# Public Health Linkages with Sustainability: Workshop Summary

ISBN
978-0-309-28786-9

148 pages
6 x 9
PAPERBACK (2013)

Christine Coussens and Erin Rusch, Rapporteurs; Roundtable on Environmental Health Sciences, Research, and Medicine; Board on Population Health and Public Health Practice; Institute of Medicine

# Public Health Linkages with Sustainability

WORKSHOP SUMMARY

Christine Coussens and Erin Rusch, *Rapporteurs*

Roundtable on Environmental Health Sciences, Research, and Medicine

Board on Population Health and Public Health Practice

INSTITUTE OF MEDICINE
*OF THE NATIONAL ACADEMIES*

THE NATIONAL ACADEMIES PRESS
Washington, D.C.
**www.nap.edu**

**THE NATIONAL ACADEMIES PRESS 500 Fifth Street, NW Washington, DC 20001**

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This activity was supported by contracts between the National Academy of Sciences and the National Institute of Environmental Health Sciences, American Chemistry Council, Arch Chemicals, and Royal Dutch Shell. The views presented in this publication do not necessarily reflect the views of the organizations or agencies that provided support for the activity.

This summary is based on the proceedings of a workshop that was sponsored by the Roundtable on Environmental Health Sciences, Research, and Medicine. It is prepared in the form of a workshop summary by and in the name of the rapporteurs as an individually authored document.

International Standard Book Number-13: 978-0-309-28786-9
International Standard Book Number-10: 0-309-28786-3

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Printed in the United States of America

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Suggested citation: IOM (Institute of Medicine). 2013. *Public health linkages with sustainability: Workshop summary.* Washington, DC: The National Academies Press

*"Knowing is not enough; we must apply.*
*Willing is not enough; we must do."*
—Goethe



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This workshop summary has been reviewed in draft form by individuals chosen for their diverse perspectives and technical expertise, in accordance with procedures approved by the National Research Council's Report Review Committee. The purpose of this independent review is to provide candid and critical comments that will assist the institution in making its published workshop summary as sound as possible and to ensure that the workshop summary meets institutional standards for objectivity, evidence, and responsiveness to the study charge. The review comments and draft manuscript remain confidential to protect the integrity of the process. We wish to thank the following individuals for their review of this workshop summary:

**Robert Goldsmith,** Novartis Pharmaceuticals Corporation
**Susan Santos,** University of Medicine and Dentistry of New Jersey
**Carlos Santos-Burgoa,** Pan American Health Organization
**Juli Trtanj,** National Oceanic and Atmospheric Administration

Although the reviewers listed above have provided many constructive comments and suggestions, they did not see the final draft of the workshop summary before its release. The review of this workshop summary was overseen by **Melvin Worth.** Appointed by the Institute of Medicine, he was responsible for making certain that an independent examination of this workshop summary was carried out in accordance with institutional procedures and that all review comments were carefully considered. Responsibility for the final content of this workshop summary rests entirely with the authors and the institution.

# CONTENTS

# 1

# INTRODUCTION

It has been 20 years since the 1992 Earth Summit in Rio de Janeiro when world leaders gathered to reaffirm the Declaration of the United Nations Conference on the Human Environment that was adopted in Stockholm on June 16, 1972. The summit built on this effort with the "goal of establishing a new and equitable global partnership through the creation of new levels of cooperation among states, key sectors of societies and people, working towards international agreements that respect the interests of all and protect the integrity of the global environmental and developmental system, and recognizing the integral and interdependent nature of the Earth" (UN, 1992). From this meeting, the member states adopted Agenda 21, an unprecedented framework for the transition to a more sustainable world. Ten years later, the Johannesburg World Summit on Sustainable Development provided an opportunity for identification and adoption of concrete steps and targets to implement aspects of Agenda 21. As world leaders prepared to gather again in 2012 in Rio de Janeiro, to assess and reaffirm the importance of the world's progress toward these efforts, the Institute of Medicine's Roundtable on Environmental Health Sciences, Research, and Medicine held a workshop to inform the policies that would be discussed at the conference.

The Roundtable was established in 1998 and provides a structured opportunity for regular and open communication among interested experts from a variety of government, academic, industry, and consumer groups in a neutral setting. Through meetings and workshops, the Roundtable facilitates discussion of current and emerging issues in environmental health sciences and decision making, identification of vulnerable populations to environmental hazards, and translation of environmental health research into public health practice. The Roundtable defines the environment broadly—one that incorporates the natural, the built, and the social environments—and considers how

changes in our environment can impact human health through direct and indirect pathways (IOM, 2006).

The Roundtable sponsored a workshop in Woods Hole, Massachusetts, on July 25-26, 2011, to consider the issue of sustainability and health. The term "sustainability" comes from the concept of sustainable development, defined in 1987 by the World Commission on Environment and Development (commonly known as the Brundtland Commission) as "development which meets the needs of the present without compromising the ability of future generations to meet their own needs" (WCED, 1987). Sustainability is built on three pillars—economic, social, and environmental—with health subsumed under the social pillar, though it can be argued that health is a cross-cutting theme or outcome of sustainability (UN, 2012). In an effort to move the topic forward within higher-level policy discussions, the workshop gathered speakers and participants to provide varied perspectives on the connections between human health and sustainability. The presentations covered alternative frameworks of sustainability in which health and public health are more centrally considered across the spectrum of sustainability policies and decisions. In particular, the workshop emphasized the intersections between sustainability and toxicology, noncommunicable diseases, energy options and air quality, food and water resources, occupational and childhood health, and the role of climate change and urbanization across these topic areas.

The workshop was organized by an independent planning committee, whose role was limited to planning the workshop, in accordance with the procedures of the National Research Council (NRC). This summary was prepared by the workshop rapporteurs as a factual summary of what occurred at the workshop. All views presented in the summary are those of the workshop participants. The summary does not contain any findings or recommendations by the planning committee or the Roundtable. The statement of task of the workshop was as follows:

> An ad hoc committee will plan and conduct a public workshop on linkages between sustainability and public health. The workshop will feature invited presentations and discussions to look at the state of the science of the intersection of public health and sustainability. In addition, the workshop will focus on when sustainability and public health do not overlap (i.e., when being green

> is not healthy), the health messages in this area, and the impact for the global community. Further, the Roundtable and its discussants will explore the implications of this intersection for the upcoming Rio+20 meeting. The committee will develop the workshop agenda, select invited speakers and discussants, and moderate the discussions. A workshop summary will be prepared by a designated rapporteur in accordance with NRC policies and procedures.

The presentations and discussions that occurred during the workshop are summarized in the subsequent chapters. Chapter 2 provides an overview of the conceptual issues and frameworks for sustainability and health, and the role that climate change plays in these discussions. Chapter 3 explores connections between energy options, air quality, and human health with additional ties to climate change mitigation. Chapter 4 considers the linkages between sustainability and food and water resources. Chapter 5 follows with further links between sustainability and occupational and childhood health. Chapter 6 presents a new framing for sustainability from a U.S. perspective. Chapter 7 concludes with health messages and strategies for dissemination. The workshop agenda can be found in Appendix A and the workshop speaker biosketches are included in Appendix B.

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# 2

# OVERVIEW OF THE LINKS BETWEEN SUSTAINABILITY AND HUMAN HEALTH

This chapter provides an overview of past events and existing frameworks that make linkages between sustainable development and human health. The chapter opens with insights into the global sustainability movement, followed by comments on how to turn the global spotlight to environmental health and sustainability issues through primarily U.S. policy processes. The role that climate change plays in sustainability and health is then outlined, and additional speakers make connections to noncommunicable diseases, economic productivity, and systems frameworks. The chapter closes with a brief discussion of these varied areas and perspectives.

## RIO+20 AND HEALTH: ROADS LEADING FROM THE RIO EARTH SUMMIT IN 1992 TO 2012

*Wilfried Kreisel, Ph.D.*
*Consultant, Energy and Health*
*Former Executive Director, Health and Environment*
*World Health Organization*

Wilfried Kreisel explained that during the events leading up to the Rio Earth Summit in 1992, health was not a primary concern of the global sustainability movement. He noted that the environmentalists and conservationists governing sustainability advocacy did not directly focus on health issues, so health and sustainability remained detached. For instance, the 1987 report *Our Common Future* by the World Commission on Environment and Development confronted challenges ultimately

presenting health harms such as toxic wastes and food security, but it did not specifically address health (WCED, 1987). This report became one of the major foundations for the 1992 Rio conference, he said, presenting an uphill battle for placing health on the agenda.

Kreisel stated that in 1989, the World Health Organization (WHO) Director-General, Dr. Hiroshi Nakajima, made the crucial decision to entwine health and environment as one of its key program priorities. Kreisel pointed out that this provided the opportunity to look more in depth at health and the environment. He noted that founding of the WHO Commission on Health and Environment followed. Its task was to review the linkages between the environment, health, and development, which also spurred the creation of expert panels to analyze these links and prepare reports for the 1992 Rio Earth Summit pertaining to food and agriculture (WHO, 1992a), energy (WHO, 1992b), industry (WHO, 1992c), and urbanization (WHO, 1992d). Leading up to 1992, it was the work of these commissions, panels, and groups that laid the foundation for emphasizing health at the Rio Earth Summit.

Kreisel noted that work from the WHO Commission on Health and Environment was used to influence Agenda 21 and the Rio Declaration, the ensuing documents from the Rio Earth Summit. Health became the cornerstone of Principle 1 of the Rio Declaration, which states that "Human beings are at the center of concerns for sustainable development. They are entitled to a *healthy* and productive life in harmony with nature" [emphasis added] (UN, 1992). He explained that Agenda 21 covered diverse, broad issues, including conservation and management of resources for development, social and economic dimensions, and means of implementation, all converging on health (UN, 1993). Each of the chapters of the agenda concentrated on chemicals, fresh water quality, managing hazardous wastes, and the protection of atmosphere, and all explicitly made linkages to health (UN, 1993). Chapter 6 was devoted to protecting and promoting human health, and contained five broad priority program areas (UN, 1993):

- Meet primary health care needs, particularly in rural areas.
- Control communicable diseases.
- Protect vulnerable groups.
- Meet the urban health challenge.
- Reduce health risks from environmental pollution and hazards.

It should be noted that noncommunicable diseases and climate change were not included with the other health topics in Agenda 21.

Kreisel noted that the goal was to comprehensively develop an intersectoral plan of action for health and emphasize the need for disease prevention over cure. He stated that Agenda 21 was one of the broadest agendas for action developed to date, and despite being 20 years old, needs little refinement today.

In the years following the Rio Earth Summit, Kreisel explained, WHO acted assertively to grow the seeds that had been sown. The World Health Assembly Resolution on Health and Environment was issued in 1993 (WHO, 1993). WHO then developed a Global Strategy for Health and Environment in 1993 (WHO, 1993) and a corresponding Action Plan in 1994 (WHO, 1994). The regional offices followed by developing regionally appropriate strategies. At the national level, more than 100 environmental health action plans arose around the world (WHO, 2002). He stated that fledgling coordination between local, regional, and global entities also emerged, as was represented by the Intergovernmental Forum on Chemical Safety (UN, 2000).

In 2000, the Millennium Development Summit gave rise to the Millennium Development Goals (MDGs) (UN General Assembly, 2000). Kreisel noted that the eight health-related MDGs focused on issues such as poverty, primary education, and environmental sustainability. Two years later, the MDGs were reaffirmed in Johannesburg at the World Summit on Sustainable Development (UN, 2002). He explained that this summit was a milestone as countries recommitted to agreed targets to reduce HIV prevalence, improve chemical production and risk assessment procedures to reduce harms to human health and the environment, and enhance cooperation to reduce air pollution.

Although there has been much progress working toward the MDGs, Kreisel stated that there are still sizeable implementation gaps. He noted that many member states do not affirm that public health and its linkages to the health of the environment are central to sustainable development. Additionally, the health sector has yet to play an active role in sustainable development policies and strategies. He explained that convergence of economic and social development with environmental protection and health has been limited, and there is little coherence between environmental and health policies. Dissociating health and environmental concerns has limited the advancement of the MDGs, he said, and many countries are not on pace to achieve key goals. Of the 84 countries for

which data are available (out of 144), only 45 are on track to reach their poverty-reduction targets (World Bank and International Monetary Fund, 2009). Looking forward, new and emerging challenges, in particular climate change, have been exacerbated in developing countries by poverty, the rapid pace of rural and urban migration, competition for scarce resources, and the concomitant challenges to provide food, infrastructure, and access to basic health, water, and energy services (UN General Assembly, 2010). In addition to poverty concerns, there is a struggle to mitigate the equity gap within poor countries, where narrowing wealth disparities within a nation has become paramount.

Kreisel stated that the time has come not only to review and assess what has been achieved on the basis of the "spirit of Rio" put forward in 1992 but also to build upon it and revive its promise of integration, unity, and aspiration (UN General Assembly, 2010). He noted that the excitement and hope experienced 20 years ago are needed to tackle modern crises and recommit political will to sustainable development. Today, problems are often discussed as though they are separate, but climate change, biodiversity loss, and scarcity of raw materials are really one and the same problem. He explained that effectively integrated, intersectoral policies are needed to address these problems—only then is sustainable development achievable. The convergence between the three pillars of sustainable development—environmental, social, and economic—is a concept of the green economy. Unfortunately, some developmental and social dimensions, in particular poverty eradication and health, have not been adequately covered in some of the policy prescriptions on the green economy (UN General Assembly, 2010). Kreisel emphasized that it is imperative that the centerpiece of sustainable development be health, and health be linked to all three pillars.

To further health in the sustainable development arena, Kreisel stated that the health sector should review and clearly present evidence about the health consequences of climate change and the expected health impacts of mitigation strategies. Within the economic sectors of transport, electricity generation, and housing, he said, there are large and instant health co-benefits to adopting green economy policies. He noted that the health sector could become an energetic supporter of this budding green economy and help to galvanize public investment in sustainable infrastructure (including public transport, renewable energy, and building retrofits to improve energy efficiency) to mitigate and adapt

to climate change (UN General Assembly, 2010). Encouraging green economy actions has the potential to

- avert a large proportion of chronic obstructive pulmonary disease due to smoke from indoor cookstoves (Wilkinson et al., 2009);
- reduce cardiovascular and respiratory disease from air pollution as private motorized transport is replaced by walking, cycling, and public transport (Boone-Heinonen et al., 2009); and
- improve health equity by lessening exposure to pollution and expanding access to clean air and water, nutritious food, and health care facilities (WHO, 2011b).

Kreisel stated that when communicating the potential health benefits from the green economy and concomitant mitigation of climate change, it is paramount to restructure the arguments within a health paradigm. He noted that evaluation of health effects touches the core of a debate that has stalled climate change negotiations—the debate about who gains and who might lose—but health co-benefits present a "win-win" situation for most people, in particular those in developing countries.

As WHO prepares for Rio+20, Kreisel said, it focuses on and advocates for health in all policies. He stated that policy decisions in other sectors really affect health outcomes, and health governance through healthy public policies needs to be maintained or improved. As mentioned, emphasizing the health co-benefits of the green economy is of great importance. He noted that it is also imperative to advocate for the prevention of environmentally and occupationally related diseases, since approximately 24 percent of the global burden of disease can be avoided by known cost-effective environmental and occupational health interventions (Smith et al., 1999; WHO, 2006). Additionally, he said, the health sector should lead by example by greening itself and reducing its ecological footprint. Moving forward, Kreisel stated, the strategies described here have the potential to improve global health and the health of the planet.

## UNDERSTANDING THE GLOBAL COMMITMENT TO ADDRESSING ENVIRONMENTAL AND HEALTH ISSUES

*David J. van Hoogstraten, Esq.*
*Director, Policy and Regulatory Affairs*
*BP Wind Energy, North America, Inc.*

David J. van Hoogstraten began by addressing how to turn the global spotlight onto environmental health issues, since it can be challenging to get people's attention. He asked the question of whether it takes a critical event or a series of events that need to be addressed urgently to capture the attention of people, or if it requires the media to fan the flames of concern. Van Hoogstraten noted that with regard to climate change, he believes that a catastrophe or large forcing event is likely needed for the United States and the international community to place this on the global agenda. He pointed out that climate change, and ozone depletion as another example, are clearly global issues that cannot be addressed by other frameworks and mechanisms at the country level, even if countries act bilaterally or regionally. However, many areas where the global community has focused in recent years could have been dealt with regionally or bilaterally, such as transboundary movement of hazardous wastes, protection of biodiversity, and prior informed consent for the transboundary movement of toxic chemicals and pesticides. He explained that in order to be placed on the global agenda, the global environmental health issue needs sufficient political will and media attention, in addition to cataclysmic conditions. For the first 50 years after World War II, international environmental efforts primarily relied on the working of the United Nations and the World Health Organization. Today, there is a large network of nongovernmental organizations (NGOs), including the World Wildlife Fund, Greenpeace, the United Nations Foundation, the Bill and Melinda Gates Foundation, and the Clinton Global Initiative, that have invested in the past two decades in sustainability and poverty elimination. Van Hoogstraten pointed out that often these organizations have been able to launch programs and provide services that governments used to deliver. A number of avenues are available to accomplish their goals; for example, these NGOs have used the power of the Internet to connect with and inform the broader public. Those investments have sparked the media's attention, and the NGOs now have a continuous and growing following.

Van Hoogstraten added that these efforts have paved the way to allow for greater public participation in current efforts and solutions.

### Current Situation for International Environmental Agreements

In order to understand the mechanism behind getting the international community to address an issue, stated van Hoogstraten, you need to understand the global environmental health treaty process, and multinational environmental health and safety agreements. He noted that the institution through which new environmental issues are placed on the global agenda has historically been the United Nations Environment Programme (UNEP) Governing Council. At the annual governing council meeting, proponents of a particular approach propose the adoption of a binding or nonbinding resolution to an international environmental or conservation challenge. When consensus on negotiating an international agreement is reached at the governing council, an international negotiating committee (INC) is appointed. The INC is composed of appointed representatives (often led by UN General Assembly members) who develop a negotiating schedule, which can run over a couple of years. Van Hoogstraten stated that the INCs have been criticized for including members who are neither conversant with the issues nor authorized to speak for more powerful segments of their governments, but noted that there appears to be better coordination today.

Van Hoogstraten explained that at the country level, for coherent national positions to be developed, treaty negotiation requires coordination among various agencies with very different mandates. In the United States, negotiations begin at the State Department by invoking the Interagency Circular 175 (or C-175) process. The C-175 process outlines

> regulations developed by the State Department to ensure the proper exercise of the treaty-making power. Specifically, the Circular 175 procedure seeks to confirm that the making of treaties and other international agreements by the United States is carried out within constitutional and other legal limitations, with due consideration of the agreement's foreign policy implications, and with appropriate involvement by the State Department. (U.S. Department of State, 2012)

The Department of State developed a handbook, *Supplementary Handbook on the C-175 Process: Routine Science and Technology Agreements*, in response to a National Research Council report *The Pervasive Role of Science, Technology, and Health in Foreign Policy: Imperatives for the Department of State* (NRC, 1999) that recommended the streamlining of the process and an interagency review of proposed international agreements. The C-175 process is very intricate, van Hoogstraten stated, with complicated interagency involvement to assess the impact a proposed agreement may have on international trade, economic affairs, defense, the environment, and so forth.

In the United States, van Hoogstraten noted, political factors including the lack of bipartisan consensus on international environmental issues has prevented the ratification of many international environmental and conservation agreements. Furthermore, for the United States to become a party to any treaty, it must be ratified by the U.S. Congress. Van Hoogstraten explained that this has proven extraordinarily difficult, even in cases when other countries have taken major steps to accommodate U.S. positions during the negotiation process (which has hurt U.S. credibility), and exemplifies the need to communicate with Congress as agreements move forward. Van Hoogstraten noted that even upon joining a global environmental agreement, the enforcement mechanisms remain weak and there is little leverage to influence outcomes and action. Generally, he said, moral persuasion of peers and the spotlight of world opinion (often made brighter by the Internet) are what prompt countries to adhere to these agreements.

### Making the Case for Environmental Health in Rio+20

Van Hoogstraten explained that the Rio+20 conference is a convocation of countries getting together to develop a plan of action that will not be legally binding, but will be binding as a political statement. Unfortunately, he noted, this conference could not fall at a worse time, given the current economic climate and lack of media focus and grassroots demand for concerted government action with respect to global environmental issues. The preparations made by the United States for the Rio+20 conference have involved mainly the Environmental Protection Agency (EPA) and the Department of State's Bureau of Oceans and International Environmental and Scientific Affairs. Beyond this, there has been limited involvement from other agencies and high-level political officials.

Despite these difficulties, Rio+20 still presents opportunities to elevate health issues onto the global environmental agenda. Van Hoogstraten noted that green energy development and green technology may play an important role in the context of sustainable development. However, there is a need to rebrand these issues in order to make clear links to the health agenda. He stated that international concerns about sustainable development are increasingly viewed in the context of poverty eradication rather than environmental protection and health promotion. When it comes to renewable energy development (e.g., wind, solar, biofuels), instead of emphasizing low- or no-carbon emissions and combating global warming, the messaging could focus on the salutary human health effects of renewable energy sources: the fact that there is no particulate matter emitted, no or low water usage, and no hazardous wastes. He emphasized that these could be rebranded as clean energy sources, as well as healthy energy sources.

## Final Remarks

Van Hoogstraten pointed out that focusing on human health aspects of multifaceted issues like climate change will likely foster progress within developed country governments. He noted that many countries have not been willing to discuss climate change at international meetings, which suggests that a different framework for tackling environmental challenges should be adopted. For example, if the international effort to reduce black carbon emissions could focus on human health—highlighting premature deaths caused by respiratory diseases, particularly among women and children—it may gain stronger and wider support.

Van Hoogstraten noted that the U.S. government does not yet have a unified strategy with respect to the role it will play in major global commitments to address key environmental challenges. He added that there is no driving issue, there are few financial commitments, and there is the ongoing risk of raising unreasonable expectations in the United States. Although all U.S. parties involved in the planning are eager to consider how to add human health to the sustainability equation, he said, there is a very small window of opportunity prior to the conference and time is quite short.

## CLIMATE CHANGE: THE NEED FOR LINKAGES FOR SUSTAINABILITY AND HEALTH

*Carlos Corvalán, Ph.D.*
*Senior Advisor on Risk Assessment and Global Environmental Change*
*Pan American Health Organization*

Carlos Corvalán noted that the meaning of sustainable development was first made prominent in the Brundtland Commission Report of 1987, which defined it as "development that meets the needs of the present without compromising the ability of future generations to meet their own needs" (WCED, 1987). The 2002 World Summit on Sustainable Development held in Johannesburg further elaborated on sustainable development, recognizing that it rests on three interdependent and mutually reinforcing pillars (UN, 2002)—the economic, social, and environmental pillars. Corvalán stated that each pillar may be addressed in its own way, but for sustainable development to be fully realized, these pillars must be integrated.

### Climate Change and Health

Corvalán explained that the 2007 International Panel on Climate Change (IPCC) report describes the linkages between the economic, social, and environmental pressures and climate change (IPCC, 2007). The dynamics that surround socioeconomic development and the drivers of climate change, he stated, eventually increase or threaten the vulnerabilities and result in a decline in human health. Socioeconomic development, he noted, includes production and consumption patterns, technology, trade, and sociocultural preferences (and the fossil fuel energy required to support these practices). Together, these alter the demand for energy and resources, which can lead to increased emissions of greenhouse gases and aerosols. In turn, he said, increased concentrations of greenhouse gases in the atmosphere are a driver of climate change, which can cause temperature and precipitation changes, sea level rise, and increased extreme weather events. Human health is of great concern, since climate change can cause changes in ecosystems, water resources, and food security that affect human health; additionally, human health is impacted directly through air pollution, heat waves, and extreme climate events. Corvalán emphasized that human health is at the

end of a very long chain of events surrounding socioeconomic development and the drivers of climate change.

Corvalán stated that a similar pattern is observed when thinking more broadly about environmental health risks. In Figure 2-1, health is located in the center, surrounded by proximal risk factors, such as air pollution, radiation, water and sanitation, and chemicals, that all impinge upon health directly. Corvalán noted that more distal factors serve as drivers for the proximal causes; these include climate change, migration, degraded ecosystems, water scarcity, and desertification. Climate change is so important because it has the ability to influence many other environmental health risk factors, as depicted by the extended arrows in Figure 2-1.

In the long term, stated Corvalán, everyone is vulnerable to climate change, but there are many populations that are likely to be disproportionately affected or unable to adapt. These include the poor, children, pregnant women, indigenous populations, the disabled, and the aged (PAHO, 2011). By 2050, the population over the age of 65 will have increased substantially, so that many countries, perhaps the whole world, will be where developed countries are today (UN, 2009).

