case." |

*The Belfer Center for Science and International Affairs (BCSIA) Discussion Papers, established in 1991, will be issued on an irregular basis with three programmatic subseries: International Security; Science, Technology, and Public Policy; and Environment and Natural Resources. Inquiries and orders may be directed to: Belfer Center for Science and International Affairs, Publications, Harvard University, 79 JFK Street, Cambridge, MA, 02138.*

BELFER CENTER FOR SCIENCE AND INTERNATIONAL AFFAIRS
JOHN F. KENNEDY SCHOOL OF GOVERNMENT
HARVARD UNIVERSITY

**Discussion Paper Series**

| | |
|---|---|
| 94-04 | Lachow, Irving. "The Global Positioning System and Cruise Missile Proliferation: Assessing the Threat." |
| 94-03 | Fairman, David, and Michael Ross. "International Aid for the Environment: Lessons from Economic Development Assistance." |
| 94-02 | Hahn, Robert W. and Carol A. May. "The Behavior of the Allowance Market: Theory and Evidence." |
| 94-01 | Bender, Rodd, Wyman Briggs, and Diane DeWitt. "Toward Statewide Unit Pricing in Massachusetts: Influencing the Policy Cycle." |
| 93-06 | Hahn, Robert W. "An Economic Analysis of Scrappage." |
| 93-05 | Hancke, Bob. "Technological Change and Its Institutional Constraints." |
| 93-04 | Portney Paul R. and Robert N. Stavins. "Regulatory Review of Environmental Policy: The Potential Role of Health-Health Analysis" |
| 93-03 | Parson, Edward A. and Richard J. Zeckhauser. "Equal measures and Fair Burdens: negotiating environmental treaties in an unequal world." |
| 93-02 | Stavins, Robert N. "Transaction Costs and the Performance of Markets for Pollution Control." |
| 93-01 | Holla, Rogier A.H.G. "Cultural Attitudes and Institutional Forces: Explaining National Differences in Biotechnology Policy." |
| 92-13 | Foster, Charles H.W. "Of Vert and Vision: Ensuring the Legacy of the Northern Forest of New England and New York." |
| 92-12 | Hane, Gerald Jiro. "Research and Development Consortia in Innovation in Japan: Case Studies in Superconductivity and Engineering Ceramics." |
| 92-11 | Vernon, Raymond. "The Triad as Policymakers." |
| 92-10 | Jorgenson, Dale W. and Peter J. Wilcoxen. "Energy, the Environment and Economic Growth." |
| 92-09 | Norberg-Bohm, Vicki and William C. Clark, et al. "International Comparisons of Environmental Hazards: Development and evaluation of a method for linking environmental data with the strategic debate management priorities for risk management." |
| 92-08 | Hart, David. "Strategies of Research Policy Advocacy: Anthropogenic Climatic Change Research, 1957-1974." |
| 92-07 | Dembinski, Matthias. "Ballistic Missile Proliferation and the New World Order: A Critical Survey of the Literature." |
| 92-06 | Shlyakhter, Alexander I. and Daniel M. Kammen. "Estimating the Range of Uncertainty in Future Development from Trends in Physical Constraints and Predictions of Global Change." |

*The Belfer Center for Science and International Affairs (BCSIA) Discussion Papers, established in 1991, will be issued on an irregular basis with three programmatic subseries: International Security; Science, Technology, and Public Policy; and Environment and Natural Resources. Inquiries and orders may be directed to: Belfer Center for Science and International Affairs, Publications, Harvard University, 79 JFK Street, Cambridge, MA, 02138.*

BELFER CENTER FOR SCIENCE AND INTERNATIONAL AFFAIRS
JOHN F. KENNEDY SCHOOL OF GOVERNMENT
HARVARD UNIVERSITY

**Discussion Paper Series**

| | |
|---|---|
| 92-05 | Eaton, Susan C. "Union Leadership Development in the 1990s and Beyond: A Report with Recommendations." |
| 92-04 | Hahn, Robert W. and Robert L. Axtell. "Reevaluating the Relationship between Transferable Property Rights and Command-and-Control Regulation." |
| 92-03 | Stavins, Robert N. and Bradley W. Whitehead. "The Greening of America's Taxes: Pollution Charges and Environmental Protection." |
| 92-02 | Parson, Edward A. "Protecting the Ozone Layer: The Evolution and Impact of International Institutions." |
| 92-01 | Branscomb, Lewis M. "S & T Information Policy in the Context of a Diffusion Oriented National Technology Policy." |
| 91-15 | Hahn, Robert W. and Robert N. Stavins. "Economic Incentives for Environmental Protection: Integrating Theory and Practice." |
| 91-14 | Hahn, Robert W. "Government Markets and the Theory of the *N* th Best." |
| 91-13 | Parson, Edward A. and William C. Clark. "Learning to Manage Global Environmental Change: A Review of Relevant Theory." |
| 91-12 | Branscomb, Lewis M. "America's Emerging Technology Policy." |
| 91-11 | Lynn-Jones, Sean M. "International Security Studies after the Cold War: An Agenda for the Future." |
| 91-10 | Rapporteur's Report of the Executive Session: "Negotiating a Global Climate Change Agreement." March 14-15, 1991. |
| 91-09 | Jorgenson, Dale W. and Peter J. Wilcoxen. "Reducing U.S. Carbon Dioxide Emissions: The Cost of Different Goals." |
| 91-08 | Montgomery, John D., et al. "Values in Conflict: Policy Interactions in the Pacific Basin." |
| 91-07 | Summary of Project 88/Round II Workshop Proceedings. "Incentive-Based Policies for Municipal Solid Waste Management." May 16, 1991. |
| 91-06 | Proceedings of Project 88/Round II Forum. "Market-Based Strategies for Environmental Protection: A Tribute to Senator John Heinz of Pennsylvania." May 16, 1991. |
| 91-05 | Foster, Charles H.W. and Peter P. Rogers. "Rebuilding the Nation's Wetland Heritage: A Challenge for the 1990s." |
| 91-04 | Lerner, Joshua. "The Impact of Patent Scope: An Empirical Examination of New Biotechnology Firms." |
| 91-03 | Gaskins, Darius and Bruce Stram. "A Meta Plan: A Policy Response to Global Warming." |
| 91-02 | Merchant, Gery E. "Freezing $CO_2$ Emissions: An Offset Policy for Slowing Global Warming." |

*The Belfer Center for Science and International Affairs (BCSIA) Discussion Papers, established in 1991, will be issued on an irregular basis with three programmatic subseries: International Security; Science, Technology, and Public Policy; and Environment and Natural Resources. Inquiries and orders may be directed to: Belfer Center for Science and International Affairs, Publications, Harvard University, 79 JFK Street, Cambridge, MA, 02138.*

BELFER CENTER FOR SCIENCE AND INTERNATIONAL AFFAIRS
JOHN F. KENNEDY SCHOOL OF GOVERNMENT
HARVARD UNIVERSITY

**Discussion Paper Series**

91-01 Jaffee, Adam and Robert N. Stavins. "Evaluating the Relative Effectiveness of Economic Incentives and Direct Regulation for Environmental Protection: Impacts on the Diffusion of Technology."

*The Belfer Center for Science and International Affairs (BCSIA) Discussion Papers, established in 1991, will be issued on an irregular basis with three programmatic subseries: International Security; Science, Technology, and Public Policy; and Environment and Natural Resources. Inquiries and orders may be directed to: Belfer Center for Science and International Affairs, Publications, Harvard University, 79 JFK Street, Cambridge, MA, 02138.*