He noted that this population may be unable to cope with the extreme weather that is predicted to be a feature of climate change. Within the past decade, there have been heat waves in Europe (2003), Australia (2009), and China (2010); historical flooding in Mexico (2007) and Pakistan (2010); and violent weather events like hurricanes and cyclones around the globe (World Meteorological Organization, 2011). He stated that these events are all consistent with climate change predictions and may especially imperil the elderly and other vulnerable populations.

Corvalán emphasized that it is important to recognize that instead of working together the three pillars of sustainable development have been disconnected, with global crises occurring under each. Under the social pillar, there has been an ongoing poverty crisis, a food crisis, and an increasing inequality crisis. Regarding the economic pillar, the past few years have witnessed a global financial crisis and an ongoing energy crisis. Finally, in the realm of the environmental pillar, ecosystem degradation has become pronounced, and, as already mentioned, the effects of climate change are starting to materialize. He noted that work under the three pillars could be integrated to avoid these crises and to further sustainable development.

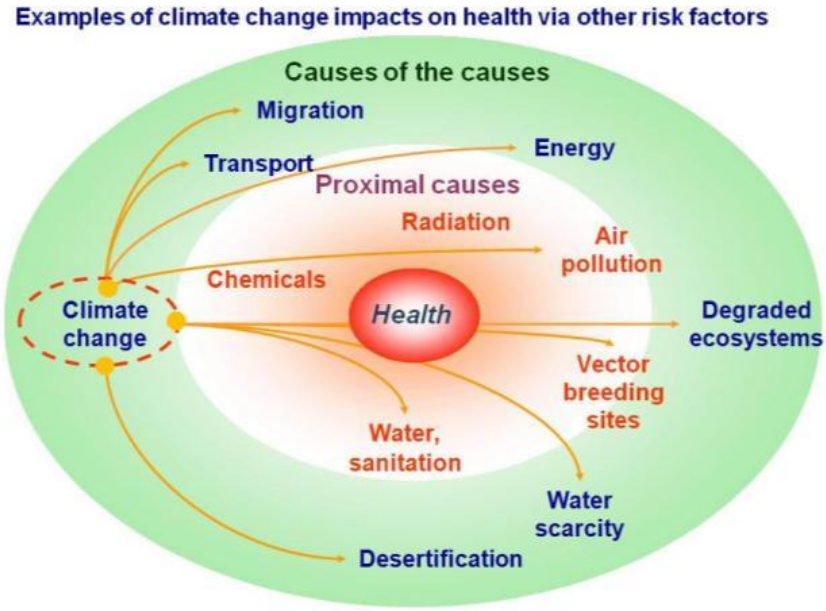


**FIGURE 2-1** Climate change impacts on other risk factors.
NOTE: Climate change affects health directly (for example, increased frequency of heat waves affects the health of vulnerable populations, in this case children, outdoor workers, and the elderly). Proximal environmental health risks (inner circle), such as radiation, air pollution, and vector-borne diseases, negatively affect health and can have negative effects. There are also distal environmental health risks (outer circle) that can affect the proximal causes. Climate change, a distal threat, impinges upon proximal causes and can exacerbate the risk they pose to health. Thus, climate change can affect health directly and indirectly.
SOURCE: Corvalán, 2011.

## An Agenda for Action

Corvalán explained that WHO and the Pan American Health Organization (PAHO) have developed a global action plan to address the implications of climate change for health and health systems. He described the plan as comprised of four parts, the first of which is to gather more evidence on the type of interventions that should be implemented to ensure that climate change adaptation is carried out properly. Second, those in the health sector need to raise awareness about climate change (which may involve making them aware of what they can do) and work to reduce the carbon footprint of the health sector. The

third part is to establish partnerships because climate change is too broad an issue for any one sector to tackle alone. He noted that the health sector needs to become a leader where health issues are concerned. Fourth, adaptation strategies need to be adopted to strengthen health systems in areas that are likely to be affected by climate change.

Corvalán stated that the green economy will be one key issue at the Rio+20 conference and will provide an opportunity to discuss climate change mitigation. UNEP defines a green economy as one that results in "improved human well-being and social equity, while significantly reducing environmental risks and ecological scarcities" (UNEP, 2010, 2011). He explained that the notion of a green economy is an important step forward because it signifies attention to climate change mitigation. The UNEP report (UNEP, 2011) described the green economy as substituting clean energy and low-carbon technologies for fossil fuels, thus addressing climate change. As outlined above, climate change has serious implications for human health, he said, and by fostering a green economy these negative health effects may be lessened.

As the Rio+20 conference approaches, WHO and PAHO are attempting to secure renewed political commitment for sustainable development and to ensure that health is incorporated in sustainable development planning. Corvalán emphasized that it is also time to define a new paradigm for the sustainable development movement with fully integrated dimensions—environmental, social, and economic—with health placed at the center. With this new agenda, he said, there is an opportunity to achieve action in climate change, health, and sustainable development for the global community.

# CURRENT AND EMERGING CHALLENGES AND OPPORTUNITIES FOR ENVIRONMENTAL HEALTH: SUSTAINABILITY, NONCOMMUNICABLE DISEASES, AND OPPORTUNITIES FOR LINKAGES

*Linda S. Birnbaum, Ph.D., D.A.B.T., A.T.S.*
*Director, National Institute of Environmental Health Sciences*
*National Institutes of Health*

Linda S. Birnbaum began by noting that the National Institute of Environmental Health Sciences (NIEHS) is committed to reducing the burden of disease and disability related to environmental factors, not only in the United States but also throughout the world. She stated that it is critical that science be translated into information and actions that will protect public health and improve people's lives, especially heading into the Rio+20 conference.

Birnbaum shared her perspective on the link between environmental health research carried out by the NIEHS and the needs of developing countries. She stated that the institute aims to support economic growth that is sustainable in terms of both natural resources and social systems, as well as in terms of human health. However, health is too often left out or discounted in discussions of sustainable development when other factors such as economics hold sway. She noted that this is a mistake. Birnbaum explained that the impact of development on human health and the resulting long-term effects on sustainability should be critical in all such discussions. The NIEHS has supported scientific endeavors relevant to sustainable development for decades. As global populations increase and resources become scarce, she stated, the NIEHS will continue to work to ensure that health is not only *not* left out of the equation but that it is given a high priority, too.

Birnbaum noted that environmental health may be seen as inherently global. Many pollutants such as mercury, greenhouse gases, and particulate matter are widely distributed around the planet, affecting human health far from the emission sources. She explained that the experiences of industrialized countries with adverse health impacts from polluted air, water, and land are becoming increasingly relevant around the world as less-developed countries are rapidly strategizing on how to achieve similar industrialization. In the race to achieve a higher standard of living, she said, public health is at risk of being compromised. Yet,

there is also the potential for disease prevention and public health protections that have been achieved in wealthier countries to be realized in developing countries.

Throughout its history, Birnbaum explained, the NIEHS has been consistently committed to the goals of protecting and improving global environmental health. Upon opening its doors, the institute welcomed scientists and students from around the world for training and collaborative research. She noted that 36 years ago the NIEHS was named by the WHO as the collaborating center for environmental health effects. For 27 years, the NIEHS has supported a cooperative agreement with the International Program on Chemical Safety, through which it has helped to provide scientific leadership and expertise to efforts to protect public health worldwide from the effects of toxic chemicals. Birnbaum stated that in addition to training partnerships, the NIEHS has funded critical research in collaboration with other countries to better understand the impacts of environmental exposures among the most affected. For example, the NIEHS funded studies of populations in the Seychelles and Faroe Islands who consume high amounts of mercury from fish and other seafood, studies which have helped improve the understanding of neuro-developmental effects of mercury exposure. She explained that this research has contributed to consumption guidelines for pregnant mothers to protect the health of their unborn children. For 12 years, NIEHS funding has supported the study of arsenic contamination of tube wells in Bangladesh. She noted that the tube wells were meant to provide pure, clean water and improve agricultural production, but tragically led to widespread toxic effects from the presence of arsenic in the groundwater. The NIEHS not only documented disease effects, but its work has resulted in a public health intervention of testing thousands of wells and guiding residents to safer drinking water sources. Birnbaum stated that another area where NIEHS is not just studying the problem but also funding research involved in public health interventions is that of indoor air pollution caused by cookstoves. Nearly 2 million people around the world die every year—and others are made sick or disabled—as a result of exposure to smoke from fuels burned in indoor cookstoves (Bruce et al., 2000; WHO, 2011c). The NIEHS is currently the largest funder of cookstoves and health research at the National Institutes of Health, supporting pioneering studies that have documented health improvements from replacing cookstoves. She noted that these are just three examples of environmental exposures that are major contributors to poor health around the world.

## Sustainable Development and Health

Birnbaum noted that WHO estimates that approximately 24 percent of the overall global burden of disease is attributable to environmental factors (WHO, 2006). The range of impact is considerable, from 12 percent in the wealthiest countries to as much as 40 percent in the poorest countries (WHO, 2004). She stated that this figure represents not just an ongoing tragedy but also a ripe opportunity for primary prevention.

Birnbaum explained that there are many definitions of both *sustainability* and *sustainable development*, but one often-cited definition is from the United Nations World Commission on Environment and Development's Brundtland Report (WCED, 1987). "Sustainable development is development that meets the *needs of the present* without compromising the ability of *future generations* to meet their own needs" (emphasis added). Although environmental health is not explicitly mentioned here, she said, clearly the terms of sustainable development cannot be met without its consideration. She noted that being able to meet the needs of the present requires not just economic development but also good health. She added that not compromising the ability of future generations requires the ability to avoid environmental insults that can persist through generations as well as persistent and ongoing toxic pollution related to new or increasingly used technologies.

From an environmental health point of view, sustainable development involves the effect of the environment on health, the resulting impact on development, and subsequent effects directed back to the environment and health (see Figure 2-2). She noted that for those who continue to suffer in poverty, traditional sanitation risks and environmental exposures continue to create barriers to individuals, community, and national economic growth, productivity, and well-being. Birnbaum stated that these are the needs of the present. Additionally, she said, the needs of future generations are reflected in how development affects the environment, and its resulting impact on health. Development has benefited the health of billions of individuals, she said, but it has also created environmental changes that have led to new exposures and threats to human health. She explained that determining how to achieve

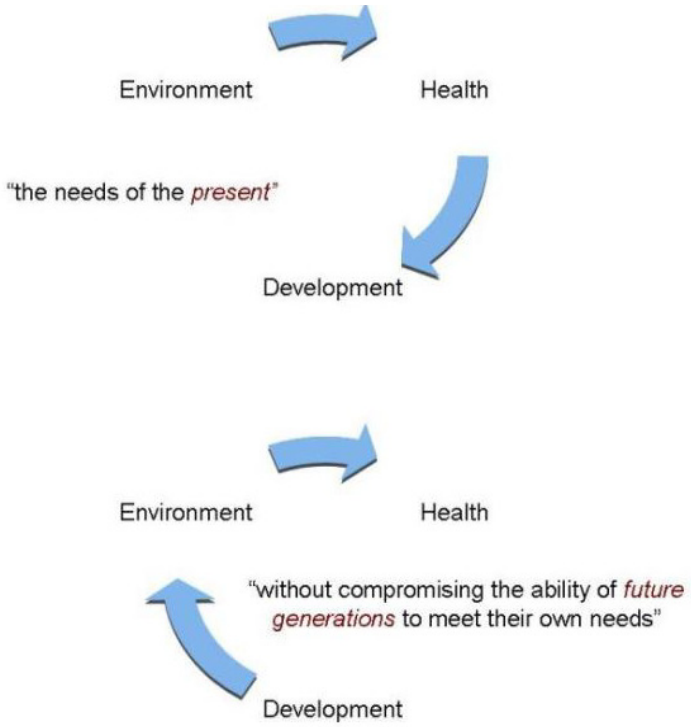


**FIGURE 2-2** Sustainable development.
NOTE: "Sustainable development is development that meets the needs of the present without compromising the ability of future generations to meet their own needs" (WCED, 1987). The environmental health paradigm recognizes that the environment can affect health and development; consequences from development can also affect the environment and health. Top panel: For those who are at risk from inadequate sanitation and environmental exposures, the environment has the greatest impact on health. Economic development and productivity are impeded by the failure to improve health. Ameliorating environmental health risks and allowing populations to flourish are necessary to meet *the needs of the present*. Bottom panel: Development can alter the environment, which can impact health. Socioeconomic development can produce pollution that persists in the environment, exposing vulnerable populations and threatening health. Avoiding environmental insults from development is necessary to ensure that *future generations are able to meet their own needs*.
SOURCE: Birnbaum, 2011.

development without these unintended consequences is an essential principle of sustainable development.

Birnbaum stated that environmental health risks can be impediments to sustainable development through multiple pathways, depending on the stage of development and the types of diseases that predominate at that stage. She noted that this is reflected in the concepts of the epidemiological transition and environmental risk transition that occur with progressive economic development (see Figure 2-3). With the epidemiological transition, the types of diseases that make the largest contribution to mortality and the burden of disease change from communicable, maternal, perinatal, and nutritional diseases (Group I conditions) to noncommunicable diseases (Group II conditions). Birnbaum explained that the environmental risk transition describes the changing contribution of environmental risks that occurs with development, and thus underlies the epidemiological transition. In the early stages of development, local exposures such as smoke from cookstoves or impure water have direct and immediate effects. Increased development gives way to exposures at the community level and ultimately the global level, such as climate change and global mercury transport from burning fossil fuels, which produce effects that are delayed. In rapidly developing countries, it is possible to observe populations simultaneously engaged in multiple stages of the transition (creating a double burden of exposure and disease among many in the poorest areas of these countries). She stated that in terms of addressing environmental health barriers to development, there is substantial progress to be made for all the conditions.

Birnbaum explained that Group I conditions, the traditional diseases of poverty, contribute a large share to the global burden of disease owing to their impact on young individuals, resulting in death or disability at a young age. She noted that they take an enormous emotional and economic toll on families and societies. The Group II chronic conditions also have a significant component attributable to environmental factors (WHO, 2006). She stated that the death rate from noncommunicable diseases is higher in low- and middle-income countries, dispelling the myth that noncommunicable diseases are primarily a problem of the developed world. In fact, 80 percent of deaths from noncommunicable diseases occur in low- and middle-income countries (WHO, 2011a). She noted that a greater proportion of people die from noncommunicable diseases at a younger age in low- and middle-income countries.

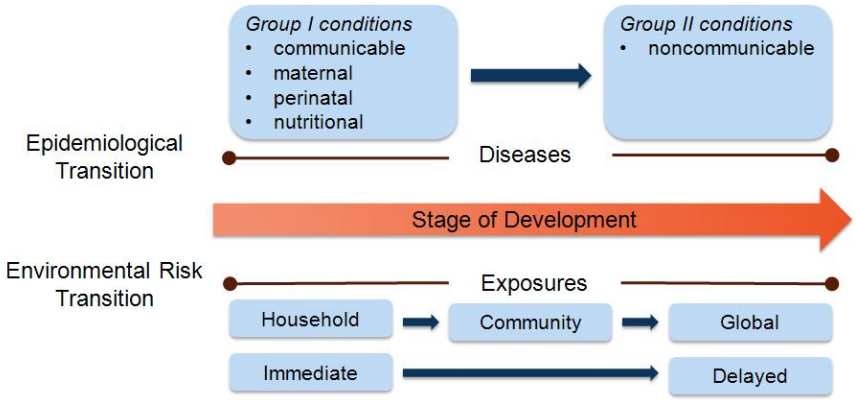


**FIGURE 2-3** A changing landscape for environmental health: The epidemiological and environmental risk transitions.
NOTE: The epidemiological transition describes how, concomitant with economic development, the types of diseases that make the greatest contribution to mortality shift from communicable, maternal, perinatal and nutritional diseases (Group I) to noncommunicable diseases (Group II) like diabetes and stroke. The environmental risk transition underlies and contributes to the epidemiological risk transition. This is the progression from local exposures with direct and immediate effects to community exposures with both immediate and delayed effects, and global exposures that primarily have delayed effects.
SOURCE: Birnbaum, 2011.

For example, it is estimated that 30 percent of noncommunicable disease deaths occur in individuals under the age of 60 in low- and middle-income countries as opposed to 13 percent in high-income countries (WHO, 2011a). According to a study by Abegunde and colleagues (2007), nearly $84 billion of economic productivity will be lost from 2005 to 2015 as a consequence of cardiovascular disease, diabetes, and stroke in 23 low- and middle-income countries. Birnbaum explained that this has important implications for development, given that in much of the developing world individuals pay out of pocket for health care expenses, thus compounding lost productivity from noncommunicable diseases with the financial burden of living with a chronic disease. The greatest effects of this fall increasingly on poorer people within these countries, where a vicious cycle may occur in which poverty exposes people to noncommunicable disease risk factors and the treatment for the resulting diseases may drive families further toward poverty (WHO,

2011a). In the United States, health care expenditures account for up to 17 percent of the gross domestic product (CMS, 2009). For low- and middle-income countries, she said, this type of expenditure in health care would be a tremendous barrier to development, making the role of prevention critical.

### The NIEHS Promotes Health in Development

Birnbaum noted that the NIEHS is actively supporting research on both sides of the epidemiological transition, furthering the idea of environmental health as a prerequisite for development. With regard to Group I communicable diseases, the NIEHS is funding cookstove research that is providing essential information for reducing the burden of respiratory tract infections in children. As for Group II noncommunicable chronic diseases, the NIEHS is conducting research on air pollution, both outdoor and indoor, as well as on carcinogenesis, developmental toxicity, and the fetal basis of adult disease, especially in respect to endocrine disruption. She stated that this work will help to address sustainable development by helping to meet the needs of the present. Birnbaum explained that addressing the rising burden of noncommunicable diseases and their environmental determinants, especially in low- and middle-income countries, will pay the greatest economic dividends as countries progress through the epidemiologic transition. This includes the importance of building research in programmatic capacity to understand pathophysiological mechanisms and strategies for prevention, and decreasing injuries through improved road traffic safety and prevention of occupational hazards.

Birnbaum stated that it is clear in examining the relationship between health and development that causality goes both ways. Without question, she said, development has resulted in economic growth and enormous health benefits for individuals in middle- and high-income countries. However, development has been accompanied by unintended effects on the environment, which have in turn had adverse effects on health. Looking through the lens of health, she said, the challenge moving forward is to understand how the rest of the world can reap the benefits of development while ensuring that unintended environmental health consequences are avoided. Birnbaum pointed out that we need to extend our understanding of the health consequences of future development (including industrialization, rapid evolution of technology, urban

expansion, and globalization) as well as effective ways to address those threats.

Birnbaum explained that much of the work in environmental health to date has been focused at the household and community levels. She stated that the larger-scale consequences of the environmental effects of development and what they mean for human health are only beginning to be recognized. These effects include climate change, urbanization, and the disruption of essential ecosystem services like biodiversity, soil health, and coastal protection. Understanding the potential negative health effects of global environmental change, she said, and the manner by which they can be averted is at the core of the discussion of sustainable development.

Birnbaum stated that the NIEHS is addressing the future needs of sustainable development through a growing research program on the health implications of climate change. A report published in NIEHS's journal *Environmental Health Perspectives* and authored by the U.S. Global Change Research Program's interagency cross-cutting workgroup (Interagency Working Group on Climate Change and Health, 2010) identifies linkages between climate change and a number of its human health effects. Importantly, this report not only outlines the various ways that climate change and its impacts may affect different disease categories but also highlights how these disease categories may be affected by measures taken to reduce greenhouse gases or adapt to climate change. To help fill the research gaps identified in the report, the NIEHS is funding research on population vulnerability to climate change impacts, which will support pilot studies to help define vulnerability factors, develop methods, and build a community of researchers in this important area. The NIEHS also sponsored a series of studies (Friel et al., 2009; Haines et al., 2009; Markandya et al., 2009; Smith et al., 2009; Wilkinson et al., 2009; Woodcock et al., 2009) published in 2009 that explored ways in which efforts to reduce greenhouse gas emissions in diverse sectors of society could have health co-benefits. She explained that these studies showed that climate change mitigation measures could also reduce risk factors that contribute to communicable and noncommunicable disease in the following categories: household energy, land transport, low carbon electricity, food and agriculture, and short-lived greenhouse gas pollutants.

In summary, Birnbaum stated, the NIEHS is providing critical scientific information in an effort to achieve sustainable and healthy

development. She noted that this information is needed to ensure that the needs of the present are met without compromising the ability of future generations to meet their needs as well. To help coordinate work in these areas, the NIEHS is developing a global environmental health and sustainable development program. Through this program, she said, the institute will increase interactions and partnerships with other federal agencies and international organizations that have the ability to help translate science into effective environmental health and sustainable development programs, policies, and initiatives.

## SUSTAINABILITY FRAMEWORKS AND OPPORTUNITIES FOR LINKAGES WITH HEALTH

*Paul Anastas, Ph.D.*
*Assistant Administrator for the Office of Research and Development and Science Advisor*
*U.S. Environmental Protection Agency*

### Today's Challenge

Paul Anastas stated that in addition to focusing on sustainability, his presentation would touch on the frameworks or constructs of green chemistry and the need for systems thinking to achieve transformative innovation. He started with the idea of persistence, noting that if the world's population lived at the same state of development as North America, Japan, and Western Europe, then we would need the equivalent of four Earths to provide all the needed resources and to allow for sustained ecosystems, sustained health, and so forth. He added that one can argue whether this projection is an overestimate or underestimate, but the message is clear: the efforts of humankind need to focus on how to achieve our goals with the one Earth we have. Anastas stated that central to this effort is addressing the grand challenges of sustainability, by simultaneously engaging with the environment, the economy, and society (see Figure 2-4). Additionally, he said, solutions to the challenges we face are within our power to design, such as how to design products that are not toxic and do not persist or bioaccumulate in the environment, people, or wildlife.


**FIGURE 2-4** The challenge of sustainability: connecting the environment, the economy, and society.
NOTE: Currently there is a connection among the three systems: the environment, the economy, and society. To broaden and achieve the goal of sustainability it is important to fully integrate these areas and engage the three systems with equal importance (as depicted in the future goal).
SOURCE: Anastas, 2011.

Anastas pointed out that the current state of manufacturing and design includes a large percentage of toxic materials that are released into the environment with impacts that may not be easily reversed. In the United States, the Toxics Release Inventory (TRI) is a publicly available database used to track information on toxic chemical releases and waste management activities (U.S. National Library of Medicine, 2013). In 2011, 4.09 billion pounds of toxic chemicals were disposed of or released directly to the air, water, and land. However, he explained, these numbers are only a tip of the iceberg as only 650 toxic chemicals and toxic chemical categories out of more than 78,000 in commerce are tracked under the TRI (EPA, 2013).

Anastas stated that there are frequent newspaper headlines about potential environmental health concerns from everyday products ranging from tainted toothpaste to lead-laced baby bibs to formaldehyde in clothing. He added that whether the concern is based on science or on public perceptions, these incidents tend to reduce confidence in products and may present a danger to our health and our environment. Anastas noted that U.S. agencies have been devoting tremendous resources to making our air cleaner and our water less contaminated. However, said Anastas, it is time to assess the current approaches and how we formulate these problems. In current efforts, decision makers and scientists may be striving to do the "right things" for air, water, and land, but is this

approach advancing sustainability? He highlighted that the currently fragmented efforts to address environmental health need a systematic view. For example, climate change is inextricably linked to energy; energy is inextricably linked to water; water to agriculture; agriculture to human health; and yet our approaches are too often reactionary and fragmented along statutory or organizational lines. Anastas stated that it is time to think about decision making as an integrated, interrelated system if society is to make significant progress. As Lisa Jackson noted in her remarks at a separate meeting of the National Academy of Sciences in November 2010, "Sustainability is about understanding that environmental challenges do not obey bright lines or numeric limits. They are not constrained by disciplinary boundaries or the boxed walls of an organizational chart. It's about ensuring that we see the big picture, and are not addressing one environmental issue only to create another consequence in the process" (EPA, 2010).

Anastas said that as we think about providing basic services and products, a more systems-oriented approach, which starts with sustainability, should be adopted. He noted that current environmental efforts are not integrated and are likely to have unintended consequences such as

- renewable biofuels that compete with our ability to provide food;
- water purification processes that use acutely lethal substances whose byproduct can be carcinogenic;
- photovoltaics—which convert solar radiation into direct current electricity—that involve rare, toxic metals;
- pesticides that increase crop yields but have toxic and bioaccumulative effects; and
- energy-saving fluorescent light bulbs that rely on the neurotoxin mercury.

What is clear from these examples, he added, is that unintended consequences do not have to be unanticipated.

Anastas stated that the traditional linear approach of creating value for society with products and energy can be characterized as a cycle in how society thinks about its materials and energy flows. However, when a sustainability approach is used, the focus moves from trying to improve conditions (exposures to chemicals, how chemicals are handled, and putting scrubbers on smokestacks) toward the nature of materials

themselves. "Historically, environmental protection has been shaped by such questions as

- What is the maximum amount of pollution that can be emitted into the air without sacrificing regulatory compliance?
- What is the highest level of toxicity that can be present in our products without breaking the law?
- How many people must fall ill before a standard needs to be strengthened?" (EPA, 2010).

Anastas stated that the traditional approach was and is essential to help assess and manage environmental risk. He noted that this is the way the EPA has operated for more than four decades; it has focused on how much environmental pollution could be allowed under the constraints of risk and law. Anastas emphasized that the opportunity now is to focus on the protection of environmental sustainability and conservation. "It is the difference between treating disease and pursuing wellness," he said. The question becomes, how do we think differently with regard to material and energy flows to provide a framework for sustainability? Anastas pointed out that there is a wide range of approaches to describe operational frameworks that are sustainable, including industrial ecology, natural step, environmental systems management and engineering, design for environment, green engineering,[1] and, as discussed below, green chemistry.

## Green Chemistry

Anastas identified green chemistry as critical for the shift toward sustainability and making linkages to health. Green chemistry aims to redesign the material basis of our society and economy including the materials used to generate, store, and transport energy and other consumer products. And, it seeks to design processes and products to reduce or eliminate the use or generation of hazardous substances. Anastas stated that there are 12 principles of green chemistry (see Box 2-1) that are not merely noble goals to benefit the birds and trees but rather a comprehensive design framework that protects human health. The goal is not only to reduce waste generation by employing waste management,

[1] Green engineering is defined as the design of systems and processes that reduce the use of hazardous substances while minimizing energy usage and the creation of unwanted byproducts (Anastas et al., 2000).

he said, but also to address all of the hazards and adverse consequences and to design for sustainability. This approach incorporates the entire life cycle of chemicals, which includes the origins of materials, manufacturing, distribution, and disposal. Anastas added that this approach has been adopted by corporations around the world and has been recognized by the U.S. Presidential Green Chemistry Challenge Award since 1996 in areas ranging from medicine, to energy, to electronics, to chemicals, to agriculture, and beyond.

**BOX 2-1**
**Twelve Principles of Green Chemistry**

1. It is better to prevent waste than to treat or clean up waste after it is formed.
2. Synthetic methods should be designed to maximize the incorporation of all materials used in the process into the final product.
3. Wherever practicable, synthetic methodologies should be designed to use and generate substances that possess little or no toxicity to human health and the environment.
4. Chemical products should be designed to preserve efficacy of function while reducing toxicity.
5. The use of auxiliary substances (e.g., solvents, separation agents, etc.) should be made unnecessary wherever possible and innocuous when used.
6. Energy requirements should be recognized for their environmental and economic impacts and should be minimized. Synthetic methods should be conducted at ambient temperature and pressure.
7. A raw material of feedstock should be renewable rather than depleting wherever technically and economically practicable.
8. Reduce derivatives—unnecessary derivatization (blocking group, protection/deprotection, temporary modification) should be avoided whenever possible.
9. Catalytic reagents (as selective as possible) are superior to stoichiometric reagents.
10. Chemical products should be designed so that at the end of their function they do not persist in the environment and break down into innocuous degradation products.
11. Analytical methodologies need to be further developed to allow for real-time, in-process monitoring and control prior to the formation of hazardous substances.
12. Substances and the form of a substance used in a chemical process should be chosen to minimize potential for chemical accidents, including releases, explosions, and fires.

SOURCE: Anastas and Warner, 1998.

Although traditional production systems try to anticipate and resist disruptions, Anastas noted that they are still vulnerable to unforeseen factors. He pointed out that an alternative is to design systems with inherent resilience by taking advantage of fundamental properties such as diversity, efficiency, adaptability, and cohesion. Anastas explained that the elements of resilience include reversibility (a system's reaction to a perturbation that does not prevent the system from returning to its original level of function); adaptability (a system's ability to change in response to new system conditions to continue to function at the highest level); and awareness (a system's ability to be aware of changes in system conditions that have the potential to disrupt system function). He noted that while this is not a mature science, experiences of designers and scientists have demonstrated that it is possible to reduce toxicity by modifying molecules and designing product characteristics with elements of resilience.

Anastas stated that green chemistry learns from nature and focuses on biomimicry, which involves examining natural models and processes to solve human challenges. As an example, the current ceramics production process is resource intensive, involving heating, beating, and treating materials. However, the molecular design of the naturally occurring abalone shell affords this material greater hardness than ceramics. Not only is the molecular design environmentally benign, he noted, but the shell has certain advantages to high-tech ceramics in its comparative malleability under stress. Anastas highlighted that unifying performance metrics will be critical to investing in this biomimicry approach.

## 21st-Century Challenges

When the United States began to value environmental protection in the 1970s, said Anastas, the goals were to address the obvious and egregious problems that surrounded the country. He noted that today's 21st-century challenges are broad in scope, nuanced in their complexity, and pervasive in their effects. He stated that it will take a new approach to address climate change, energy choices, multipollutant exposures, diminished water quality due to agriculture, and chemical and biological terrorism. He added that this means moving away from an environmental protection paradigm that focuses on what you need to stop doing, what you need to reduce, what you need to eliminate, what you need to ban, or what you need to minimize. Anastas suggested that a better approach may be to focus on what society can create, innovate, and transform

through new sustainable design frameworks. He emphasized that there is a need to leapfrog toward solutions that break these research and industry silos—moving toward an integrated and transdisciplinary research approach.

## DISCUSSION

A brief discussion followed the presentations and the remarks are summarized in this section. Kreisel asked a question of van Hoogstraten, inquiring whether health could really be a driving force for sustainable development within the Rio+20 agenda. Van Hoogstraten stated that while some people may argue against focusing on health or note that it is a risky choice, there can be a benefit in repackaging the same issue in a different way, and emphasized that the health aspects of some of these complex problems may provide that opportunity. John Balbus then noted that U.S. interagency working groups are often lacking the leadership or perspective of the U.S. Department of Health and Human Services (HHS), which may make it difficult for health to be central to these debates. Balbus asked van Hoogstraten to elaborate on the high-level discussions and considerations that often take place separately from these interagency processes. Van Hoogstraten agreed that many interagency working groups, in which he participated, could have and should have had a voice from HHS. With regard to the other question, he said many of these issues never actually result in a high-level group convening, which is what you want to have happen. He suggested that you should use the stakeholders and constituent groups to try to get a high-level group to focus on your issue, and noted that adding an ambassador to the process—who is a well-known figure, has a great deal of respect, and can speak with the heads of state from the United States and other governments—could also facilitate the process.

Daniel Schrag commented on the idea of utilizing systems thinking to achieve a solution that fits climate change, biodiversity, human health, and sustainable development together in harmony, which was outlined in the presentation from Corvalán. Schrag noted that this idea is often deceptive, since hard choices that need to be made often involve conflict between these areas. For example, he said, options to solve the problem of fossil fuel emissions may be harmful to biodiversity, and there may be

energy options that benefit human health but negatively impact the climate. Schrag emphasized the need to realize the real trade-offs and difficult choices that exist when discussing systems solutions to these complicated issues. Juli Trtanj then returned to the discussion around the Rio+20 conference and noted the need to advocate for integrating health across the working group topic areas (e.g., jobs, energy, cities, food, water, oceans, and disasters) or placing a discrete health topic area on the agenda. She explained that climate change may not be highlighted at the conference and suggested strategizing on how the health community can deliver on something and articulate it to make it viable. She stated that this will likely require support from inside and outside the federal government to practically put messaging forward and deliver on what is outlined.

Shifting to points made in the presentation from Birnbaum, Robert Goldsmith commented on her description of essentially two sets of human diseases—those that are macroenvironmental (e.g., water, air, and the like) and those that are microenvironmental (e.g., diet and nutrition). Goldsmith stated that there appears to be a perfect storm brewing in some developing locations where ecological disruption from development is still occurring and where Western restaurant chains are changing the local diet. Goldsmith asked Birnbaum to comment on how a more systematic approach could be taken to investigate what could be a perfect storm where these noncommunicable morbidity contributors are coming together in populations. Birnbaum noted that some NIEHS grantees are trying to investigate these issues in terms of vulnerability assessments; for example, some studies at the international level are looking at the association between obesity, diabetes, and heart disease and multiple kinds of microenvironmental stressors (including nutrition) and macroenvironmental stressors (beyond chemical exposures). Jamie Bartram added a comment on the household, community, and global exposures that Birnbaum outlined with the environmental risk transition (depicted in Figure 2-3). He noted that those scales of exposure relate to many infectious outcomes as well as many toxic exposures and their associated outcomes. Bartram stated that when we look at a level beyond the community level, but still less than the global level, in many cases we can see the co-benefits of interventions for different environmental and infectious exposures, and this ability to demonstrate co-benefits can strengthen the overall argument for environmental health as a component of the public health agenda.

Edward Doyle then came back to Birnbaum's comment regarding lost economic productivity from noncommunicable diseases. He noted the lack of traction on some of these issues within the policy arena because of the current focus on budget issues and jobs, and asked if we can develop economic arguments to support a public relations campaign for the environmental and health issues. Birnbaum agreed that this is important and pointed out that *The Lancet* published a series of articles in November 2010 looking at ways to economize the benefits of climate change mitigation in order to exemplify the money that could be saved from health care expenditures. She continued to state that there is a need to develop accountability measures and economizing information on the advantages of controlling diseases related to environmental exposures, and to generate a larger effort around these areas. Balbus noted that there are many issues at the intersection of environmental health economics and sustainable development. For example, he said, it is difficult to put a value on premature mortality, and when looking across countries, economists often tie that to GDP per capita, which puts the value of life in a developing country at a fraction of the value of life in the United States. Balbus stated that most public health professionals would disagree with this approach of discounting in economics; not just the traditional discount rate of future values but also the discounting across cultures and countries based on their wealth. He noted that to further sustainable development on an international scale, we need to find language that economists and public health professionals can use to address the issue of disparities in a more ethical and productive way.

Following up on comments from Anastas, William Sullivan asked the presenter to reflect on his first point regarding the need for four planet Earths if the world's population had the same level of consumption as North America, Japan, and Western Europe. Anastas noted that in order to address the consumption issue, we do not just need improved efficiency; we really need to fundamentally change the function and performance of sectors (such as energy, lighting, or food production). He continued to state that this may require a shift from an economy based on material flows to one of performance and value in order to meet sustainability conditions. John Spengler responded to the biomimicry approach that Anastas presented and noted that academic institutions have not applied this to fully integrate and implement sustainability, from individual jobs to performance metrics. Anastas agreed with the points made by Spengler and stated that the current organizational, reward, and metric systems are all fundamentally in opposition to many

of the things that are most sustainable. Spengler went on to note that 5-year community assessment plans and transportation plans conducted by the U.S. Department of Housing and Urban Development (HUD) and the U.S. Department of Transportation (DoT), respectively, have only been integrated recently. Anastas pointed out that HUD, DoT, and EPA came together on this issue wonderfully and noted that the Committee on Environment, Natural Resources, and Sustainability of the National Science and Technology Council is looking into additional interagency sustainability initiatives that can pull across the federal agencies.[2] Hernando Perez emphasized that occupational health seems conspicuously absent in these discussions and asked Anastas to comment on whether or not he thinks this is something that should be incorporated into green chemistry. Anastas stated that occupational health is indeed included in the discussions he is involved with and described work he did with the BlueGreen Alliance to ensure that unions were aware of changes that could be made in manufacturing, transport, and extraction that directly affect them and improve environmental conditions. However, Anastas noted that occupation health could be emphasized more. Lynn Goldman highlighted how Anastas was able to look far ahead in his presentation to lay out an approach to completely change the current U.S. landscape, noting that change needs to occur not just with government and regulatory systems but also with universities, industry, and so forth. She emphasized that the whole concept of resilience is about people incorporating ideas about sustainability and design from the very beginning of everything.

Hartwig de Haen concluded by noting the varied perspectives that were presented during this session. On the one hand, he said, we heard that health needs to be placed at the center of these discussions about sustainable development, and there is a clear and logical way to accomplish this through the Rio+20 conference. On the opposite extreme, he said, we heard that health people are too naïve to engage in these discussions because they just see things from one point of view; they do not understand trade-offs or the complexity of the issues. Because the health community is often viewed this way, he was happy to be reminded of this when putting health into perspective for global agendas. He also noted that we heard the U.S. government can exert its

[2] Additional information on the Committee on Environment, Natural Resources, and Sustainability of the National Science and Technology Council can be found at http://www.whitehouse.gov/administration/eop/ostp/nstc/committees/cenrs.

influence in a lot of ways, either in support of or against a treaty or issue. De Haen emphasized the need to continue these discussions when examining complex issues around energy, food, water, and childhood and occupational health in the subsequent sessions.

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# 3

# LINKS BETWEEN ENERGY, AIR QUALITY, AND HUMAN HEALTH

This chapter considers the connections between energy choices and human health, with a focus on the health impacts of climate change mitigation and air quality. It is suggested that energy changes could lessen the environmental problems associated with climate change (e.g., increased drought, flooding, heat waves, and storms), while also addressing the high burdens of illness (e.g., cancer, cardiovascular disease, and pneumonia) that impact populations throughout the world. In discussing policy options (primarily looking at the United States), the presenters try to address the difficult trade-offs that may be required to adapt the current energy system to benefit human health. A summary of the presentations is provided.

## THE ROLE OF PUBLIC HEALTH IN THE ENERGY-CLIMATE CHALLENGE

*Daniel P. Schrag, Ph.D.*
*Director, Harvard University Center for the Environment*
*Sturgis Hooper Professor of Geology and Professor of Environmental Science and Engineering*
*Harvard University*

Daniel P. Schrag began his presentation by highlighting that the world energy system has changed substantially from 1800 to the present: transitioning from mostly wood to the onset of coal, then the growth of oil, natural gas, and hydropower, and most recently the arrival of nuclear energy. Roughly 85 percent of the energy in the United States now comes from fossil fuels. Combustion of fossil fuels has resulted in a

steadily increasing concentration of carbon dioxide in the atmosphere; in 1957, the concentration of atmospheric carbon dioxide at Mauna Loa, Hawaii, was 315 parts per million, and today it is nearly 400 parts per million (Keeling and Scripps Institution of Oceanography, 2012; Tans and NOAA/ESRL, 2011). Schrag noted that we know from measurements of air bubbles trapped in ice cores that the concentration today is higher than it has ever been for at least the past 800,000 years, and probably for several million years. When carbon dioxide is released into the atmosphere, roughly 50 percent is taken up by the land and ocean within about 1 year (Archer and Brovkin, 2008). What remains is slowly taken up by the ocean over several thousand years, all except for 10 to 20 percent, which will remain in the atmosphere for tens of thousands of years (Archer and Brovkin, 2008). Thus, there is a very long "tail" of the impact of human activities on the carbon cycle, he said, and our decisions about energy choices over the next several decades will affect the Earth for tens of thousands of years.

Carbon dioxide and other greenhouse gases are known to contribute to the radiative forcing[1] of climate change (IPCC, 2007). There are many different ways to estimate the sensitivity of Earth's climate to changes in carbon dioxide concentration, but Schrag cited a useful geological comparison to put the projected changes over the next century in perspective. Twenty-thousand years ago, much of North America was covered by the Laurentide ice sheet, sea level was 130 meters lower than today, and global average temperature was 5 degrees Celsius colder (Bluemle et al., 1999). The transition from that climate, called the "Last Glacial Maximum,"[2] to the preindustrial climate took roughly 10,000 years (Clark et al., 2009). Schrag noted that over the next 100 years, models predict that the Earth may warm by approximately 5 degrees Celsius (IPCC, 2007), highlighting that this is the same magnitude of change but 100 times faster. Because the time scale of this temperature change is so much shorter than what the Earth has experienced over geologic history, said Schrag, it is difficult to predict exactly how human society or natural ecosystem will react to these changes. Schrag stated

[1] Radiative forcing is used to compare how a range of human and natural factors drive warming or cooling influences on global climate; positive forcing tends to warm the surface while negative forcing tends to cool it (IPCC, 2007).

[2] The Last Glacial Maximum is the most recent interval in the Earth's climate history when global ice sheets were at their maximum extension, which occurred between 26,500 and 19,000–20,000 years ago (Clark et al., 2009).

that some of the greatest impacts for human society may include droughts, heat waves, floods, storms, sea level rise, and changes in mountain snowmelt.

It is often stated that there is great uncertainty in the predictions of future climate change (IPCC, 2007), and Schrag noted that is correct. He went on to add that no human has ever witnessed carbon dioxide levels as high as they are today (IPCC, 2007), so it is a very challenging scientific problem to predict how the Earth system will respond. However, this uncertainty is sometimes taken to mean that future climate change is likely to be milder than scientists predict. Many lines of evidence suggest that the opposite is true, and Schrag suggested that scientists have been overly conservative in their predictions. He cited the concern about the collapse of Ross Ice Shelf [3] as a good example. The flow of ice from West Antarctica into the Ross Sea is impeded by the Ross Ice Shelf, which is a piece of glacial ice more than 250 meters thick that has flowed out over the ocean (Crary et al., 1962). If the entire Ross Ice Shelf breaks off from Antarctica, it would allow the very rapid flow of ice from West and East Antarctica into the Ross Sea, which could cause sea level to rise rapidly, possibly a meter or more over a century (Oppenheimer, 1998). Schrag stated that this has been described as a low-probability, high-consequence event, but our understanding of whether this will occur is limited by the sparse data available on oceanographic conditions around the perimeter of Antarctica. In fact, he added, the collapse of the Ross Ice Shelf is an event of high consequence and unknown probability; it might be very unlikely or it might be absolutely certain, we just do not know. But because scientists tend to be conservative in their assessments (e.g., relying upon 95 percent confidence intervals), the public perception of risk may be lower than reality.

## Impacts of Climate Change on Human Health

Schrag noted that climate change will impact human health in several areas, including

- changes in the distribution of infectious disease,
- water scarcity,

[3] The Ross Ice Shelf, located in Antarctica, is the largest floating freshwater ice formation in the world (Crary et al., 1962).

- nutritional changes,
- food availability, and
- population displacement.

Some experts believe that nutrition and food availability will be impacted the most, especially in low-income countries, he said. This will likely result in both direct changes (e.g., malnutrition) and indirect changes (increased diseases). Additionally, Schrag emphasized that the world food system may be further strained by factors other than climate change, such as global economic growth, global population growth, and more countries transitioning to a Western-style diet. These factors are projected to result in a doubling of global food demand by 2050 (Tilman et al., 2011).

Schrag stated that models and observational studies show that temperature can have a great impact on agricultural yields. Experimental and crop-based models that investigate temperature changes in the tropics and subtropics show that a 1 degree Celsius increase in growing season temperature can result in a 2.5–16 percent loss in yields of maize, rice, and wheat (Lobell et al., 2008; Peng et al., 2004). These estimates are also supported by observational data from other regions. In 2010, Russian wheat production decreased by more than 30 percent compared to the previous year because of extreme heat waves during the growing season (USDA, 2011). Schrag noted that the country was forced to ban grain exports through the middle of 2011 in order to meet domestic demands throughout this period. With studies predicting a rise in the average temperature for the latter part of the century, the most extreme summer temperatures observed over the last few decades may become the average summer conditions in the future (Battisti and Naylor, 2009). In addition to temperature change, Schrag said the increasing concentration of carbon dioxide in the atmosphere impacts the concentration of several essential nutrients in today's plants. This can cause serious iron, iodine, and zinc deficiencies for those who rely on grains for these micronutrients (mostly people in the developing world); these deficiencies already affect half the world's population and lead to serious illness (Loladze, 2002). Overall, Schrag emphasized that climate change can be viewed as an additional destabilization of an already tenuous relationship between humanity and the global resource base.

Schrag stated that it is very important to consider the impacts that climate change mitigation can have on health. And, he added, moving away from fossil fuels can be beneficial for health for many reasons.

Results from the Harvard Six Cities Study show that when adjusting for other health risk factors, particulate air pollution in the United States is associated with mortality (Dockery et al., 1993). Additionally, researchers have found that when the particulate air pollution decreases (such as during local steel mill closures), hospital admissions for pneumonia, bronchitis, and asthma also decrease (Pope, 1989). Schrag noted that the health community and the climate change community can come together to support cleaner energy sources and move away from obvious failures in the market (such as dirty, conventional coal-fired power plants).

### Is Technology the Answer?

Scientists and policy makers are currently laying out ways to reduce carbon emissions and mitigate climate change. Schrag noted that the proposed solutions appear to fall into three categories: (1) efficiency or conservation of energy sources, (2) nonfossil fuel energy (such as renewable or nuclear energy), and (3) carbon capture and storage of fossil fuel energy. He said it is clear that innovation in technology in each of these areas is an important part of the solution. The public may have some willingness to put a penalty (such as a carbon tax or additional regulation) on fossil fuel technologies that contribute greenhouse gases in the atmosphere, but in the long run, nonfossil technologies will have to be economically competitive. At the same time, he noted, social attitudes may also play an important role, and concerns about health will be of primary importance.

Schrag suggested that new policies to reduce the concentration of atmospheric carbon dioxide may require tough choices and trade-offs to effectively rebuild the global energy system. Many of the trade-offs may be based on values, which can impact many of the decisions that lie ahead. Schrag added that the values can change depending on whose health is being considered; addressing global health may involve very different solutions with different mechanisms compared to addressing health in the United States or the developing world. Global efforts may possibly fall short of what is required to prevent massive suffering of human societies and the natural world. He noted that how the world will react is still unknown.

## ENERGY AND HEALTH: WHO IS AT RISK?

*Paul Wilkinson, F.R.C.P., M.P.H.*
*Professor in Environmental Epidemiology*
*London School of Hygiene and Tropical Medicine*

Paul Wilkinson stated that the way energy is used has many impacts on human health. He noted that some adverse health impacts arise from a lack of access to adequate energy sources (often seen in low-income settings, though fuel poverty is also a problem in many higher-income settings), while others occur from overdependence on access to energy sources, especially in high-income settings. For instance, too much access may produce overconsumption or sedentary lifestyles at the household level, road injuries or outdoor air pollution at the local level, and climate change or other low-probability, high-impact environmental events at the global level. In contrast, inadequate or inefficient energy sources may result in indoor air pollution or lost human potential at the household level, lack of infrastructure or decreased health protection at the local level, and energy insecurity and price volatility or international tensions at the global level.

Wilkinson proposed that the outcomes observed at the global level are difficult to measure—the consequences of energy price volatility are complex and largely indirect, and those of climate change are somewhat uncertain and largely in the future—but they could represent very large impacts on health. Wilkinson stated that it is much easier to quantify events at the local and household levels. For instance, the problem of indoor air pollution can be assessed by investigating the burden of illness related to indoor smoke from burning solid fuels in the home (from which 2 million people die prematurely each year) (WHO, 2011a). Additionally, he noted, overconsumption and lack of physical activity can be depicted in obesity trends (which are increasing throughout the United States and spreading globally), as well as in increased deaths due to cardiovascular disease or other chronic diseases that are partly attributable to these risk factors.

When comparing what is known about the health impact of climate change to other burdens of disease that are affecting the world (e.g., lack of access to clean water, malnutrition, and HIV/AIDS), Wilkinson emphasized that the understood *direct* health consequences of climate change, though appreciable, do not present a uniquely large threat that

alone justifies an unprecedented social response. Wilkinson stated that the case for transformative action on climate change is based rather on the potentially widespread adverse impacts across many areas, including social, environmental, and economic disruption. Health impacts add to this case, but are only one element of it. Moreover, he noted that many of the threats of greatest concern arise not from the potential for incremental "linear" changes but from the smaller and largely unquantifiable chance of catastrophic change that could negate decades of economic and social advance. Wilkinson asserted that behavior change alone, without major change in technology and infrastructure, is unlikely to achieve more than a small reduction in energy consumption, and its effect on greenhouse gas emissions may well be overwhelmed by increasing wealth and economic trends. Nonetheless, he said, behavior change *can* in principle make a major contribution to population health; the main uncertainty is how to achieve change. It is perhaps more realistic to motivate behavior change with evidence of (near-term) health and societal benefits (which may also help climate change) than motivating it with the need to solve climate change (which may provide some health benefits). He noted that this represents a subtle shift in emphasis for motivating accelerated mitigation action, and emphasizing the potential for social and public health benefits.

Wilkinson asserted that achieving a major reduction in the world's dependence on carbon-based fuels is important—in part to tackle the serious threat of climate change but also because of the associated current adverse public health burdens, concerns about energy security, and the potential for improving health and quality of life. He stated that there are many examples of actions aimed at reducing dependence on fossil fuels that also may help address major public health priorities. The health effects, which are often but not universally positive, provide an additional rationale for mitigation action. Wilkinson noted that major change in all sectors of the economy is required to meet greenhouse gas reduction targets, and will be transformative. A modeling exercise looked at a combination of quite major changes for London, including substantial reductions in bus, car, and building emissions and an assumption that 50 percent of shorter journeys will be made in the future by walking, cycling, or public transportation. This model would likely achieve around a 22 percent reduction in carbon dioxide emissions, which is still far short of the needed target of an 80 percent or a 90 percent reduction by mid-century for high-income economies such as the United Kingdom (Woodcock et al., 2009). However, these changes could

make an appreciable contribution to addressing high burdens of public health illness while also helping to lessen environmental problems. For instance, vehicle transport is responsible for environmental pollution and climate change, but it also causes road injuries, contributes to physical inactivity (with consequences on chronic disease and mental well-being), and leads to overweight and obesity. Wilkinson stated that promotion of active transport (increased walking and cycling with reductions in car use) could therefore address multiple public health burdens. Modeling based in London shows that large increases in walking or cycling in place of motor transport can result in a 10–19 percent reduction in total ischemic heart disease burden, a 10–18 percent reduction in cerebrovascular disease burden, and a 12–13 percent reduction in total breast cancer burden, although with some increase in risk of road injury (Woodcock et al., 2009). Increased active transport is also associated with much greater reductions in disability-adjusted life-years (DALYs) when compared to interventions that only lowered motor vehicle carbon dioxide emissions and air pollutants (7,332 DALYs compared to 160 DALYs saved per million population per year, respectively) (Woodcock et al., 2009).

Wilkinson noted that public health benefits are also measurable with respect to changes in home heating. A study that compared the effects of outdoor temperature on cardiovascular death showed a stronger association between outdoor temperature and mortality in colder (less energy efficient) homes than in warmer (more energy efficient) homes, (Wilkinson et al., 2009). In other words, he said, warmer homes were associated with a protective effect against cold-related cardiovascular death. Models show that improved energy efficiency or retrofitted insulation (roof insulation, window upgrades, etc.) can also protect against increased indoor temperatures during periods of overheating, and potentially against the ingress of harmful pollutants from the outdoor air (although there is a risk of increasing the concentration of pollutants from indoor sources, including radon, secondhand tobacco smoke, and combustion-related particles) (Mavrogianni et al., 2011). Finally, Wilkinson said, the source of primary energy used for electricity generation is relevant not only for mitigation but also to air pollution and occupational risks to health (Markandya and Wilkinson, 2007). He added that lignite, coal, and oil—which have the highest emissions in terms of carbon dioxide—are the most dangerous in terms of serious illness and death from air pollution (Markandya and Wilkinson, 2007). Wilkinson emphasized that among the options with both low greenhouse gas

emissions and low health impact is nuclear energy, which overall appears to have one of the lowest levels of adverse health impact under normal plant operations. He noted that the estimate changes when nuclear accidents or disaster health effects are incorporated, but they are still low compared with the high burdens associated with fossil fuel burning (Markandya and Wilkinson, 2007).

### Who Is at Risk?

Wilkinson stressed the importance of looking at the impacts of climate change interventions and assessing the potential co-benefits to health. He pointed out that to some degree everyone is at risk of energy-related exposures (and consequent climate change), but the burden falls disproportionately on the poor. The risks are of different forms: some are deferred (e.g., those associated with climate change); some are not readily visible but pervasive (e.g., air pollution); and some are very visible but uncommon (e.g., nuclear risk). Wilkinson emphasized that future sustainable energy plans may involve many often difficult choices, which will need to take account of the different forms of risks and benefits and the overarching imperatives for climate change. He noted that nuclear energy is a particularly difficult issue—despite its feasibility and ability to reduce emissions, and its historically low overall health impact—because of public perceptions and fears. Wilkinson asserted that all choices entail advantages and disadvantages. But as a general principle, he said that the move to a low-carbon economy can have the potential for appreciable ancillary impacts on public health, which are important to consider in any decision process.

## ENERGY AND NONCOMMUNICABLE DISEASES: HOUSEHOLD AIR POLLUTION

*Kirk R. Smith, M.P.H., Ph.D.*
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Kirk R. Smith began by stating that among all species, humans alone can control fire, which suggests that controlling fire is the oldest occupation in human history. He noted that perhaps a million years ago,

cooking hearths became a regular feature in human habitation. Today, a smaller percentage of the world population uses solid fuels (consisting of coal and various forms of biomass, such as wood, crops, and dung)[4] to cook than any time in human history (approximately 40 percent) (WHO, 2011b). However, the absolute number of people using solid fuels throughout the world is still rising because of persistent population growth and poverty (WHO, 2011a). Smith emphasized that there were more people using solid fuels for cooking in 2010 (nearly 3 billion) than the total world population in 1950 (Smith, 2011; UNDP and WHO, 2009). Overall, Smith stressed that the absolute scale of this practice is showing no sign of abating.

Smith stated that the three main solid fuels used globally are coal, crop residues, and wood. He noted that the smoke from biomass fuels in simple stoves contains many toxic pollutants, such as respirable small particles ($PM_{2.5}$), carbon monoxide, nitrogen dioxide, hydrocarbons (e.g., benzene and 1,3-butadiene), oxygenated organics (e.g., formaldehyde and methanol), and chlorinated organics (e.g., methylene chloride and dioxin) (Naeher et al., 2007). Coal combustion has these pollutants plus a range of other contaminants. Additionally, researchers have found that the exposures from a typical wood-fired cookstove in India exceed the health-based standards for small particles (often the best single indicator of overall air pollution), carbon monoxide, 1,3-butadiene, and two IARC Group 1 carcinogens—benzene and formaldehyde (Smith, 2011). In a study based on thousands of measures combined with modeling across India, the average personal concentration of $PM_{2.5}$ exposure for households using solid fuels was far beyond the U.S. Environmental Protection Agency standard and the World Health Organization (WHO) guideline (285 $\mu g/m^3$ compared to 15 $\mu g/m^3$ and 10–35 $\mu g/m^3$, respectively) (Balakrishnan et al., 2011).

Smith went on to state that the 2000 Comparative Risk Assessment Project, managed and first published by WHO in the *World Health Report 2002* as part of the Global Burden of Disease Project, was able to

[4] "Biomass fuels" include wood, crops, and dung that are burned to support the basic energy needs of daily life, including cooking, lighting, and climatic control (Sinha and Nag, 2011). The term "solid fuels" includes biomass fuels, along with coal, which can produce different air pollutants compared to biomass when burned (Sinha and Nag, 2011). Smith provides evidence on the environmental and health effects of burning biomass fuels, coal, and solid fuels (the two together) throughout his presentation.

show consistent associations between indoor use of solid fuels and three diseases: (1) acute lower respiratory infections in children, (2) chronic obstructive pulmonary disease (COPD), and (3) lung cancer (WHO, 2002). When ranked with all major risk factors, the top risk factor in 2000 was malnutrition, followed by unsafe sex, and other factors that affect many populations (high blood pressure, tobacco consumption, and alcohol consumption) (WHO, 2002). The first environmental risk factor on the list, unsafe water and sanitation, appears at number six, and indoor smoke from solid fuels was listed at number eight (WHO, 2002).

Revised estimates for the attributable burdens of disease from about 60 risk factors worldwide were provided in the Global Burden of Disease Study 2010 and published in *The Lancet* in late 2012. In addition to better estimates of household air pollution exposure[5] and risks for the diseases in the previous version, sufficient evidence has become available to include the risk of additional disease categories, including cardiovascular disease and cataracts. For the year 2010, household air pollution ranked as the fourth most important risk factor globally—after high blood pressure, smoking, and alcohol use—and second overall for females (Lim et al., 2012).

### RESPIRE: Quantifying Health Effects of Household Air Pollution

RESPIRE (Randomized Exposure Study of Pollution Indoors and Respiratory Effects) was initiated to address a request by the international health community for randomized controlled trials (RCTs)—the gold standard for assessing causality—that assess linkages between household air pollution and potential health effects (including acute lower respiratory infections [ALRI]). Smith noted that public health budgets are minimal in many poor countries, and it is difficult for public health officials to divert money from supplying antibiotics or vaccines when the benefit of improved cookstoves has not been quantified. (A natural experiment that introduced improved cookstoves to China in 1980 did demonstrate a reduction in COPD rates [Chapman et al., 2005], but this study was not randomized.) In the 1980s, a randomized control study measuring ALRI in children was designed, but it remained unfunded until the U.S. National Institute of Environmental

[5] Household air pollution includes the air pollutants (including organic, inorganic, and particulate matters) that are produced from the combustion of solid fuels in the home (Sinha and Nag, 2011).

Health Sciences offered financial support in 2001. The design of RESPIRE allowed a chimney cookstove to be randomly given to households in place of open cook fires in a community in the highlands of Guatemala (Smith et al., 2011). Smith stated that passive diffusion tubes that are often used by industrial hygienists were worn by inhabitants to measure exposures. Before the intervention, there were similar levels of carbon monoxide in the kitchens; after the intervention, however, there was a 90 percent reduction of carbon monoxide levels in the kitchens of those who received a stove (Smith et al., 2011). Nevertheless, the personal exposure for the children was reduced only by 50 percent (Smith et al., 2011). In fact, the level of carbon monoxide exposure among some children with the chimney stoves overlapped the level of exposure for some children with the open fire, and some of the children with the chimney stoves even had higher levels of carbon monoxide exposure than the children with the open fire did (Smith et al., 2011). Thus, in spite of being highly popular, well used, and reducing household air pollution substantially, the chimney stove was not very good at reducing actual carbon monoxide exposure, the important parameter for health (Smith et al., 2011). Additionally, much of the children's carbon monoxide exposure was occurring not in the kitchen, but around the home, and the chimney contributed to this exposure by venting smoke to the outdoor area (Smith et al., 2011). Smith stated that the overall lesson here is that it would be better to eliminate the pollution in the first place rather than moving it somewhere.

In this study, the primary health outcome was physician-diagnosed pneumonia, where a strong exposure-response relationship was observed (Smith et al., 2011). From these data, it is possible to estimate that a 90 percent reduction in smoke exposure will eliminate 85 percent of severe pneumonia confirmed by X-ray (Smith et al., 2011). Smith emphasized that this is a significant effect, and arguably larger than the impact of any vaccine or nutritional supplement. Thus, he stated, exposure to household air pollution is an important cause of ill health, at least in certain populations throughout the world.

### Beyond the Kitchen: Impacts on Outdoor Air Quality and Climate

Combined data from several international air pollution data sets show that household air pollution from solid fuels are a significant source of ambient air pollution in many regions (Lim et al., 2012). Globally, household air pollution represents 16 percent of the burden of disease

from ambient particulate matter pollution (Lim et al., 2012), but in some heavily polluted regions such as India, it accounts for more than 25 percent (Chafe, 2010). Smith noted that the densely populated river valleys of India and China, rather than the cities, are where many households are burning solid fuels poorly. Smith argued that the significant outdoor air pollution found in China and India, as well as many other middle-income countries, cannot be solved without addressing household air pollution sources as well as others.

In addition to the health implications, Smith pointed out that there is also a global climate impact from the combustion of biomass fuel. For example, Unger and colleagues (2010) provide an instantaneous look at the radiative forcing at 2020 due to continuous year 2000 emissions. It is interesting to note that biomass fuel use exerts the second largest net positive radiative forcing among the economic sectors examined (Unger et al., 2010). Smith stated that use of biomass fuel impacts the climate partly because of the deforestation it causes and carbon dioxide emissions it produces, and partly because of the non–carbon dioxide pollutants it emits.

### Cardiovascular Disease and Household Air Pollution

Smith described the results of a study that might shift how the public health community approaches air pollution. A recent seminal analysis from Pope and colleagues (2009) compared the adjusted relative risks of cardiovascular and cardiopulmonary mortality from ambient (outdoor) air pollution, environmental tobacco smoke, and active smoking. Active smokers inhaled the greatest amount of $PM_{2.5}$ per day, higher than 10 mg (and some exposures were greater than 100 mg) (Pope et al., 2009). People exposed to ambient air pollution and environmental tobacco smoke inhaled lower doses of $PM_{2.5}$, less than 1 mg per day (Pope et al., 2009). Smith noted that the authors found a clear relationship between the inhaled doses of $PM_{2.5}$ and cardiovascular disease mortality. However, the relationship is highly nonlinear in that the estimated relative risk for ambient air pollution is 1.2, compared to 2.0 for active smoking when the inhaled dose of $PM_{2.5}$ is increased by three orders of magnitude (Smith and Peel, 2010). Smith added that there is a gap in the data in the range of 1–20 mg of $PM_{2.5}$ per day; but, this range correlates to the exposures observed worldwide for the women in households using solid fuels (Smith and Peel, 2010). Based on this model, he said, a 1.5–1.6 relative risk of heart disease would be expected for these women.

Recalling that 40 percent of the world's population is exposed to similar concentrations of household air pollution, Smith proposed that the global burden of cardiovascular disease due to household air pollution exposure is likely high.

Smith stated that because the results support a nonlinear model, appropriate policy decisions can be difficult to determine. He noted that transitioning a moderately dirty city to a clean city appears to result in greater reductions in cardiovascular disease mortality than providing a good chimney or even a plain stove to households with much higher PM exposures. An improved stove has little effect on the health of those exposed to household air pollution, he said, since the PM exposures need to decrease to levels much lower than those observed with stove use to make any difference in the cardiovascular disease mortality risk.

Similarly, Smith added, the household air pollution exposures to children need to decrease greatly to observe a health benefit and reduce pneumonia rates. When comparing rates of pneumonia in children exposed to an open household fire with those exposed to a chimney stove, only a small difference is detected. Smith noted that more than 40 percent of the children exposed to the open fire contracted pneumonia every year. Even the very well operating chimney stove in RESPIRE provides a relatively small benefit by reducing the rate of pneumonia only to 35 percent or so, he said, but the goal should be to decrease the pneumonia rate substantially. Again, Smith emphasized the lesson from all of this is that it is not enough just to move the household air pollution—the pollution should be eliminated or significantly decreased.

From this work and other studies on smoking and ambient air pollution, Smith stated, it is recognized that combustion particles cause more health effects than do other environmental contaminants. He noted that active smoking—placing a burning object directly into the mouth—results in the most premature deaths, nearly 6 million per year (WHO, 2011d). Smith added that environmental tobacco smoke—being surrounded by others as they place burning objects in their mouths—causes approximately 600,000 deaths annually (WHO, 2011d). Additionally, ambient air pollution, which is largely but not entirely the result of fuel burning, causes 3 million deaths each year (Lim et al., 2012). But, he added, the oldest burning practice, solid fuel for cooking, still causes more ill health than any other particle source except smoking, leading to 3.5 million deaths per year (Lim et al., 2012). Smith asserted that the message is clear: even with some overlap among smokers, those

exposed to environmental tobacco smoke, those exposed to urban pollution, and those exposed to household air pollution, there is substantial global ill health from combustion particles.

### Noncommunicable Diseases and the "Bottom Billion"

Smith stated that the classic epidemiological transition is usually defined as the trend of declining infectious diseases and rising noncommunicable diseases (NCDs) as economic development proceeds (Omran, 1971). He outlined that the "big four" of the NCDs are cancer, cardiovascular disease (CVD), COPD, and diabetes. Smith said that this is commonly misinterpreted, however, and instead should be regarded as a mortality transition, not one relating to the risk actually experienced by individuals going through their lives. He noted that when the numbers of young people dying of infectious diseases are reduced in developing countries, these youths become older adults. As older adults, he said, they still must die from something, and they likely die from NCDs. As societies progress up the socioeconomic ladder, the sharp decrease in communicable diseases actually acts to reveal an already existing high rate of NCDs (Smith and Ezzati, 2005). For example, COPD is common in both developing and developed countries. In fact, the death rates from these respiratory diseases are higher in poor countries (WHO, 2011c), and 90 percent of deaths attributable to COPD occur in low- and middle-income countries (WHO, 2011c). Smith stated that a previous hypothesis specified smoking as the primary risk factor for COPD. But, he noted, the incidence of COPD is high in developing countries despite the fact that women in Africa, India, and China do not smoke.

Smith described that the risk factors commonly associated with NCDs in rich countries—lack of physical activity, high-fat diets, obesity, and smoking—do not generally apply to the 2 billion poorest of the world's population. Smith proposed that there are some infectious agents of poverty that contribute to NCDs (for example, rheumatic heart disease), but the use of solid fuels is the one environmental risk factor that is shared by essentially 100 percent of the bottom 2 billion people living in poverty. Currently, he said, three of the four major categories of NCDs are strongly associated with household air pollution, the exception being diabetes (although dioxin, a byproduct released during the incomplete combustion of solid fuels, may be linked to diabetes). Smith pointed out that solid fuel use is thus an important factor in this NCD burden among the poor.

Smith outlined how the environmental health risk transition that underlies the epidemiological transition demonstrates that as economic development proceeds, the household-level risks fall, the community-level risks rise and then decline, and the global-level risks increase (see Figure 3-1). Smith stated that data on solid fuel use have altered the environmental health risk paradigm: risk factors that were once considered solely household burdens are now recognized as affecting outdoor air pollution in communities and also global climate change. Smith noted that the environmental health risk transition is a helpful framework that lays out some of the connections, so that data can be used to further describe the relationships between household, community, and global risks that arise throughout the development process.

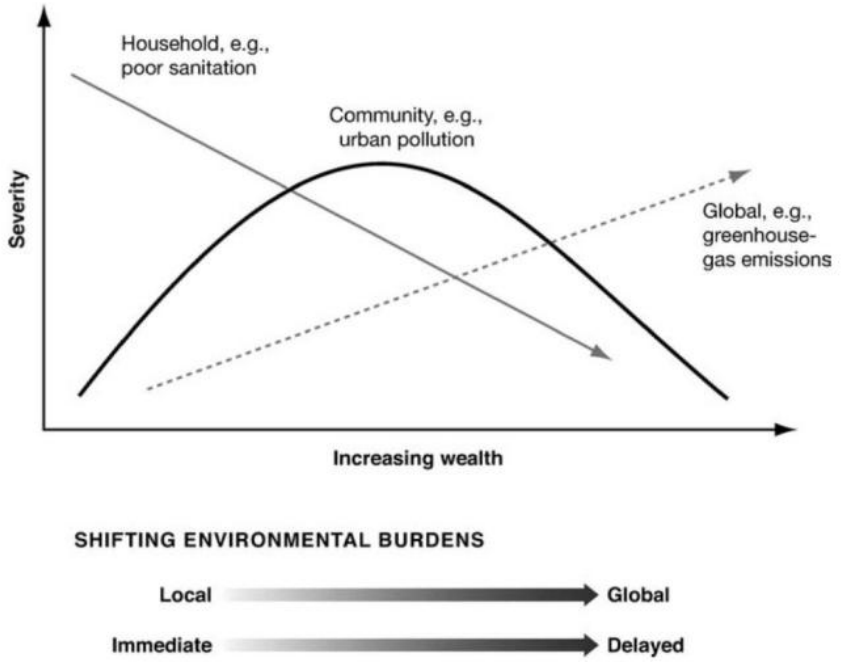


**FIGURE 3-1** The environmental health risk transition.
SOURCE: Smith and Ezzati, 2005.

### If It Doesn't Take Fifty Years, It Isn't Worth Doing

Smith noted that monumental health changes do take a while, and establishing the risk, even conclusively, is insufficient by itself to influence change. The First Royal Commission on Air Pollution in London in 1315 recommended banning coal burning in the city, but this recommendation was not taken up until the 1950s after the infamous "London Smog" of 1952. In 1854, the work of John Snow supported the use of adequate sanitation and water for disease prevention; yet, one-third of the world's population still has inadequate water and sanitation today. Additionally, Sir Ronald Ross received the Nobel Prize in 1902 for showing conclusively the causes of malaria, but the world still has hundreds of millions who suffer from it today. Thus, the relatively recent recognition that household air pollution is a serious risk cannot be expected, by itself, to fix the problem, and Smith proposed that considerably more work is needed.

## DISCUSSION

A discussion followed the presentations and the remarks are summarized in this section. Lynn Goldman noted that all of the speakers, in one way or another, made points about nuclear power, which may diverge with the views of many environmentalists. Goldman highlighted that nuclear plants require enormous investments for building and maintenance, and asked the speakers to describe ways in which they would persuade people to support allocating the required resources. Additionally, she asked about the sustainability of nuclear energy given what is known about the limitations in the supply of nuclear materials to fuel the plants and how expanding nuclear power would impact the supply of the fuel. Daniel Schrag noted that people talk about the limitations of uranium, but in fact, the price of uranium has little impact on the price of nuclear power. For instance, he said, if the price of uranium is increased 10-fold, the price of nuclear power would likely increase by less than 1 percent. Among environmentalists, said Schrag, there appears to be a split in the environmental community on nuclear energy. Schrag stated that nuclear plants are likely not being built in the United States because of price; the current price of natural gas counters the economic argument for investing in nuclear energy. Additionally,

Schrag noted that the focus should not be on teaching people to be unafraid of nuclear energy; instead, the lesson should be that just because it can be measured, this does not mean it is dangerous. He highlighted that more may be known about the risk of nuclear radiation than any other environmental risk factor, but it is difficult for the public to understand the importance of dose or orders of magnitude of exposure.

Paul Wilkinson addressed the questions by stating that even though he does not advocate for nuclear energy, he would like to see the issue debated properly. He emphasized that in order to be serious about climate change mitigation, large-scale choices need to be considered, and nuclear energy is one of them. Wilkinson noted that the health argument is often not adequately represented in these debates and more should be done to address this. Wilfried Kreisel joined the discussion, sharing his experience with leading a WHO program on the health effects of the Chernobyl accident that occurred in the Ukraine in 1986. Kreisel noted that at the time, conservative estimates were produced for radiation-induced death, cancer, leukemia, and so on. He stated that when the results were published in 1996, the public confused the number of radiation-induced diseases and the total number of diseases related to non-radiation causes. For example, Kreisel said, in the Chernobyl accident, only 50 people had been killed initially by radiation, but there were hundreds of thousands of people who suffered from mental disorders and alcohol consumption because they believed they received a lethal dose of radiation. Smith agreed that there were major health impacts of the Chernobyl accident because of fear, disruption, anger, loss of jobs, and so forth; but, he asked, was that due to the accident or the poor information people received about the accident? Additionally, he asked about the role of the environmental health community in these situations, noting that efforts should likely focus on making people less afraid if in fact there is no imminent damage.

Martin Philbert provided a comment and question to the group around the issue of why the environmental health community has been unsuccessful in influencing energy policy changes. Philbert noted that the discussions appear to no longer be about the science, and at least in the system in the United States, they have become inextricably bound with politics (not policy, but politics). Because of the politics, he stated, science-based regulatory agencies in the United States often have to chart a new course every 2 years. Philbert asked the speakers to comment on ways of moving forward to substantively address the kind of problems

outlined in this session. Schrag stated that understanding the U.S. political system with respect to energy can be challenging. He noted that the politics in the United States with respect to coal are quite difficult, given that there is bipartisan support for coal in the Senate; this complicates passing climate change legislation that includes reducing coal use. Schrag suggested that a change in coal policies may likely come from the politics surrounding natural gas and hydraulic fracturing, in that states like Pennsylvania are transforming from coal states to natural gas states. Schrag continued to say that in some ways the debate is no longer about the environment and more about industry; but, if the natural gas industry can push for a climate bill that puts a price on carbon, coal use will likely still be reduced.

Goldman joined the discussion by noting the importance of constituent concerns in political discourse. She stated that voters often do not recognize that climate change is occurring, nor do they sense the urgency of the problem; if they felt it was an urgent problem, she said, the politics would likely take care of themselves. Juli Trtanj added a comment about value and perceptions, noting that the climate debate can be framed in terms of helping people adapt and respond, rather than just focusing on the environmental or public health connection. Trtanj also said that there are adaptation options across time scales, with adaptation bordering on mitigation in the long term and adaptation on shorter time scales on the individual level. The point about short-term political realities in the United States is well taken, stated Trtanj, and we need to be more strategic in articulating what we mean by adaptation for what audiences and time scales, and including specific value-oriented win-win scenarios in the discussion. Trtanj noted that this will help the public health community move forward a little faster in the political process.

Carlos Corvalán made one final comment during the discussion about inequalities and climate change. Corvalán noted that to simplify the climate change argument there are two phenomena. The first includes areas similar to Queensland, Australia, where the cost of bananas, for instance, increases but those who do not have the money find alternative food options. The second includes droughts taking place in areas of Africa, where people are not able to eat anything at all. Corvalán stated that we cannot say we are all equally vulnerable, and the issue of inequality is an inherent component of climate change.

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# 4

# SUSTAINABILITY LINKS TO FOOD AND WATER RESOURCES

This chapter considers food and water at the nexus of sustainable development. Although other ecosystem services are critical to environmental health, these two resources generate continued health concerns through means such as infections, antibiotic resistance, under- and over-nutrition, and exposures to chemicals. As noted by the speakers, it is clear that humans are putting greater pressure on natural resources to meet basic needs for a growing population. These challenges are subject to national and global policy debate: for example, about how countries will assure food and water security. A summary of the presentations follows in which the speakers outline strategies for improved management of these resources.

## FOOD SYSTEMS, SUSTAINABILITY, AND PUBLIC HEALTH

*Molly Anderson, Ph.D.*
*Partridge Chair in Food and Sustainable Agriculture Systems*
*College of the Atlantic*

Molly Anderson began her presentation by stating that although the terms "food systems" and "agriculture" are often believed to be synonymous, agricultural production is only the beginning of the food system. She noted that food systems are extensive, and they include food processing, food sales and distribution, food preparation, and, ultimately, food consumption. Anderson emphasized that food systems require diverse inputs, from seeds, fertilizer, and animal stock for agriculture, to financial capital, machinery, labor, energy, and water, which are necessary for all parts of the system to function. Additionally, there are

institutions that govern control of, access to, and use of inputs by different actors in the food system.

Anderson noted that food production and food systems are affected by and reside at the center of social, economic, and environmental concerns (McIntyre et al., 2009a,b). From an environmental perspective, food systems are interwoven with soils, water, climate, and biodiversity. Anderson proposed that social implications of food systems, culture, traditions, and gender roles usually play a part in determining what food is produced, who labors, and who profits. From an economic perspective, marketing practices and trade are tightly interlaced with profit; additionally, these three areas interact with each other, as depicted in Figure 4-1. For example, economic value can be assigned to environmental services, and culture can dictate which foods are cultivated and commercialized. Anderson pointed out that history indicates that an attempt to maximize any one of the economic, social, or environmental aspects will result in trade-offs for the other two areas. In the existing food system, Anderson said, several years of overemphasizing the economic side by increasing production has resulted in serious social and environmental impacts.

## Food Systems and Public Health

Anderson stated that hunger and malnutrition provide major linkages between food systems and public health. The number of undernourished people in the world has steadily increased in recent years, reaching an estimated 1.023 billion individuals in 2009 (FAO, 2010), resulting in a world food crisis. The number of undernourished people decreased to 925 million globally in 2010 (FAO, 2010). However, the Food Price Index spiked again in 2011, to a higher level than in 2009 (FAO, 2011). Anderson noted that when the numbers are released for 2011, there will likely be even greater hunger and malnutrition, above the 1.023 billion of undernourished people in 2009. Anderson added that high food prices show no sign of abating.

Climate change is also connected to food systems, said Anderson, with projected effects on food, water, ecosystems, and risk of abrupt and major irreversible changes. With just over a 1 degree Celsius increase in the global temperature, the frequency of extreme weather events (e.g., rising intensity of storms, forest fires, droughts, flooding, and heat waves) will increase (IPCC, 2007). Agricultural yields will decrease in

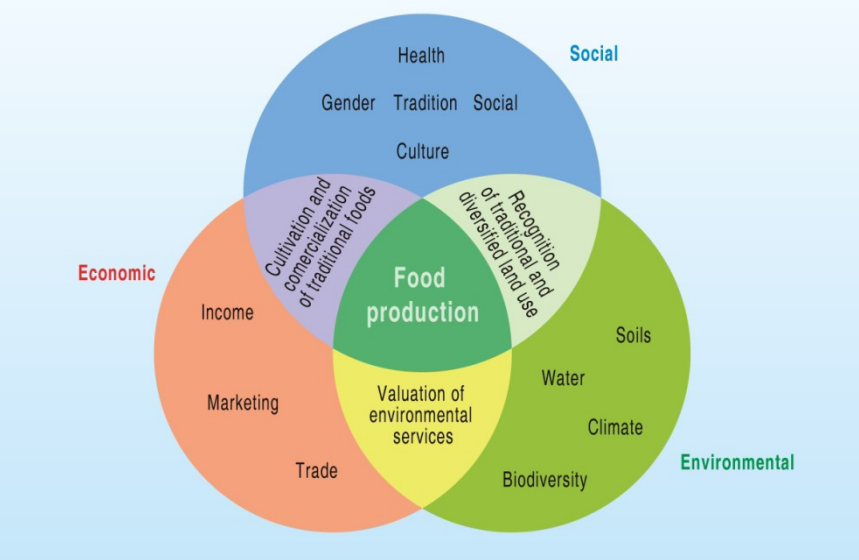


**FIGURE 4-1** The inescapable interconnectedness of agriculture's different roles and functions.
NOTE: Social, economic, and environmental concerns are tied to food production. Social factors, such as culture, tradition, and gender roles, can determine the types of food produced, and which members of society bear the labor and cost burdens. Economic factors, such as trade and income, also impinge upon food production. Environmental factors, such as water and soil quality, affect (and are affected by) food production. These three aspects interact with each other (for example, in the assignment of monetary values to environmental services). An effort to maximize one aspect, such as the economic outcomes of food production, will undermine the other two (social and environmental) aspects.
SOURCE: IAASTD, 2008. Design by UNEP/GRID-Arendal, Ketill Berger (http://www.grida.no/graphicslib/detail/a-multifunctional-perspective-of-agriculture_1097).

many developed regions, as seen in Figure 4-2 (Cline, 2007). Anderson noted that although some posit that temperature increases will cause yields in higher latitudes to increase and benefit those who dwell there, this may be offset by the unpredictability of precipitation in these same areas. If farmers cannot foretell precipitation patterns, they will be unable to make informed decisions about what to plant and when to plant, which will limit their efficient use of resources to maintain a reliable food

supply. Overall, Anderson stated that there are no winners from climate change because of the resulting instability in the food system.

Anderson noted that modern food production systems are also creating environmental impacts and instability by degrading vital resources necessary for food production. According to the Global Assessment of Human Induced Soil Degradation, 40 percent of the land for global food production has been degraded, and this number will likely increase if current land use practices continue (Wood et al., 2000). Water shortages have begun and are likely to intensify as water withdrawal as a percentage of total available water increases (UNEP, 2008). Anderson stated that if less fresh water is available per capita

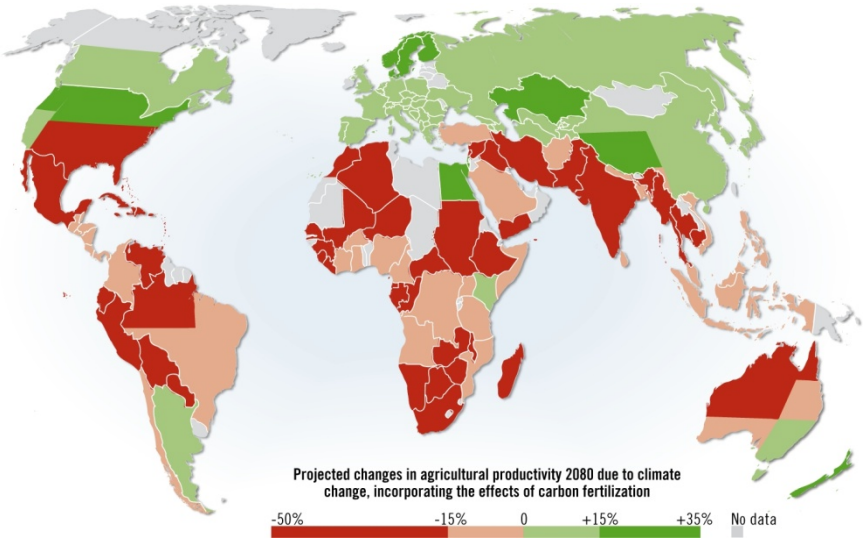


**FIGURE 4-2** Agricultural productivity: Projected changes due to climate change.
NOTE: An increase in average temperature is a predicted consequence of climate change. This temperature shift is likely to affect agricultural yields. Tropical, subtropical, and some temperate areas will witness a decrease in yields, which may be as great as 50 percent. Higher-latitude regions may experience an increase in agricultural productivity by as much as 35 percent. However, other effects of climate change, such as altered precipitation patterns, may undercut some of these yield increases.
SOURCE: Cline, 2007. Design by UNEP/GRID-Arendal, Hugo Ahlenius (http://www.grida.no/graphicslib/detail/projected-agriculture-in-2080-due-to-climate-change_15f0).

food production systems will need to develop more efficient methods for water usage in the future. Additionally, marine resources are being over-exploited, causing some marine ecosystems to crash (UNEP, 2007). Anderson explained that aquaculture is being used to replace fishing in order to meet increased demands for fish and seafood, but these methods introduce new environmental problems and are not a cure-all for food systems and public health in that they are often not sustainable and cannot be expected to meet all future protein needs.

Anderson outlined how the industrialized food production model that developing countries have been encouraged to adopt creates a multitude of negative environmental impacts. These farming methods may degrade soil via salinization, compaction, and nutrient depletion, and exacerbate climate change due to high energy requirements (McIntyre et al., 2009a,b; Woods et al., 2010). Industrial animal agriculture techniques at concentrated animal feeding operations can create bacteria that are resistant to antibiotic treatment (Gilchrist et al., 2007). These concentrated animal feeding operations also concentrate animal waste, and this can lead to exposure to pathogens and air quality problems (Heederik et al., 2007). Anderson noted that food safety risk is exacerbated in centralized processing systems because foods from different sites are mixed together during processing and then redistributed over a wide geographical area such that any contamination is distributed widely, as happened, for example, during a 2006 incident of fresh spinach contamination by *E. coli* 0157:H7 that killed 3 people and sickened 199 (CDC, 2006). Industrialized farming also results in occupational exposure to hazardous chemicals in pesticides (Calvert et al., 2008). Finally, diet-related diseases are linked with the products and policies that are intimately connected with this particular way of producing food (Lang et al., 2009). Anderson emphasized that it is clear that food systems are intrinsically tied to virtually every environmental health issue.

## Trends in Food Systems

As a consequence of the Green Revolution, stated Anderson, the total production of food increased from the late 1960s to the present day. She described that this was due to an increase in the productivity of commodity crops (not necessarily the staple crops on which people in developing countries rely) through the use of high-yielding varieties and energy intensive practices (such as irrigation and fertilization) spreading

around the globe (Huang et al., 2002). Anderson noted that the energy required for industrialized agriculture, particularly fertilization, will likely restrict how much longer industrialized agriculture will be a viable option for food production. Anderson pointed out that despite the steep augmentation in yield per capita and the drop in the price of food, food consumption still is grossly inequitable among developed and developing nations (FAO, 2012).

*Gender Issues*

Anderson stated that there has been an inequitable distribution of the benefits from research and development on food systems. She explained that one of the biggest sources of inequality is gender, since relatively few women are trained for agricultural research and extension, and in some countries, particularly sub-Saharan countries where women farmers are in the majority, there are cultural barriers that prevent women who are responsible for growing the crops from working with male extension support staff (FAO, 1997). Women in these countries are often unable to benefit from extension and training services on new technologies (FAO, 1995).

*Research Funding*

Anderson proposed that similarly concerning are the long-term declines in research funding and the shift from public to private sources of funding in industrialized nations. Additionally, there has been market and power concentration within the food system over the past 40 years so that decisions about food are currently in the hands of a few businesses at the trading, processing, and retail levels. Anderson noted that this limits opportunities for small-scale farmers in the food system.

*Global Value Chains*

Trends can also be seen in global value chains, as depicted in Figure 4-3. Anderson explained that independent farmers of commodity crops in Sector II are either disappearing or are contracting with transnational corporations in Sector I that sell undifferentiated goods globally. Large, vertically integrated supermarkets and processing centers are consuming independent grocers and independent packers, she said, so that Sector II is disappearing because of pressures from Sector I. On the other side of

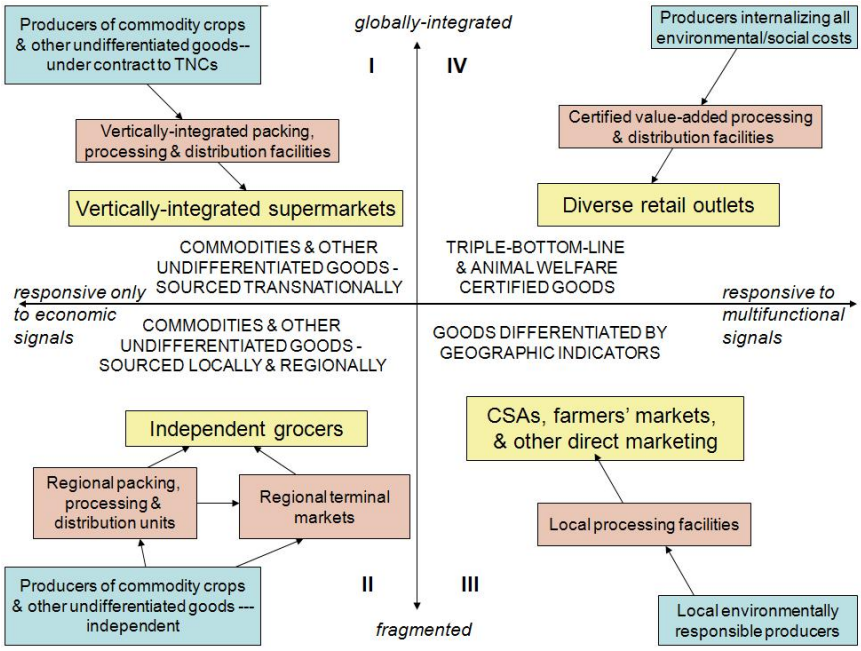


**FIGURE 4-3** Global value chain trends.
NOTE: Global value chains can be characterized by their level of integration (a continuum from global integration to fragmentation; vertical axis) and by the types of signals to which they respond (a continuum from primarily economic signals to multifunctional [social, environmental, welfare, safety] signals; horizontal axis). These classifications create four types of products and value chains: commodities and other undifferentiated goods sourced transnationally from vertically integrated supply chains (Sector I); commodities and other undifferentiated goods sourced locally and regionally from independent producers and sold by independent grocers (Sector II); goods differentiated by geographic indicators that are only sold locally (e.g., at farmers' markets) by producers who follow environmentally sustainable practices (Sector III); and triple-bottom-line and animal-welfare-certified goods from producers who internalize all environmental and social costs (Sector IV). These value chains have undergone change in recent years. The independent producers and grocers have been contracting with transnational corporations (Sector II is being absorbed by Sector I). Producers in Sectors III and IV have become more responsive to economic signals in order to stay competitive, shifting closer to Sector I.
SOURCE: M. D. Anderson and L. Firbank, unpublished.

the spectrum, Anderson noted, small, locally oriented farms in Sector III provide differentiated goods, and certified food producers (fair trade, humane certified, etc.) in Sector IV are sensitive to environmental and social concerns. Recently, the number of players in the market for certified goods has expanded; so producers and distributors in Sector IV have begun paying closer attention to prices to compete with similar companies (shifting these sectors closer to Sector I). Anderson stated that the market share of Sectors III and IV is important, because focusing on multifunctional and local/regional agricultural systems is likely to decrease negative impacts on smallholders.

## IAASTD and the Way Forward

Anderson noted that the aims of the International Assessment of Agricultural Knowledge, Science, and Technology for Development (IAASTD) were to review more than 60 years of publications to assess the impacts of agricultural knowledge, science, and technology on reducing hunger and poverty, improving rural livelihoods and human health, and facilitating true sustainable development (McIntyre et al., 2009a,b). It was intergovernmental, interdisciplinary, and sponsored by many organizations (such as United Nations agencies and the World Bank). Developing and industrialized nations, men and women, civil society, and government representatives were all involved in leadership roles. Anderson highlighted the following key messages from the IAASTD:

1. Investment in agriculture needs to increase and be redirected, with investments that target rural areas and strengthen farmers', women's, and community organizations. Also, there should be investment in technology that is appropriate for local control, paired with a commitment to assist farmers in acquiring what they need to become entrepreneurs, especially securing access for smallholders and women.

2. The methods through which agricultural knowledge is generated, distributed, and used needs to be altered. Local farmers should be invited into the process, and institutions should be more responsive to farmers' needs. To achieve this, traditional and scientific knowledge should be integrated, for example, through participatory farmer-scientist partnerships; investments should be

made in education and technical assistance, especially for women, as well.

3. Fair, equitable access to resources and markets is necessary, as is democratic decision making. Public institutions should focus on public goods, and antitrust and competition regulations should be implemented. Laws of ownership should be revised to allow secure access by women and smallholders. To become more democratic, discussions about the world food system need to allow all major stakeholders to participate in the decision making.
4. Managing for multifunctionality is crucial, and it involves empowering marginalized stakeholders to participate in the food system. Investment should be balanced between the environmental, social, and economic aspects of agriculture. Market and trade policies that provide fair returns to food system workers should be implemented. Ecosystems should be maintained and restored.
5. Management for resilience is necessary. Diversity should be promoted at all scales, from crops to business models; food reserves should be accumulated so that food is available when needed. Decentralized food systems can create buffers that will ease food shocks brought on by disasters, famine, or other system shocks. As seen with the 2007–2008 financial crisis, shocks can reverberate through the globalized food system if buffers are not in place.

Anderson argued that solutions to the problems of modern food systems can be shaped by multi-stakeholder assessments and United Nations assessments. She stated that reform of food governance mechanisms, such as recent reform of the Food and Agriculture Organization (FAO) of the United Nations Committee on Food Security, can play an important role in altering food systems. Anderson added that rights-based approaches to food and development that increase participation and focus on vulnerable populations such as women, children, and smallholders may have a substantial chance at success. She explained that this is because these strategies focus on the "how" of development, which is at least as important as the "what." Anderson emphasized that when attention is on identifying the most vulnerable people and what they need, there is the most promise of actually having an impact on food security and malnutrition.

## NATURAL RESOURCES, SUSTAINABILITY, AND HEALTH

*Jamie Bartram, Ph.D.*
*Don and Jennifer Holzworth Distinguished Professor and*
*Director of the Water Institute*
*University of North Carolina at Chapel Hill*

Jamie Bartram began by stating that water, health, and sustainable development are interconnected. He noted that these linkages were recognized during the Rio Summit and in Agenda 21, which was adopted in 1992 by 178 governments globally. In fact, he said, the supporting documents from the workshop included a specific chapter on water resources addressing protection of the quality and supply of freshwater resources that also addressed drinking water, sanitation, and hygiene.

Accelerating since that time, stated Bartram, substantive shifts have occurred in the development of policy and the management of water at the international level; these efforts have largely followed two tracks, one focused on the human need for water, generally coupled with sanitation, and the other focused on water resources and their management. Bartram noted that the former has included

- declaration of the International Drinking Water Supply and Sanitation Decade (the 1980s);
- establishment in response to the end-of-decade review of the Water Supply and Sanitation Collaboration Council, initially hosted by the World Health Organization (WHO);
- establishment of the Millennium Development Goals (MDGs) including a target for drinking water at the Millennium Summit in 2000;
- reaffirmation of the MDGs and the inclusion of sanitation alongside water as a target in 2002;
- declaration of the Decade "Water for Life" in 2006–2015;
- declaration of the International Year of Sanitation in 2008;
- declaration in 2010 by the UN General Assembly that recognized the human right to water and sanitation and follow-up by the Human Rights Council;
- establishment by the United Nations Secretary-General of "Sustainable Sanitation: Five-Year Drive to 2015"; and

- passage of the World Health Assembly Resolutions related to water in 2011.

Of the two water policy tracks mentioned, Bartram noted that the track focused on water resources and their management has included specific concern for transboundary water and more recently often emphasized integrated water resources management (IWRM)—a policy and management approach that recognizes that water has many different and sometimes competing uses that need to be reconciled at the watershed level. Bartram stated that efforts that have used this approach include the Global Water Partnership, which was established in 1996 with the backing of a limited number of governments to advocate for integrated water resources management; the World Water Council, which was also reestablished in 1996 with the support of a limited number of governments to principally but not exclusively focus on water resources; and the World Commission on Dams, which was a time-limited body established in 1998 to address the international concern principally about large dams and their management.

Bartram explained that within the UN system there have been proposals to develop the United Nations Environment Programme (UNEP) into a single environmental agency within the UN system. Contrastingly, he noted that "UN-Water" was established to increase coordination and coherence across more than 27 UN bodies that are involved in water issues, recognizing that water (and environment more broadly) are cross-cutting issues that benefit from integration in other disciplines and sectors. Evidently, he emphasized, there is overlap and potential competition between these water, sanitation, and hygiene perspectives for policy and financing at the international, national, and local levels.

Bartram stated that since the advent of the MDGs, time-bound quantified targets have been supported by coherent monitoring efforts for provision of drinking water and sanitation. He explained that this has been accompanied by a trend toward greater transparency and accountability as evidenced by the series of regional intergovernmental sanitation conferences and MDG monitoring. Most recently, the recognition of the human right to water and sanitation by the UN General Assembly and its Human Rights Council has facilitated policy attention around this issue and is likely to contribute to future accountability at the country level.

Bartram noted that logistical issues may challenge the effectiveness of these efforts. For example, the MDGs include a target, added in 2002, to halve the proportion of the population without basic sanitation between 1990 and 2015. As seen in Figure 4-4, the target will be missed by approximately 1 billion people worldwide. Conversely, the effort to halve the proportion of those without improved drinking water sources is actually ahead of the MDG target as seen in Figure 4-5. Bartram noted that the data on drinking water access, however, only tell a part of the story. For drinking water, he said, 87 percent of the population has access to improved water *sources*, but only 54 percent of the population has access to improved drinking water in the home. Bartram stated that the remainder of the population needs to walk up to half an hour and carry it to the household.

Furthermore, Bartram explained, while the notion of *safety* is written in the MDG target for water and sanitation, it does not have metrics associated with it. The problem, he stated, is that of that 87 percent of the population with access to improved water sources—whether in the home or at a distance from the home—only about 72 percent use *safe* water. Bartram also pointed out that basic sanitation metrics should include the proportion of flush toilets that flush untreated sewage into the environment, a practice that significantly affects the achievement of the goal of basic sanitation.

### Water as a Recyclable Resource

Bartram noted that water scarcity affects one in three people and is experienced on every continent. He explained that the prevalence and severity of water scarcity are increasing as demands for water rise along with population growth, urbanization, and increases in household and industrial uses. These demands are exacerbated by climate change, he said, which is associated with an increasing frequency of extreme events (such as floods and droughts).

While much debate treats water as if it were a finite resource, said Bartram, it is in fact recyclable, providing the opportunity for positive outcomes from effective management action. Bartram stated that in the public health arena, there are potentially substantive benefits from increased engagement with water management throughout the water cycle, noting that many drivers (e.g., agriculture, urbanization, climate change, and population growth) lead to intensification of the cycling

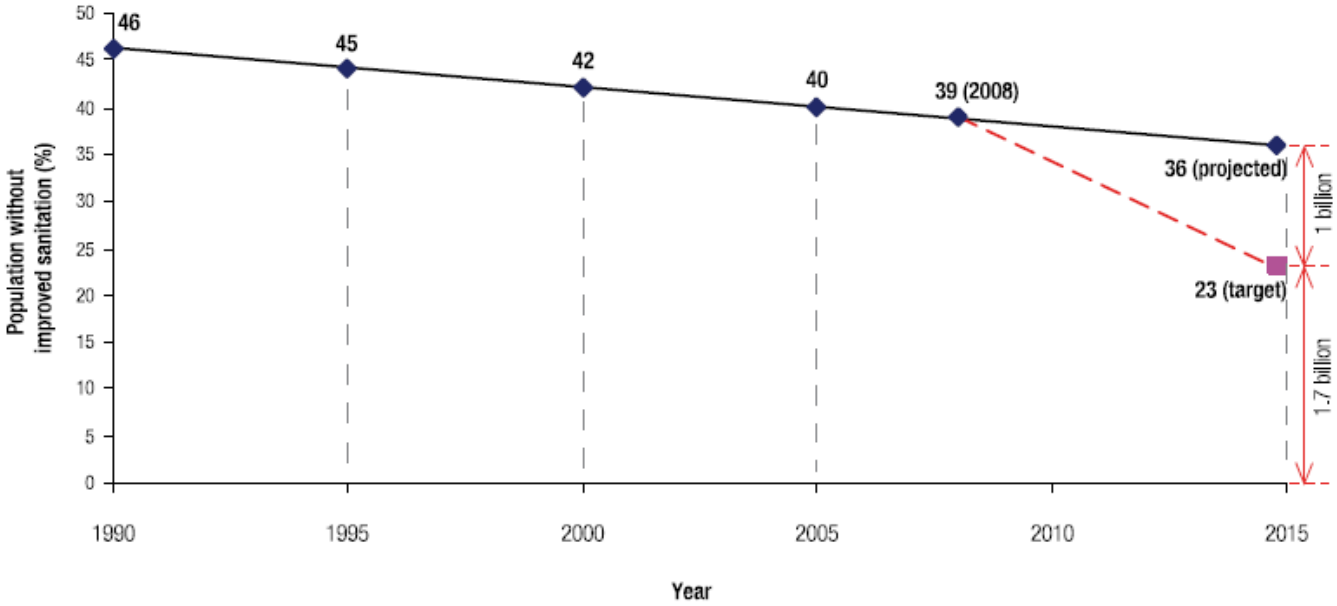


**FIGURE 4-4** Access to improved sanitation, 1990–2015.
NOTE: Considering the projection for 2015, the mark will be missed by an estimated 1 billion people. Discounting sewerage without treatment reduces 2010 coverage to around 40%.
SOURCE: WHO/UNICEF, 2010. Reprinted with permission from the World Health Organization and UNICEF.

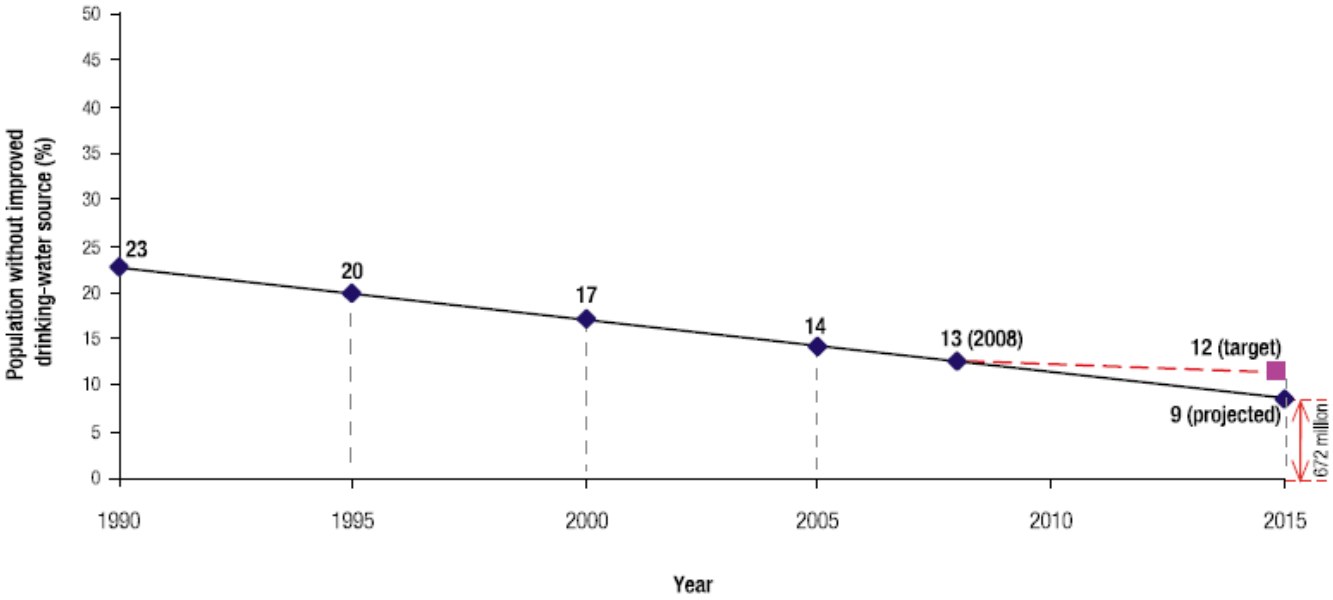


**FIGURE 4-5** Access to improved drinking water sources, 1990–2015.
NOTE: Improved sources include sources protected from contamination up to around 30 minutes collection time from the household. Despite meeting the goal for 2015 (to halve the proportion of the population without sustainable access to safe drinking-water), 672 million people will remain unserved (9%) in 2015.
SOURCE: WHO/UNICEF, 2010. Reprinted with permission from the World Health Organization and UNICEF.

process and of human interaction with water that may be polluted. For example, Bartram explained, the majority of emerging and reemerging infections in recent decades are from zoonotic sources, and the associated health concerns are likely to be intensified because of the water cycle linkages between livestock waste and human populations. However, within public health and water management, human interaction is often viewed as a separate process from the underlying natural water cycle. Batram noted that in the future this paradigm will likely be challenged and found deficient as the extent of human impact on the underlying cycle is increasingly appreciated. Thus, he said, a new logic in water management is likely needed (including management to protect and improve health) to directly address the interconnectedness among the natural water cycle and the overlapping water demands by humankind.

Bartram stated that managing the waters needed for drinking, recreation and bathing, agriculture (including irrigation), seafood production, and so forth, is expensive and problematic. He noted that the costs (in both financial and health terms) are largely associated with the practice of using water routes for waste disposal. In fact, he said, the self-purification capacities of many water resources are limited and the ecosystem services they render to humankind in the form of waste treatment are often underappreciated and overloaded. Bartram noted that this management approach is reflected in legislation. For example, he added, most countries strictly regulate the direct use of wastewater, whether it is for toilet flushing or for agriculture, and yet do not think it is necessary to regulate the indirect use of that same wastewater once it is discharged into water resources that may be used for human contact and in food production. Bartram emphasized that these practices contribute to the intensification process referred to above and lead to inconsistencies in health protection, whether it is between hazards or between exposure routes.

Bartram pointed out that a specific challenge to effective water resource management and use relates to the multiple sectors that interact with water and the diverse disciplines engaged in its management. Bartram stated that effective future management will require multidisciplinary perspectives in order to integrate and understand water-related hazards, which will likely challenge team members who use different vocabulary and different underlying approaches. Bartram noted that there are fundamental differences in how stakeholder groups understand and describe risk. Even within the discipline of public health,

he said, risks associated with radiation, infectious diseases, toxic chemicals, and nutrient intake deficiencies cannot be readily compared and discussed meaningfully.

## Water Needs in the Future

Bartram stated that there are currently two available technological approaches to sanitation. At one extreme, sewerage is associated with extremely high costs, environmental pollution, adverse health effects, and use of large quantities of water; but, sewerage is aspired to over the alternative extreme, which is some form of ground latrine. Neither model is ideal, said Bartram, and thus incentives are needed to encourage engineers, managers, and entrepreneurs to develop alternatives that are affordable, applicable in high-density and disperse rural settings, not reliant on costly long-term fixed infrastructure, and able to facilitate public health protection and recovery of the nutrient resources contained in human excreta. Bartram noted that while such options are not unimaginable, they are needed and unavailable today.

Bartram explained that one of the consequences of economic development has been a change in the way that water is used in the immediate human environment leading to an intensification of water resources—wanting water to do more things. For example, legionellosis was first recognized in 1976, and, in effect, a natural bacterial occupant of the water environment became a health issue because humankind was doing something new with water. Bartram noted that *Legionella* species are found in aquatic environments and thrive in warm water and warm, damp places, such as potable water distribution systems, cooling towers and evaporative condensers, natural spas, hot tubs, and swimming pools. Bartram stated that such environments are common in health care facilities, hotels, schools, and ships, and many of these environments are disproportionately used by more vulnerable population groups. In more recent times, he added, nontuberculous mycobacteria have emerged as a similar problem: for example, for people living with HIV/AIDS. Bartram emphasized that hazards arising from microbial growth are emerging, and such emergence is likely to continue with intensification of the water cycle and human interaction with it. The current model, said Bartram, is that society changes the way it uses water and then awaits the emergence of a health problem in order to respond. Bartram asked for a new model where public health proactively looks for opportunities to identify and

preventively solve problems. Such an approach, he said, would secure efficiencies and synergies in problem solving.

Bartram stated that the application of a health impact assessment to water resources management would be illustrative. Frequently, irrigation schemes have been associated with the introduction or exacerbation of schistosomiasis and substantive adverse health impacts. Once schemes are established, he added, introduction (or retrofitting) of water management measures to control risk is costly and complex. Bartram noted that health impact assessments provide a means to identify the potential future risk and in doing so, enable less costly and potentially more effective measures to be engineered from the outset.

On a larger scale, stated Bartram, increasing numbers of countries around the world are experimenting with the use of desalination to provide or supplement drinking water. Although the total capacity is increasing, there is a lack of information on health effects of consumption of the resulting water. Bartram highlighted that there are anecdotal reports of dental problems because of decreased fluoride intake and some suggestive evidence for reduced calcium and magnesium intakes associated with bone and heart disease. This example, he said, underscores the disengagement between the health community and *proactive* public health engagement in management of water to protect and improve health. Bartram emphasized that the health system has opportunities to steer policy and technology changes for potential benefit, but to be effective, the field needs to be actively engaged and positioned ahead of the curve.

Bartram pointed out that energy provides examples of more distal links between water and health. He noted that the way society manages water has a large energy consequence, with some reports suggesting that 20–40 percent of energy use in midsized cities in developed nations is being used on water and sanitation (California Energy Commission, 2006; WEF, 2011). Those developed cities have been shown to be inefficient in pumping water, as approximately 20 percent of all treated and pumped water is lost through water leakage (Environment Canada, 2004). Bartram stated that similar trends are seen in irrigation systems. For cities and nations that are grappling with managing water and energy resources, Bartram noted that there are opportunities to improve the system with direct and indirect health benefits.

Until the 1970s, stated Bartram, environmental health was embedded in the health systems of many countries. Following the UN Conference

on the Human Environment in 1972 and the Mar del Plata conference in 1977, he said, countries began to create ministries of the environment, environmental agencies, or similar bodies such as the Environmental Protection Agency in the United States. Bartram noted that many of these agencies were created by cutting all or part of the environmental health capacity from ministries of health in order to seed the creation of a new agency. He added that one of the unintended consequences was that environment and health diverged, and the discipline and practice of environmental health lacked effective leadership. As the world starts to focus on the post-2015 development agenda, he noted, there is an opportunity for environmental health to act as a driver of the path forward. As part of this effort, he said, there is a need to identify the co-benefits and recognize that health does not invariably align with sustainable development. Bartram emphasized that without health system engagement, opportunities to exploit synergies and opportunities to avert or minimize risks will be missed. However, health systems are often poorly engaged in these processes, and when engaged, they are poorly equipped to participate. Thus, Bartram noted a need for primary leadership and better coordination between the health system and environmental health (see Figure 4-6).

## DISCUSSION

A discussion followed the presentations summarized above. Richard Jackson noted that the 20th-century approach to addressing challenges was to fragment the issue into smaller and smaller pieces, while the 21st century sees value in integration and horizontal thinking. Jackson stated that the stovepipes that were artificially created cannot adequately address the need to move toward sustainable, mutually beneficial solutions. Paul Wilkinson asserted that many solutions to proceed sustainably are already known, especially for energy and climate change. Wilkinson suggested that it is a question of decision making.

Lynn Goldman stated that a disconnect between health and the environment occurred when environmental health was moved from health agencies to environmental agencies. Goldman noted that in order for the health agency to be involved, there is a need to communicate why the linkages between the environment and health are important.

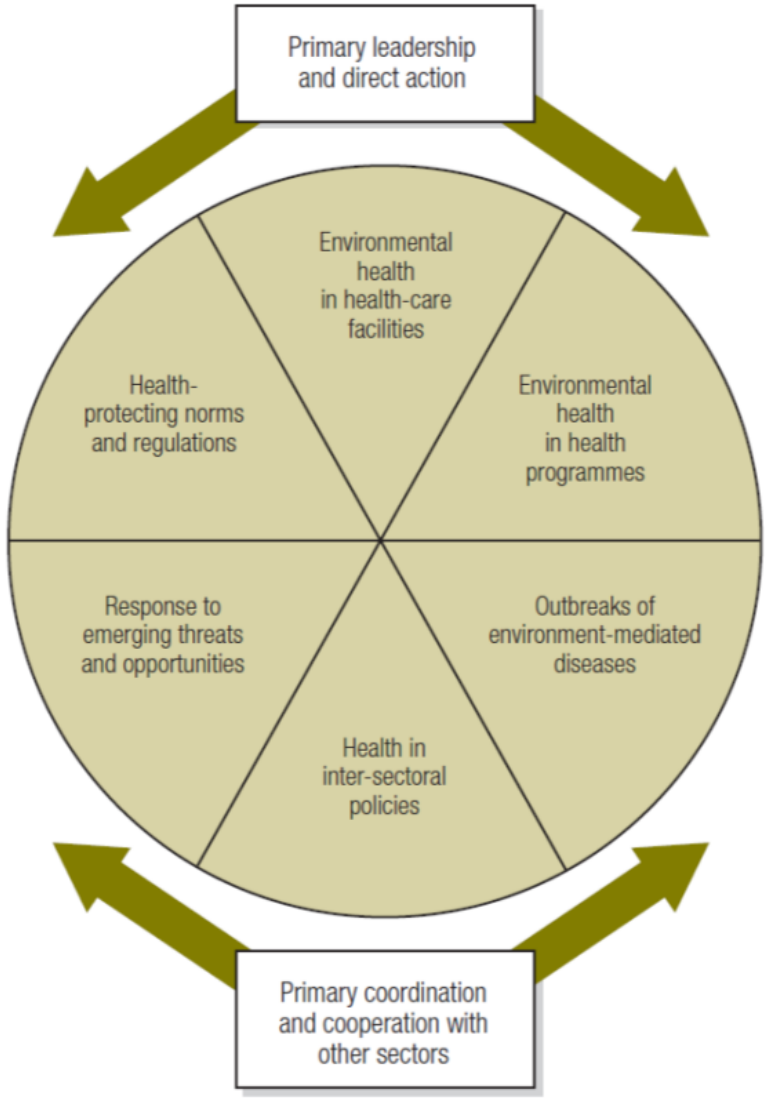


**FIGURE 4-6** Health sector functions to secure environmental health.
SOURCE: Rehfuess et al., 2009. More health for your buck: Health sector functions to secure environmental health. *Bulletin of the World Health Organization* 87: Figure 1, page 881. Reprinted with permission from the World Health Organization.

However, Kirk Smith noted that many in the environmental health community benefit from not being associated with ministries of health as toxicological results are reported as odds ratios and not in a burden of disease context. Smith stated that there is concern in the field about decision makers not acting, but this may in part be caused by scientists providing information that makes it very difficult for decision makers to act.

Wilfried Kreisel noted that urbanization is continuing to increase, primarily in developing countries. Kreisel stated that this trend will have an effect on sustainable agriculture and water availability. Anderson pointed out that rural urban migration is related to trade policies and the lack of available land on which to adequately make a living. Anderson explained that there is a need to ensure that rural areas offer the same opportunities as urban areas to stave off urbanization. At the same time, Anderson said, there have been opportunities to create urban agriculture zones in many cities around the world to meet access to locally grown food. Anderson further noted that urban agriculture has its own challenges as heavy metals, such as lead, can be in the soil. Similarly, Bartram noted that climate change and extreme weather events are a growing concern as a significant number of the population live on the coast. Bartram stated that large coastal cities face a number of unanswered questions including how these regions can grow and remain sustainable. For example, Bartram said, with increased urbanization, there is a larger human footprint, which can result in runoff and contamination of seafood. As the world begins to move toward sustainability, Bartram emphasized, these issues need a multidisciplinary approach to address them.

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# 5

# SUSTAINABILITY LINKS TO OCCUPATIONAL AND CHILDHOOD HEALTH

This chapter focuses on opportunities for sustainability with regard to occupational and childhood health. The first presentation provides an overview of exposure and risk profiles among agricultural workers within the United States and Egypt, and summarizes innovative solutions that are being developed to protect worker health. The second presentation provides a broader view of the connections between sustainability and global worker protection and outlines challenges that exist with regard to safety hazards and toxic chemicals in the workplace. The third presentation looks at exposures during child development that contribute to risk of disease, and outlines an indicator approach to address this problem area. A summary of the presentations follows, along with a summary of the discussion that took place.

## EXPOSURE AND RISK PROFILES IN THE AGRICULTURAL WORKPLACE: OPPORTUNITIES FOR SUSTAINABILITY

*Richard A. Fenske, Ph.D., M.P.H*
*Professor and Associate Chair of Environmental and Occupational Health Sciences*
*University of Washington*

Richard A. Fenske began by noting that the Occupational Safety and Health Act of 1970[1] tries "to assure so far as possible every working man

[1] Occupational Safety and Health Act of 1970, Public Law 91-596, 91st Cong., December 29, 1970.

and woman in the Nation safe and healthful working conditions and to preserve our human resources." Fenske noted that Figure 5-1 is a commonly used diagram that illustrates the components of sustainable development. He asked the group to consider where occupational health and safety fits into this type of diagram, which highlights the intersection of social, environmental, and economic factors.

Fenske noted that past U.S. legislation on sustainability has lacked language focusing on the health and safety of workers. For example, while the Food, Agriculture, and Conservation Trade Act of 1990[2] states that a goal of sustainable agriculture is to "enhance the quality of life for farmers and society as a whole," it does not discuss health and safety specifically, and worker health remains unaddressed. He added that in the 1991 National Research Council report *Sustainable Agriculture Research and Education in the Field*, there is no mention of occupational health and safety (NRC, 1991). In 1997, he said, a report from the President's Council on Sustainable Development (1997) laid out nine policy recommendations without a mention of worker health and safety. Similarly, these issues are absent from a 2003 report entitled *21st-Century Agriculture: A Critical Role for Science and Technology* from the U.S. Department of Agriculture (2003). He noted that these add to the separation between health and the environment that is continually seen in policy development.

Fenske stated that even the Agenda 21 report from the 1992 Rio Earth Summit (see Chapter 2 for additional background information) does not include worker health and safety in the chapter on sustainable agriculture and rural development. However, one section is devoted to the role of workers and trade unions, in which there is a call for

- mechanisms on safety, health, and sustainable development;
- reductions in occupational accidents, injuries, and diseases; and
- increases in the provision of workers' education, training and retraining, particularly in the area of occupational health and safety and environment (UN, 1993).

He noted that it would be beneficial to apply this language to current policy development within and outside the United States.

[2] Food, Agriculture, and Conservation Trade Act of 1990, Public Law 101-624, 101st Cong., November 28, 1990.

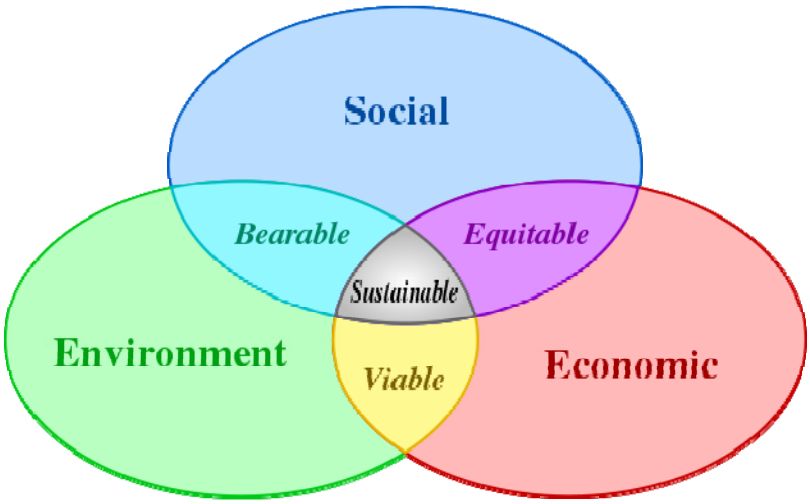


**FIGURE 5-1** Components of sustainable development.
SOURCE: Johann Dréo (http://en.wikipedia.org/wiki/File:Sustainable_development.svg).

### Reducing Workplace Exposure in the Northwest Tree Fruit Industry

When workers are interacting with pesticides, Fenske stated, the U.S. Environmental Protection Agency (EPA) Worker Protection Standard emphasizes the use of personal protective equipment, restricted entry intervals, and worker training. In practice, he said, the use of restricted entry intervals and worker training are resource intensive and difficult to maintain. He noted that the premise of restricted entry involves monitoring exposure levels in the field and allowing for reentry once the levels are safe; however, these levels are difficult to calculate. Similarly, while training is an important component of ensuring worker safety and health, he said, the transient nature of the workforce requires frequent training and retraining, which can end up being impractical.

In looking specifically at the tree fruit industry, high pesticide exposures exist because of the use of airblast applications, the absence of cabs on tractors, and the open loading systems, which can result in chemical spills and splashes. To exacerbate the problem, he said, the vast

majority of pesticide handlers are Spanish speaking, with low education levels, but since the pesticide labels and instructions are in English, the inadvertent misuse of the chemicals is common.

Fenske noted that pesticide exposure among tree fruit workers has been a controversial issue. He explained that a decade ago in Washington State, growers stated that there was no pesticide safety problem in the agricultural workplace, but farmworker advocates argued that a silent epidemic of poisoning existed in the fields. He added that this argument led to a ruling by the Washington State Supreme Court in 2004 that cholinesterase monitoring should be provided to agricultural workers.[3] This program is not part of the federal standard, and in 2011, Washington and California were the only two states to monitor cholinesterase for worker safety. Cholinesterase is an enzyme required for proper nerve impulse transmission, and certain classes of pesticides act as cholinesterase inhibitors in the human body (Furman, 2010). Depression in cholinesterase levels inhibits the control over nerve impulses to the muscles, which can lead to serious health consequences.

Fenske stated that under this initiative in Washington (see Figure 5-2), a significant cholinesterase depression will trigger a workplace evaluation or even reassignment of the worker if the depression is severe enough. When the program started in 2004, he said, 20 percent of monitored workers experienced cholinesterase depression that exceeded regulatory thresholds; this figure was cut to 3 percent in 2010. He noted that this monitoring program can benefit everyone involved by reassuring relevant stakeholders such as farmers and workers, and enabling state regulators to better monitor worker safety and health.

Fenske explained that researchers at the University of Washington School of Public Health are piloting another approach to developing practical and cost-effective solutions to reduce pesticide exposures. He stated that an expert working group, which included the field workers themselves, was assembled to discuss these agricultural workplace safety

[3] The Washington State Cholinesterase Monitoring rule "requires agricultural employers to provide medical monitoring for workers who handle toxicity Category I or II organophosphate or N-methyl-carbamate cholinesterase-inhibiting pesticides…workers who handle cholinesterase-inhibiting pesticides for 30 or more hours in any consecutive 30-day period are covered by the medical monitoring requirements of the rule" (http://www.lni.wa.gov/Safety/Topics/AtoZ/Cholinesterase/Providers.asp [accessed May 17, 2013]).

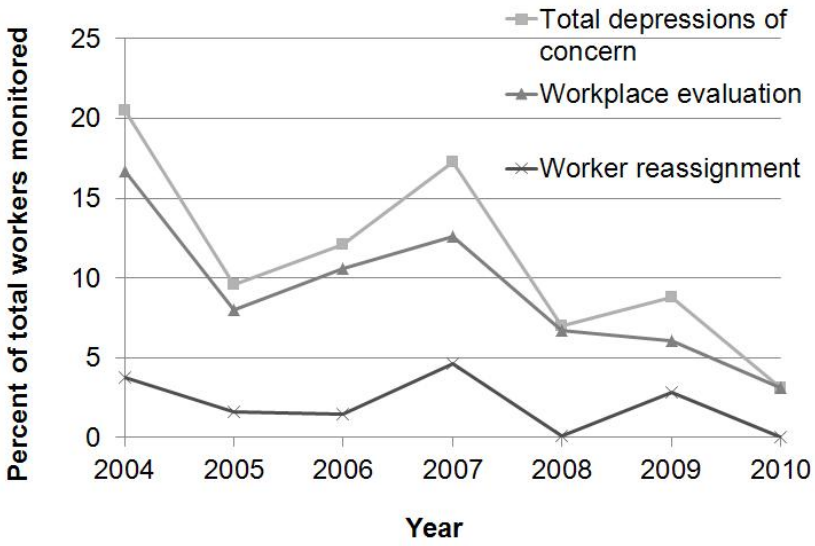


**FIGURE 5-2** Washington State Cholinesterase Monitoring Program: Percent of workers with cholinesterase depressions that exceeded regulatory thresholds.
NOTE: The Washington State Cholinesterase Monitoring Program demonstrated that a substantial percentage of workers have exhibited cholinesterase depressions that exceeded regulatory thresholds; however, these levels have decreased over time.
SOURCE: Fenske, 2011.

concerns. He noted that a reoccurring theme after 4 years of evaluation was the sentiment from field managers and workers that safety equipment requires a level of compliance that is not always enforceable, and that this practice has not been normalized into the workplace. Overall, the team identified a need to promote a safety climate and culture in the workplace. To help communicate this, he said, fluorescent tracers were incorporated into the pesticides and air-blast applicators in the field and the field workers were later photographed under ultraviolet light. He noted this can be effective in showing people the patterns of skin exposure that occur, even underneath protective clothing.

Fenske stated that multiple other dynamic factors may alter the risk profile of pesticides in the near future. He noted that many new agricultural chemicals have been developed with significantly lower mammalian toxicity that require much less product to treat the same acreage of land. However, adoption of these chemicals is very slow due

to the enormous risk farmers take in using new chemicals, since ineffective products may reduce crop yields and lead to financial hardships. Currently, he said, the Washington State University Pest Management Transition Project is working with farmers to gradually switch to the use of these compounds. He noted that there remains a need to incentivize more large-scale transition toward adoption of such new, reduced risk agricultural chemicals.

Fenske explained that further changing the agricultural landscape is a new trend in orchard design. New apple trees are now being supported physically with an architectural structure called a V-trellis in order to promote more automation into the maintenance of apple orchards. He noted that new innovations in spray equipment are allowing for reduced chemical drift and improved pesticide delivery for the efficient treatment of trellised apple trees. Additionally, sprayer prototypes are being developed that may eliminate the need for a driver in the future. He emphasized that designing these orchards with safety in mind can significantly reduce exposure risks for workers.

### Reducing Workplace Exposure in the Nile Delta

Fenske noted that a project funded by the U.S. National Institutes of Health (NIH) is under way in Egypt with the aim of identifying new biomarkers of neurotoxicity in the human population. In Egypt, cotton fields are sprayed with pesticides by hand with a team of workers spraying a field together. He explained that they commonly do not wear shoes, gloves, or other protective clothing and are openly exposed to the chemicals on a regular basis. During the growing seasons, urinary metabolite data were collected from the pesticide applicators, technicians, and engineers working in cotton production[4] (Farahat et al., 2010). The results indicated that high levels of these pesticides were internalized and persisted in the body days after exposure (Farahat et al., 2010). When compared to the Washington State exposure rates in tree fruit workers, metabolic pesticide levels among cotton pesticide

[4] "Each field station has a team of employees in three job categories with potential pesticide exposure: (1) applicators who apply pesticides with backpack sprayers, (2) technicians who walk each row with the applicator to direct the path of the applicator and point out any heavy insect infestations in the field, and (3) engineers who periodically walk the fields but more often direct the application process from the edge of the field" (Farahat et al., 2010).

applicators in Egypt were over 50 times greater, and supervisor levels were nearly 4 times greater. He emphasized that the Egyptian cotton workers were experiencing significant exposure to pesticides and resulting neurobehavioral deficits.

Fenske stated that understanding the social landscape is also important to shift attention toward farmer protection. He explained that physical laborers often belong to underprivileged or otherwise at-risk groups, both in the United States and abroad; but, researchers can utilize the expertise of these individuals through focus groups to develop, test, and evaluate potential worker health and safety solutions. For example, with the aid of focus group discussions in Egypt, practical personal protective equipment that could be made from inexpensive, readily available materials that were realistic in the local context was developed to reduce dermal exposure. He noted that testing of this new clothing (which looks similar to pants or chaps) is currently under way, with biological monitoring to determine exposure reduction rates. He stated that initiatives such as these hold promise in successfully reducing workplace exposures and incorporating health into sustainable agricultural practices.

## Final Remarks

Fenske stated that reducing pesticide exposure among agricultural workers, within and outside the United States, requires both robust research programs and community engagement. He noted that research programs need to include a balanced group of experts in health, safety, and workplace environments to have rigorous yet realistic research initiatives. Additionally, building trust through mutual respect and building capacity in communities are essential components to developing a sustainable agricultural system. With respect to the Rio+20 conference and other upcoming meetings, he said, some of the ideas that were already presented in Agenda 21 could be emphasized. He noted that this could include developing an inventory of international pesticide use, developing surveillance programs for agricultural workers, and supporting integrated pest management practices. He stated that these programs and practices would better inform the future of a sustainable agricultural workplace throughout the world.

## SUSTAINABILITY AND HEALTH: IMPACTS FOR WORKERS

*David M. Michaels, Ph.D.*
*Assistant Secretary of Labor*
*Occupational Safety and Health Administration*
*U.S. Department of Labor*

David M. Michaels noted that when thinking about sustainability and the use of resources into the future, clearly one set of resources we have to think about preserving is our workforce and the health and safety of our workers. Within many of the basic issues of sustainability, he said, the workforce is often forgotten or neglected, so there is an opportunity to raise some attention around these issues.

In planning sustainable development, Michaels said, the carbon-based economy is of particular concern. In addition to the more well-known environmental issues linked with the production and use of fossil fuels, he said, these activities are associated with high levels of injuries, illnesses, and fatalities among workers employed in coal mining and oil drilling and refining. He noted that shifting away from carbon dependence provides hope for improving worker health and safety.

However, Michaels stated, a shift to renewable energy and recycled or "green" products does not necessarily equate with improved health and safety in the workplace. For example, workers involved with wind turbines are at increased risk of injury from falls and arc flashes. He noted that the lesson to learn is that old hazards are often still associated with these new technologies and jobs. When looking at recycling facilities, a component of sustainability, he said, workers are exposed to increased fatality rates compared with the general waste management industry, with regular fires occurring from the chemicals or metals (including arsenic, cadmium, and other heavy metals) brought to the facility. He noted that these workplace hazards are seen in the United States and other countries.

Michaels explained that much of the discussion and advocacy on issues of toxic chemicals fails to recognize that workers are often akin to "canaries in the coal mine" as their chemical exposure levels are far higher than those which occur in communities. While the workers may be healthier than the children or some of the elderly population exposed to various pollutants, he said, their exposure levels can be many times higher and quite concentrated. He noted that it is for this reason that

much of the epidemiological research done on toxic chemicals is performed on workers; measuring the effects on less exposed nonworkers is more difficult. For example, a series of studies were performed on Bisphenol A (BPA)—a chemical found in plastics used to make products such as water bottles—involving chemical workers in China who were exposed to BPA through the manufacturing process (Li et al., 2011). The researchers found lower sperm counts and sperm vitality among these workers compared with men who did not have detectable BPA levels (Li et al., 2011). While this is an important research finding, he said, little discussion or advocacy has taken place to protect these workers, and to link occupational health and public health in chemical manufacturing.

Michaels stated that some progress is being made to incorporate sustainability initiatives into occupational and public health in the United States and abroad. He noted that one area of promise is the U.S. health care sector. Under the banner of the Healthier Hospitals Initiative, hundreds of the nation's leading health systems are working in collaboration to integrate the "three safeties"—patient safety, environmental safety, and worker safety—into hospital operations. Michaels noted that worker safety is also becoming a component of the Global Reporting Initiative (Food and Agriculture Organization of the United Nations), an effort by many multinational companies to increase awareness of their global social and environmental impact. He pointed out that the American Industrial Hygiene Association, the American Society of Safety Engineers, and the Global Reporting Initiative have also formed an alliance to develop ways in which the participating corporations report on worker injury and illness rates.

Michaels noted the need to consider our larger role in global worker protection and determine the responsibility we have to workers who are clearly exposed to safety hazards and toxic chemicals at levels that would not be permitted in the general populations of our countries. He stated that there is a great challenge ahead of us to develop sustainable activities and productions that are good for the health of people, good for the earth, and make us feel good.

## EARLY CHILDHOOD EXPOSURE AND HEALTH RISKS: INCORPORATING SUSTAINABILITY

*Lauren Zeise, Ph.D.*
*Chief, Reproductive and Cancer Hazard Assessment Section*
*Office of Environmental Health Hazard Assessment*
*California Environmental Protection Agency*

Lauren Zeise explained that the mosaic of environmental laws that are supported by risk assessment address a defined set of environmental chemical risks that affect child health. However, she said, numerous environmental chemical stressors are likely not covered. She stated that the overall impact of environmental chemicals on a child's well-being can be worsened by poor access to health care and psychosocial stressors. She noted that concern about health being harmed—even if all activities in a community are in compliance with environmental regulations—combined with the fact that vulnerable and disadvantaged groups bear a disproportionate burden of harm, has motivated the development of methods to address these environmental justice concerns and cumulative impacts. Using indicator approaches, these methods attempt to measure the overall impact of environmental burdens at the community level. Zeise pointed out that California is exploring the use of these techniques to identify highly impacted communities for priority attention and investment. At the international level, she said, children's environmental health indicators are being developed and used to track a child's environmental health and provide the basis for measuring the effectiveness of policies that seek to improve environmental conditions for children. She noted that initiatives like these complement existing risk-based approaches and show promise for incorporating a broader set of sustainability concerns in decision making that can improve outcomes affecting child environmental health and well-being.

### Early Life Susceptibility

Zeise stated that fetal and childhood stages of life can include periods of increased susceptibility to environmental exposures, chemicals, and other stressors. When exposures to carcinogens occur in utero and in childhood, she said, there is more time for the disease to manifest itself over the life course. She noted that there is also enhanced inherent susceptibility in early life, a period of rapid growth and development in

the life cycle. The concern for enhanced susceptibility has been established through human studies, she said, and cancer is used as an exemplar end point. She explained that rates of radiation-induced thyroid cancer are considerably greater in individuals exposed as infants or in early childhood than as adolescents or adults. She noted that other examples include dramatic increases in vaginal adenocarcinoma in offspring of women who took the drug diethylstilbestrol for morning sickness during pregnancy, and greater rates of lymphoma in children and adolescents who took immunosuppressive drugs (often part of transplant therapy) as compared to adults.

Zeise stated that protecting the vulnerable is a key feature in all major environmental laws. She added that the decision-making processes that provide for protections from environmental chemicals and pesticides in air, drinking water, and food all rely on risk assessment methods. She noted that changes in risk assessment methodology require adequate scientific evidence to better address early life sensitivity. Thus, she said, California and the EPA reviewed the scientific literature to answer key questions regarding environmental chemical exposures during early childhood, including

- Are large increases in early-life sensitivity common?
- How much do age sensitivities differ chemical by chemical and across early age windows?
- What specific changes should California adopt to address age-at-exposure differences in cancer susceptibility?

Zeise pointed out that the literature included experimental data from studies on environmental chemicals in which animals exposed during early life stages were compared with animals exposed to the same chemical during adulthood. She noted that the results of these experiments were systematically compiled and analyzed to address the above questions for carcinogens. She added that other efforts were undertaken to consider changes to non-cancer risk assessment methods.

Zeise explained that the analyses of the animal model studies with fetal-only and adult-only exposure groups showed variability in susceptibility across the environmental chemicals studied. At the mean, she said, the fetus was 20 times more susceptible to carcinogens than the adult; however, the median susceptibility was higher by only a factor of 3, reflecting a skewed distribution. That is, she said, for some chemicals the fetus exhibited very high susceptibility, while for some others it was less susceptible. However, she noted, the established practice has been to

not include this prenatal exposure window at all in estimating cancer risk among populations.

Zeise stated that another aspect of risk assessment is exposure assessment. She noted that numerous environmental factors can cause young children to experience higher rates of exposure to chemicals than adults. For example, she said, bottle-fed infants tend to experience close to an order of magnitude more exposure than adults to drinking water, on a per-body-weight basis. She stated that exposure through certain foods can also be many times higher in infants and young children than in adolescents or adults. She added that the increased breathing rates of children also can increase their exposure. Finally, she said, behavioral factors such as crawling, hand-to-mouth activity, restricted diets, and activities associated with adolescence all can increase rates of chemical exposures in young people. She noted that systematic analyses of data on such exposure parameters also support changes in methods to adequately address the young in exposure assessment.

### Sustainability, Risk Assessment, and Risk Management

Zeise explained that under the current regulatory structure and risk assessment paradigm, toxicity data generation cannot keep pace with need. A 2007 National Research Council (NRC) report, entitled *Toxicity Testing in the 21st Century: A Vision and a Strategy* (NRC, 2007), introduced a new toxicity testing paradigm to address this problem. She noted that the testing would focus on upstream events rather than frank toxicity outcomes like cancer and birth defects. She stated that a suite of different toxicity tools including short-term tissue culture tests and toxicogenomics screens of cells and cell components would provide the basis for chemical evaluation and decision making. She added that considerable resources and research are required for implementation. Through a memorandum of understanding among key federal agencies, work to realize the vision has been ongoing and promising, but time frames predicted for a fully functional testing system are long (15 to 20 years out). She noted that it is widely recognized that the current risk assessment/risk management paradigm—that relies on data that are costly and time intensive to generate—is unable to address a large array of environmental chemicals (GAO, 2005; NRC, 2007, 2009).

Zeise stated that formal consideration of predictions based on sparse information (e.g., physiochemical properties, structural activity modeling, and available short-term tests) have been promoted as a way

forward (NRC, 2009). However, regulatory agencies would be attempting this in an atmosphere that has been challenging even in information-rich cases (NRC, 2009). With few exceptions, she said, the regulatory agency has the burden of proof to show harm before taking action. She noted that a shift in the burden of proof is a key feature of some proposals to reform chemical policy (Woodruff et al., 2011). In California under the Proposition 65 program, the burden of proof is on businesses over a certain size when they cause significant exposures to chemicals "known to the state" to cause cancer or reproductive (including developmental) toxicity. Zeise added that roughly 270 chemicals are listed as causing reproductive toxicity within the program, many because of effects on development from in utero exposure. She stated that violations can lead to relatively stiff fines if a business has knowingly caused exposures for a protracted period. She noted that this shift in burden has led to protections in child health as products that contain known developmental toxicants are reformulated or removed from the market.

## DISCUSSION

A discussion followed the presentations and the remarks are summarized in this section. Lynn Goldman questioned whether the personal protective equipment for the cotton field workers described by Fenske in the Egypt example goes far enough, given that the protective clothing only covers the legs, still leaving the arms and front and back of the upper body exposed. Fenske noted that while in the Washington State example improvements in exposure tend to be technological, in Egypt smaller steps, including getting workers to wear shoes, will have an impact. He noted that the physical environment in Egypt should also be considered, and the protective pants are important because workers still wear them even in high temperatures (which may be transferable to agricultural workers in similar climates). Fenske stated that in addition to protective clothing, researchers are working with the field workers to better understand the issue of drift, so people can remain upwind of the drift and decrease pesticide exposures. While this is a starting point, he said, better methods still need to be developed for the Egyptian cotton field workers. John Balbus then asked whether the personal protective clothing, or intervention component of the study, was included in the

research proposal and also asked if the right design elements appear to be funded in global environmental health programs. Fenske noted that while the intervention was part of the original study design in the proposal, it was a small component compared to the exposure monitoring and neuroscience pieces. Fenske stated that the invention component alone likely would not have been funded, which is unfortunate.

Kirk Smith introduced the topic of environmental justice and noted that workers tend to be exposed to higher risks than is the general public; sometimes this increased risk may be justified by a benefit from the job, but at other times the worker does not understand the risk being taken. Smith noted that part of any sustainability framework should include moving to a system where workers are not treated differently than the general public because we are all workers in one place or another. He added that the real environmental injustice in the United States, and most of the world, is likely the increased relative risk that exists between occupational and public realms with regard to chemical exposures. Smith then asked what would the world look like if we protected workers just as much as we protect the public. Smith noted that we should try to link this thinking to broader discussions of sustainability. Carlos Corvalán added to this by noting the need to look at the social gradient when comparing occupational risks among workers. Corvalán stated that jobs with the highest risks likely correlate with the bottom part of the social gradient, whereas the social elites are likely connected to jobs with minimal risks. Similar to what Smith outlined, Corvalán emphasized the need to link social determinant issues with environmental health justice and sustainability topics in high-level meetings and discussions within and across countries.

John Spengler commented on the presentation from Michaels, noting the complexity of the Global Reporting Initiative and the reporting difficulties given that many multinational companies subcontract their workers. Michaels noted that with the Global Reporting Initiative there is an attempt to integrate at least basic injury illness rates into the voluntary reporting of the multinational companies involved, but as Spengler noted, it can be difficult to track contractor employees. Michaels explained that when workers are hired by subcontractors, the workers are often transferred for short periods of time to different facilities, which benefits the subcontractor in terms of avoiding paying taxes or health benefits, but makes collecting health and safety data and assessing responsibility quite challenging.

Fenske pointed out that in the United States in Washington State contract labor is a growing industry, similar to that seen in California in agriculture, but noted that associations for these workers (such as the Washington Contract Loggers Association) are being organized and include members interested in improving the health and safety of the workforce. Fenske asked Michaels to share his thoughts. Michaels stated that he is seeing this same model developing across the United States, and noted that these associations should be included when considering reporting and discussions with different employer groups. Fenske then emphasized that the problem of the worker being moved from place to place and the lack of responsibility to track exposure data for that worker still appears to remain with this model, which may be remedied by having the contractor take a role in protecting worker health and safety.

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# 6

# NEW SUSTAINABILITY FRAMING

This chapter focuses on new efforts for sustainability and ways to include health considerations in major decisions and policies affecting society. The speakers approach the topic from a U.S. perspective, highlighting the need for integrated solutions to complex problems that cross economic, social, and environmental domains. Emphasis is placed on decision makers to consider the broader landscape and potential health impacts when adopting policies and programs. A summary of the presentations follows in which the speakers outline strategies for new sustainability opportunities.

## THE HEALTH LENS OF SUSTAINABILITY

*Richard J. Jackson, M.D., M.P.H.*
*Professor and Chair, Department of Environmental Health Sciences*
*School of Public Health*
*University of California, Los Angeles*

Richard J. Jackson explained that the physical environment we design as a society can impact human health. For example, where buildings and homes are built may determine how far people drive and how much air pollution is created, and how roads are built and where forests are removed may increase the extent of water pollution. Jackson stated that scientists and decision makers tend to focus on the end of the disease model, looking at particulates and water pollutants, and tend to overlook the upstream drivers of disease. What this means in practice, he said, is that issues related to atmospheric carbon dioxide ($CO_2$) levels, global warming, economic difficulties, obesity, diabetes, and other diseases are

each addressed as separate problems without recognizing that solutions must be proposed to solve them collectively.

Jackson stated that society is on a collision course where the economic, social (including health), and environmental factors are likely to result in a "perfect storm" that will affect our nation's well-being. He noted that the country continues in a severe recession that has disproportionately impacted the poor, young adults, and African Americans. At the same time, the health of children in the United States is impacted, where over the last three decades, overweight and obesity rates have increased threefold among 12–19-year-olds and fourfold among 6–11-year-olds (Babey et al., 2009). The rate of obesity among adults in the United States has doubled over this same period. But more strikingly, the overall prevalence of diabetes in U.S. adults has doubled in just 10 years and the estimated cost of diagnosed diabetes in the United States increased to $245 billion in 2012, a 41 percent increase over 2007 estimates (American Diabetes Association, 2013). And with the current trends in care, U.S. health care expenditures are expected to reach almost 20 percent of GDP in the next 6 years (Keehan et al., 2008). Jackson emphasized that no country can likely survive once it starts spending over approximately 25 percent of its income on a non-wealth-generating activity.

Turning to the environmental factors, Jackson noted that current $CO_2$ levels are now dramatically higher in the earth's atmosphere than they have been in more than 650,000 years (Schrag, 2011). He stated that much of the global carbon emissions are produced through transportation and electricity generation mechanisms. Jackson pointed out that sustained elevated levels of $CO_2$ in the atmosphere will require many generations to dissipate, leading to global warming and serious loss of land and fresh water aquifers due to increased ocean levels. For many decision makers, he said, the magnitude of these effects is difficult to comprehend. Jackson noted that political leaders often dismiss health issues, particularly environmental issues, until the leaders themselves are affected either personally or politically (such as when insecticide levels in the Sacramento River killed a significant number of fish or when New Orleans was confronted with the environmental health effects of Hurricane Katrina).

Jackson described that the crisis the world faces today is as much of a moral and ethical dilemma as it is a technical, environmental, social, and economic problem. The Environmental Protection Agency's (EPA's)

draft regulation on greenhouse gas loading received criticism from the energy sector suggesting that it may negatively impact economic growth and job creation within the United States (API, 2011). Jackson noted that while scientists have been quick to discuss the technical issues around these regulations, they have been slow to provide insight on the moral and ethical issues. He stated that there is a moral obligation among scientists to discuss the social and cultural failings that are affecting the population (naming greed as an example of a moral failing embedded in our society). Jackson emphasized that as a guardian or caretaker, the Earth should be able to provide adequate food, water, clothing, and shelter for the next generations, but this will require more serious thought and action than what is seen in society today.

## 21st-Century Solutions

Jackson stated that we need to embrace 21st-century solutions with integrated strategies and plans to address multiple interlinked problems. He noted that with the exception of immunization efforts, overall population health is marginally affected by medical care decisions; health is determined more by decisions made about agriculture, transportation, housing, economic, and education policies than it is by medical decisions.

Jackson emphasized that this reality argues that decision makers need to embrace a "health in all policies" approach, which would be the first feature of a 21st-century solution. He stated that scattered throughout the country are examples where co-benefits can be gained through interconnected solutions to pressing issues. Looking at personal health and transit, a study conducted on the light rail system in Charlotte, North Carolina, concluded that the likelihood that passengers would meet their physical activity standards was statistically higher than that of nonpassengers (MacDonald et al., 2010). On average, these passengers weighed 5 to 6 pounds less over the course of 2 years and were 81 percent less likely to become obese over time (MacDonald et al., 2010). Jackson noted that these individuals did not even realize they were exercising since this health behavior was simply built into their lives.

Jackson stated that a second feature of a 21st-century solution is inclusion of the "hardware and software," in that both social and physical components are needed to achieve these goals. A simple example, he said, can be found in providing safe routes for children to travel to school, where safe paths with crosswalks *and* social networks (the

parents, parent-teacher associations, and school organizations) are utilized to promote health and safety. Jackson asserted that all too often the physical environment is emphasized with minimal consideration for the social environment.

Jackson noted that top-down and bottom-up leadership (from ethical, personal, social, and economic perspectives) is a third feature of a 21st-century solution. For example, prior to the 1993 National Research Council (NRC) report *Pesticides in the Diets of Infants and Children,* the general viewpoint was that people were not being significantly exposed to pesticides and regulations were not needed (NRC, 1993). One outcome from this report was the Food Quality Protection Act of 1996[1] that gave the EPA broad authority to study pesticides and to study the effects on infants. Jackson pointed out that this top-down leadership subsequently led to significant reductions in the residues of pesticides in food, as well as fewer applications and longer preharvest intervals.[2] With bottom-up leadership, New York City has transitioned from possessing virtually no bicycle lanes to approximately 900 miles of them (New York City Department of City Planning, 2013). Jackson stated that not only does biking dramatically reduce carbon emissions, it also promotes health and well-being and is less expensive than driving. These examples show how top-down and bottom-up leadership works and how solutions need to be driven from both ends.

Jackson explained that a fourth feature of a 21st-century solution includes examining the positive and negative health impacts that may arise from government policies and decisions. For example, the U.S. interstate highway system was one of the largest capital investments in the history of the world, yet population health was never considered during its development. In 1969, the National Environment Policy Act (NEPA)[3] was enacted and was one of the first laws that established a broad national framework for protecting the environment. NEPA assures that all branches of government give proper consideration to the

[1] Food Quality Protection Act of 1996, Public Law 104-170, 104th Cong., August 3, 1996.

[2] The preharvest interval is a function of a pesticide's use pattern and of the amount of pesticide residues allowed on the crop at harvest. See http://onvegetables.files.wordpress.com/2010/07/factsheet_respect_phirei_english_2007.pdf (accessed April 24, 2013).

[3] National Policy Environmental Act of 1969 (NEPA), Public Law 91-190, 91st Cong., January 1, 1970.

environment prior to undertaking any major federal action that could significantly affect the environment.

Jackson proposed that health impact assessments (HIAs) are necessary to ensure that health is taken into account in major decisions affecting society. An HIA is "a combination of procedures, methods, and tools by which a policy, program, or project may be judged as to its potential effects on the health of a population, and the distribution of those effects within the population" (Gothenburg Consensus Paper, 1999). He noted that the goal of a HIA is to focus the attention of decision makers on the health consequences of the projects and policies they are considering to allow for better informed decisions with respect to health. For example, as a result of an HIA, walking and bicycle routes were included in the design of the Cooper River Bridge in Charleston, South Carolina. Once installed, these routes became very popular with tourists and residents alike and provided an opportunity for physical activity.

Jackson stated that many people believe that NEPA has required HIAs all along. However, the typical environmental impact statement required by NEPA before a project can begin generally contains only a brief and perfunctory HIA statement indicating that no air or water standards will be violated. Jackson noted that this lack of health consideration is inadequate to deal with the crises facing society today. He added that HIAs must be adopted in a cross-cutting fashion when dealing with global issues such as economics, health, environment, transportation, housing, and education. Overall, Jackson said, HIAs must contain a fair weighing of risks and benefits of a proposed action, and the resulting recommendations should be implemented in a collective manner to solve multiple major societal problems.

## SUSTAINABILITY AND EXPOSURE: INSIGHTS FROM THE NRC REPORT

*Bernard D. Goldstein, M.D.*
*Professor Emeritus, Department of Environmental and Occupational Health*
*Graduate School of Public Health*
*University of Pittsburgh*

Bernard D. Goldstein noted that the origins of the U.S government's interest in sustainability dates back to the U.S. National Environmental Policy Act of 1969,[4] signed by President Richard Nixon, where the federal government recognized the interactions of human activity (i.e., urbanization, industrialization, population growth, and resource exploitation) with the natural environment and the ultimate effect on the welfare of humans. The act affirmed a national policy that "means to create and maintain conditions, under which humans and nature can exist in productive harmony, that permit fulfilling the social, economic, and other requirements of present and future generations." Reaffirmed in Executive Order 13514, signed by President Barack Obama on October 5, 2009, this act laid out the rationale for the importance of the United States to be economically productive while protecting valuable resources and human health.

Goldstein stated that in an effort to incorporate sustainability concepts into their agency's program and to move toward an integrated systems approach to solve complex environmental challenges, the EPA commissioned a National Research Council (NRC) consensus committee. The Committee on Incorporating Sustainability in the U.S. Environmental Protection Agency had a statement of task to advise the EPA on an operational shift within the agency from a risk assessment/risk management (RA/RM) focus to one of sustainability.[5] The committee, comprising 12 experts from an array of disciplines, held a two-day workshop consisting of data-gathering sessions. During these

[4] National Policy Environmental Act of 1969 (NEPA), Public Law 91-190, 91st Cong., January 1, 1970.

[5] This report was released shortly after Dr. Goldstein's presentation. The interested reader is directed to the National Academies Press's website for access to the PDF of the report: http://www.nap.edu/catalog.php?record_id=13152.

sessions, Goldstein said, the committee heard from EPA officials, state agencies, industry representatives, universities, and nongovernmental organizations. The resulting report addressed the following key questions (NRC, 2011):

- "What should be the operational framework for sustainability for EPA?
- How can the EPA decision-making process rooted in the risk assessment/risk management (RA/RM) paradigm be integrated into this new sustainability framework?
- What scientific and analytical tools are needed to support the framework?
- What expertise is needed to support the framework?"

Goldstein suggested that should the EPA adopt the framework prescribed by the committee and reorganize from a RA/RM paradigm to one of sustainability, it will likely be a slow transition. For example, the Clean Air Act of 1970[6] and the Clean Water Act of 1972,[7] both of which involved risk-based approaches, were passed years prior to the EPA's alignment with the RA/RM paradigm. Approximately a decade after the seminal 1983 NRC report *Risk Assessment in the Federal Government* (also known as the Red Book) (NRC, 1983) was released, which defined the RA/RM paradigm, the EPA reorganized itself to follow the report recommendations.

Goldstein noted that an adoption of the sustainability framework by the EPA will require more international collaboration than previously required for the implementation of the risk paradigms. When the National Academy of Sciences developed the current RA/RM paradigm in 1983, the United States defined hazard as being intrinsic and risk as requiring exposure. Other countries were defining the terms the opposite way, he stated. Goldstein outlined that as the United States had the most experience and was leading the field, the global community adopted and adjusted their models of risk assessment to align with the U.S. framework. Currently, he said, other countries are producing far more and potentially superior work regarding sustainability frameworks than

[6] Clean Air Act of 1970, 84 Stat. 1676, Public Law 91-604, 91st Cong., December 31, 1970.

[7] Federal Water Pollution Control Act Amendments of 1972 (Clean Water Act), 83 Stat. 852, Public Law 92-500, 92nd Cong., October 18, 1972.

the United States is producing. Thus, adopting a sustainability paradigm will require far more global cooperation with international partners.

Goldstein proposed that implementing a sustainability framework within the EPA would be a two-step process. He stated that the *Sustainability and the U.S. EPA* report (NRC, 2011) focuses on defining the framework, and this framework will then be scaled up under the broader NRC study that began in September 2011: *Sustainability Linkages in the Federal Government*. This stage-two report will focus on the details for how the framework may best be implemented.

Similar to the adaptation of the risk assessment paradigm, measuring the efficacy of implementing the sustainability paradigm is critical, stated Goldstein. The 2011 report contains the framework for approaching sustainability, but the tools that need to be developed have to comply with the legal framework for the EPA as determined by Congress. He noted that these tools will need to be progressively realized and developed, including trade-off, economic environmental justice, and life-cycle analyses. He added that risk assessment and risk management are seen as continuing and as fitting well under the sustainability framework. The shift to sustainability aims to empower the EPA to go beyond decreasing the risk level by considering the social and economic inputs. Goldstein emphasized that the goal is to maximize benefits while reducing risk, and implementing the framework will require additional expertise and multisectoral collaboration.

## DISCUSSION

A discussion followed the presentations from Jackson and Goldstein and the remarks are summarized in this section. John Balbus commented on the compelling way Jackson framed the obesity epidemic in the United States, and asked the presenter to describe the nature of the evidence that supports interventions in the built environment to address obesity. As an example, Jackson stated, of the additional 25 pounds on the average adult body, approximately 5 to 6 of those pounds seem to be well-linked to non-walkable environments. A second major contributor to this weight gain is the availability of food in our communities, where high-calorie and high-fat options are more accessible and less costly than healthier food options. Similar to evidence that supports tobacco

interventions, noted Jackson, tax policies for sugar-sweetened beverages, environmental policies to create physical areas where people can exercise, and social policies to reframe the problem through advertising could all work to address obesity. William Sullivan highlighted a challenge in assessing the effectiveness of interventions within the built environment given the inability to randomly assign people to live in treatment or control conditions. Sullivan emphasized the need to carry out smart studies to raise the visibility of these interventions and produce results that can control for self-selection bias and other methodological limitations. Hernando Perez commented on the need to consider the social environment in addition to the built environment in these settings. Perez stated that even the ideal built environment would not be utilized by a community lacking social supports or public safety structures. Nsedu Witherspoon noted the importance of including mental health in discussions around communities and obesity as well. Looking at the health sustainability implications, Wilfried Kreisel stated that obesity could be addressed similarly to how we approach climate change and its impacts on health, given that both problems involve national, international, moral, and ethical constraints.

Jackson noted how the research around public health and urban planning is changing, with joint programs being initiated throughout the United States to develop integrated solutions that cross domains. Jackson emphasized the need to start talking more about this research and potential solutions. Jamie Bartram went back to the idea of study design and noted that in environmental health there is a very complex matrix to determine intervention impact, which is intrinsically linked to the randomized controlled trial (RCT) approach. However, he said, the RCTs are a small part of a large, complex question. Bartram suggested that it may be useful to guide how evidence from different disciplines and sectors can be joined to give a practical view to these complex questions and interventions (which may parallel the HIA way of thinking). Kirk Smith agreed with the need for more intervention research and noted that scalability should be included in the framework given that it can be difficult to effectively study an intervention that can be scaled up through existing societal mechanisms, such as legislation or taxes. Smith also noted that many people are interested in the dose response of interventions with regard to scalability, to assess the cost required to achieve an effect that makes sense on a larger scale.

Shifting to communications strategies, Paul Wilkinson noted the need to utilize positive messages when presenting information to promote a sustainability agenda since people in general respond better to positive ideas. Wilkinson stated that sustainable interventions are often things that can dramatically improve the quality of life for people, children, families, communities, and so forth, which should be emphasized rather than what you must not do or other negative framing techniques. Witherspoon noted the need to assist with and communicate on existing programs that may be addressing the complex problems around obesity, poverty, and crime in order to raise the visibility of positive outcomes. Ciro Sumaya then presented the idea of partnerships, and the benefit that could be realized by reaching out to champions in the field or stakeholder and advocate groups that could help make a movement around these particular sustainability and environmental health issues. Similar to what was mentioned above, Sumaya noted the importance of articulating the successes or resiliencies that may exist within communities that are already working on these issues and the need to make good use of these experiences through modeling or other interventional research activities. Goldstein stated that this type of research could be placed into the sustainability framework that he described earlier to assess the co-benefits that may result from various interventions. He pointed out that this framework could incorporate social, economic, and environmental benefits from an intervention which also decreases obesity within the United States. Goldstein concluded by noting that the major intervention put forward to address obesity will likely be medical if the quality of evidence to support environmental health interventions does not improve.

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# 7

# HEALTH MESSAGES AND STRATEGIES FOR DISSEMINATION

In the previous chapters, speakers identified the divides that exist between sustainability and environmental protection and health promotion in the United States and the larger international community, and presented potential solutions to bridging these gaps. This chapter focuses on discussing strategies for disseminating these solutions within the environmental health community, as well as broader groups. A summary of this discussion follows, which mainly emphasizes communication strategies for connecting with the general public in the United States.

Linda McCauley started this discussion by stating that individuals need to be challenged to think about how to take information and collectively help chart a course for environmental health. McCauley noted the need for the environmental health community to define the messages and identify the audience upfront—which may include U.S. government agencies or the global community—in order to have an impact with its communication strategy. She asked the workshop participants to share their thoughts on the communication messages that should be utilized to move forward the key environmental health and sustainability issues that were discussed during the workshop.

Martin Philbert noted that scientists often labor under the misconception that because they can define risks to the fifth or sixth decimal place, this information will influence the person making daily decisions in the supermarket. Philbert stated that the general public does not understand, for instance, the implications that purchasing high-thread-count Egyptian cotton sheets may have on a worker thousands of miles away. Philbert noted there is a disconnect between the scientist, who imagines a world in which sustainability prevails, and the general public, which needs to be convinced that sustainability is the next logical

step to a state of improved health for everyone. Philbert agreed with the need to identify who to convince, the steps needed, and the mechanisms available to achieve the goal.

Kirk Smith noted the need to focus on problems that actually cause substantial ill health and contribute to the global burden of disease estimates. He added that the public often reacts to stories of more severe chemicals or disease (such as childhood cancer), than to more common hazards that result in greater rates of morbidity and mortality (such as accidents). Lauren Zeise added that we often cannot identify the cumulative effects of low-level environmental exposures in the myriad of things we are exposed to in our daily lives. Zeise agreed with the need to look at the big contributors, but noted that she did not know the extent to which the attributable risk of these low-level chemical exposures can be assessed with the current methodology. Zeise noted that it would be useful to better understand the extent to which some of the underlying environmental chemicals and chemicals present in food and food processing contribute to death and disease.

Jamie Bartram noted the need to address both communication that is internal to the environmental health community, as well as communication that is external. With regard to internal communication, he said, two things that have come up in our discussions are the need to talk about (1) metrics and approaches to sustainability and environmental health, and (2) how we can bring the available evidence usefully together to further environmental health and sustainability initiatives. Bartram noted that with external communication, the messaging in many domains of science tends to focus on what does not work and uses that as a basis of how to proceed, rather than looking at what does work. Bartram explained that the communication strategy should be relevant to people in terms of enabling or empowering them to act in ways that they perceive to be relevant to their lives. This form of communication is much better than a very complex risk message, he said, which even if conveyed correctly is not something that can be translated into immediate practical action for people.

John Spengler stated that people in the Ministry of Environment in the Netherlands found that imagery was effective in getting the population to support their National Environmental Policy Plan. For instance, he said, the communication strategy included multiple images of what the Netherlands would look like from a population and environmental perspective 25 years into the future without the policy

plan, and the public did not want that image. Linking this to the work of the Institute of Medicine, he said, we have to do more to get our messages out to the public, which may include investing in short videos with experts providing effective sound bites and with imagery around the message. Spengler noted that this type of communication would be better than just releasing a hard copy report or summary that remains on the bookshelf in most cases. Additionally, Spengler said, we have to take our messages and disseminate them into PowerPoint slides and lecture materials, so the information is packaged for environmental health courses in graduate schools, undergraduate schools, and community colleges across the country.

Wilfried Kreisel introduced the topic of health literacy and noted that for a health message to be effective the audience needs to understand the health message, which often depends on where they are located on the social gradient in society. Kreisel stated that in the United States we would like to reach those at the lower end of the social gradient, but we have not been able to improve the health literacy among the poorer segments of society. He noted that our health messages tend to reach a few and not really those who are crucial to improve population health, which is important in the debate on health equity, health literacy, and health sustainability.

Nsedu Witherspoon pointed out that many groups in the United States are certainly working on targeted messages at the local level, including messages on air pollutants and pesticide exposure targeted at mothers and pregnant women. Witherspoon noted that we should appreciate that these localized efforts are under way and perhaps try to uplift these efforts or assist in discussing the action or implementation steps. Robert Goldsmith continued with this topic area and noted the need to find common ground, not just with groups with similar messaging but also with groups on the other side of some of these environmental health and sustainability issues, to build bridges and move things forward in a collaborative way.

Goldsmith stated that the best solutions to put forward may be innovations that have both a sustainability impact as well as a return on investment. He noted that efforts could focus on validating potential solutions to these high-level environmental health and sustainability issues, with the pros and cons adequately presented for policy makers to debate the merits. Over the course of the workshop, Goldsmith said, wonderful solutions were presented that could work on the global scale

or on the local scale, and it would be nice to see this group develop innovative messaging to introduce these issues to broader groups. Richard Jackson then noted that the good solutions tend to solve multiple problems or challenges, and this is a positive message that may resonate.

Luiz Galvão stated that with the green economy discussions taking place, there is a perfect opportunity to place environmental health at the center of the agenda. Additionally, Galvão said, there are grassroots efforts targeting noncommunicable diseases (NCDs) in developing countries that provide an opportunity to inform discussions with some of the information that was presented here. Galvão emphasized that he sees this as a great opportunity for how environmental health can become a perfect solution for a perfect storm. Galvão added that he is uncertain of the exact processes that should be employed, but noted that we should take advantage of the possibility to collaborate with other experts or advocacy groups who are present at large meetings focusing on the green economy or NCDs, in addition to finding ways to collaborate with outside groups leading up to and during the Rio+20 conference.

# A

# WORKSHOP AGENDA

## ENSURING AND STRENGTHENING PUBLIC HEALTH LINKAGES IN A SUSTAINABLE WORLD

**July 25–26, 2011**
**J. Erik Jonsson Conference Center**
**Woods Hole, MA**

### Monday, July 25, 2011

| | |
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| 8:00 a.m. | Working Breakfast |
| 8:30 a.m. | Opening Comments<br>*Lynn Goldman, M.D., M.P.H.,*<br>*Professor and Dean*<br>*School of Public Health and Health Services,*<br>*George Washington University* |
| 8:45 a.m. | Overview of Sustainability: Conceptual Issues, Frameworks, and Opportunities for Linkages with Health<br>*Paul Anastas, Ph.D.*<br>*Assistant Administrator for the Office of Research and Development and Science Advisor*<br>*U.S. Environmental Protection Agency* |
| 9:15 a.m. | Understanding the Global Commitment to Addressing Environmental and Health Issues<br>*David J. van Hoogstraten, Esq.*<br>*Director, Policy and Regulatory Affairs, BP Wind Energy, North America, Inc.* |
| 9:40 a.m. | Discussion |
| 10:10 a.m. | Break |

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| 10:25 a.m. | Current and Emerging Challenges and Opportunities for Environmental Health: Sustainability, Noncommunicable Diseases, and Opportunities for Linkages<br>*Linda Birnbaum, Ph.D., D.A.B.T., A.T.S.*<br>*Director*<br>*National Institute of Environmental Health Sciences*<br>*National Institutes of Health* |
| 10:50 a.m. | Discussion |
| 11:10 a.m. | Rio+20 and Health: The Roads Leading from the Original Rio Summit<br>*Wilfried Kreisel, Ph.D.*<br>*Consultant, Energy and Health*<br>*Former Executive Director, Health and Environment*<br>*World Health Organization (retired)* |
| 11:35 a.m. | Climate Change: The Need for Linkages for Sustainability and Health<br>*Carlos Corvalán, Ph.D.*<br>*Senior Advisor on Risk Assessment and Global Environmental Change*<br>*Pan American Health Organization* |
| 12:00 p.m. | Discussion<br>• What is a green economy?<br>• What is the role of health?<br>• What is a framework for health and sustainability? |
| 12:30 p.m. | Working Lunch |
| 1:15 p.m. | **Session 1: Energy – The Role of Public Health in Energy** |

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| 1:20 p.m. | Energy, Climate, and Human Health<br>*Daniel P. Schrag, Ph.D.*<br>*Director, Harvard University Center for the Environment*<br>*Sturgis Hooper Professor of Geology and Professor of Environmental Science and Engineering*<br>*Harvard University* |
| 1:45 p.m. | Energy and Health: Who is at Risk?<br>*Paul Wilkinson, F.R.C.P., M.P.H.*<br>*Professor in Environmental Epidemiology*<br>*Department of Social and Environmental Health Research*<br>*London School of Hygiene and Tropical Medicine* |
| 2:10 p.m. | Energy and Noncommunicable Diseases: Household Air Pollution<br>*Kirk Smith, M.P.H., Ph.D.*<br>*Professor of Global Environmental Health*<br>*School of Public Health*<br>*University of California, Berkeley* |
| 2:35 p.m. | Discussion |
| 3:10 p.m. | Break |
| 3:30 p.m. | **Session 2: The Impact of Sustainability on Food and Natural Resources for Health** |
| 3:35 p.m. | Food, Sustainability, and Health<br>*Molly Anderson, Ph.D.*<br>*Partridge Chair in Food and Sustainable Agriculture Systems,*<br>*College of the Atlantic* |

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| 4:00 p.m. | Natural Resources, Sustainability, and Health<br>*Jamie Bartram, Ph.D.*<br>*Don and Jennifer Holzworth Distinguished Professor and*<br>*Director of the Water Institute*<br>*Gillings School of Global Public Health*<br>*University of North Carolina at Chapel Hill* |
| 4:25 p.m. | Discussion |
| 4:50 p.m. | Discussion of Health Risks and Opportunities for Sustainability<br>*Facilitator: John Balbus, Roundtable Member* |
| 6:00 p.m. | Adjourn for day |

**Tuesday, July 26, 2011**

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| 8:00 a.m. | Working Breakfast |
| 8:30 a.m. | Welcome Back/Final Comments from Yesterday |
| 8:35 a.m. | **Session 3: Fetal Basis of Adult Disease, Exposures, Health, and Sustainability** |
| 8:35 a.m. | The Health Lens of Sustainability<br>*Richard J. Jackson, M.D., M.P.H.*<br>*Professor and Chair, Department of Environmental Health Sciences*<br>*School of Public Health*<br>*University of California, Los Angeles* |
| 9:05 a.m. | Sustainability and Exposure: Insights from the NRC Report<br>*Bernard D. Goldstein, M.D.*<br>*Professor Emeritus, Department of Environmental and Occupational Health*<br>*Graduate School of Public Health*<br>*University of Pittsburgh* |
| 9:20 a.m. | Discussion |

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| 10:15 a.m. | Early Childhood Exposure and Health Risks: Incorporating Sustainability<br>*Lauren Zeise, Ph.D.*<br>*Chief, Reproductive and Cancer Hazard Assessment Section*<br>*Office of Environmental Health Hazard Assessment*<br>*California Environmental Protection Agency* |
| 10:40 a.m. | Changing Exposure and Risk Profiles: Opportunities for Sustainability<br>*Richard Fenske, Ph.D., M.P.H.*<br>*Professor and Associate Chair of Environmental and Occupational Health Sciences*<br>*University of Washington* |
| 11:05 a.m. | Discussion |
| 11:50 a.m. | Working Lunch |
| 12:50 p.m. | Sustainability and Health: Impacts for Workers<br>*David Michaels, Ph.D.*<br>*Assistant Secretary of Labor*<br>*Occupational Safety and Health Administration*<br>*U.S. Department of Labor* |
| 1:05 p.m. | What are Health Messages and the Strategies for Dissemination?<br>*Facilitator: Linda McCauley, Roundtable Member* |
| 2:45 p.m. | Next Steps or Outlining a Framework<br>*Lynn Goldman, M.D., M.P.H.*<br>*Professor and Dean*<br>*School of Public Health and Health Services*<br>*George Washington University* |
| 3:15 p.m. | Adjourn |

# B

# SPEAKER BIOSKETCHES

**Paul Anastas, Ph.D.,** is the assistant administrator for the U.S. Environmental Protection Agency (EPA) Office of Research and Development (ORD) and the science advisor to the agency. Known widely as the "Father of Green Chemistry" for his groundbreaking research on the design, manufacture, and use of minimally toxic, environmentally friendly chemicals, Dr. Anastas has an extensive record of leadership in government, academia, and the private sector. At the time he was nominated by President Obama to lead ORD, Dr. Anastas was the director of the Center for Green Chemistry and Green Engineering, and the inaugural Teresa and H. John Heinz III Professor in the Practice of Chemistry for the Environment at Yale University's School of Forestry and Environmental Studies. Prior to joining the Yale faculty, Dr. Anastas was the founding director of the Green Chemistry Institute, headquartered at the American Chemical Society in Washington, DC. From 1999 to 2004, he worked at the White House Office of Science and Technology Policy, concluding his service there as the assistant director for the environment. Dr. Anastas began his career as a staff chemist at the EPA, where he rose to the positions of chief of the Industrial Chemistry Branch, and director of the U.S. Green Chemistry Program. It was during his work at the EPA that Dr. Anastas coined the term "green chemistry."

Trained as a synthetic organic chemist, Dr. Anastas has focused his research interests on the design of safer chemicals, bio-based polymers, and new methodologies of chemical synthesis that are more efficient and less hazardous to the environment. A leading writer on the subjects of sustainability, green chemistry, and green engineering, he has published ten books, including *Benign by Design*, *Designing Safer Polymers*, *Green Engineering*, and his seminal work with co-author John Warner, *Green Chemistry: Theory and Practice*.

**Molly Anderson, Ph.D.,** is the Partridge Chair in Food and Sustainable Agriculture Systems at the College of the Atlantic. She has focused her

career on food systems issues and is especially interested in effective multi-stakeholder collaborations for sustainability. Her professional writing and speaking is on food security, food politics, food rights, food sovereignty, and sustainability metrics. She was a coordinating lead author on the North America/Europe section of the International Assessment of Agricultural Knowledge, Science, and Technology for Development.

Most recently, Dr. Anderson has been consulting on science and policy for social justice, ecological integrity, and democratic food systems. Prior to that, she held two interim positions at Oxfam America (2002–2005) and a faculty position at Tufts University, where she taught, administered programs, built partnerships, and conducted research for 14 years. She co-founded and for 5 years directed the Agriculture, Food and Environment Graduate Degree Program in the School of Nutrition Science & Policy at Tufts. She also directed the Tufts Institute of the Environment for 2 years.

**Jamie Bartram, Ph.D.,** is a Don and Jennifer Holzworth Distinguished Professor in the Gillings School of Global Public Health of the University of North Carolina (UNC) at Chapel Hill and director of the Water Institute at UNC. Dr. Bartram has worked in diverse areas of public health and disease prevention, especially in relation to environment and health and water supply and sanitation. He has worked in more than 60 developing and developed countries worldwide. From 1998 to 2009, he worked at the World Health Organization's headquarters, leading the Water, Sanitation, Hygiene, and Health Unit and the Unit for Assessing and Managing Environmental Risks to Health.

Dr. Bartram was awarded the IWA (International Water Association) Grand Award in 2004 for international leadership in development and application of evidence-based policy and good practice; he is an honorary professor at the University of Wales at Aberystwyth and a visiting professor at the Universities of Bristol and Surrey, UK. He was the first elected chair of UN-Water. He was previously manager, Water and Wastes, at the WHO European Centre for Environment and Health in Rome and head of the Environmental Health Division of the Robens Institute of the University of Surrey in the United Kingdom.

**Linda S. Birnbaum, Ph.D., D.A.B.T., A.T.S.,** is the director of the National Institute of Environmental Health Sciences (NIEHS) and National Toxicology Program (NTP). She oversees a $730-million

budget that funds multidisciplinary biomedical research programs, prevention, and intervention efforts that encompass training, education, technology transfer, and community outreach. NIEHS is located in the Research Triangle Park, near Durham, Raleigh, and Chapel Hill, North Carolina.

Dr. Birnbaum received her Ph.D. in microbiology from the University of Illinois, Urbana, and has held several different positions with NIEHS and EPA. She is a diplomat of the American Board of Toxicology and a fellow of the Academy of Toxicological Sciences. Dr. Birnbaum is the author of more than 650 peer-reviewed publications, book chapters, abstracts, and reports. She is an adjunct professor at the University of North Carolina, Chapel Hill, and at Duke University. Dr. Birnbaum is the former vice president of the American Aging Association, the former chairperson of the Division of Toxicology of the American Society of Pharmacology and Experimental Therapeutics, and the former president of the Society of Toxicology.

She has received numerous awards, including the Conservation Award from the National Wildlife Fund, the Ambassador Award from the Mid-Atlantic Chapter of the Society of Toxicology, the EPA's Health Science Achievement Award and the Diversity Leadership Award, and numerous EPA Science and Technological Achievement Awards.

**Carlos Corvalán, Ph.D.,** is a senior advisor on Risk Assessment and Global Environmental Change at the Pan American Health Organization (PAHO), based in Washington, DC. He joined the World Health Organization (WHO) in 1993 and PAHO in 2008. He is editor and author of the WHO book *Decision-Making in Environmental Health: From Evidence to Action*, the WHO report *Climate Change and Human Health: Risks and Responses*, and the WHO report *Ecosystems and Human Well-Being: Health Synthesis*, which was WHO's contribution to the Millennium Ecosystem Assessment. He also coauthored WHO's report on preventing diseases through healthy environments. For many years he has been giving workshops to representatives from ministries of health and other government officials and experts to promote awareness and action related to protecting health from climate and other environmental changes. Corvalán has a master of public health degree from Sydney University, Australia, and a Ph.D. in environmental health from Nijmegen University, the Netherlands.

**Richard A. Fenske, Ph.D., M.P.H.,** is professor and associate chair of environmental and occupational health sciences at the University of

Washington (UW), and has served as director of the NIOSH-supported Pacific Northwest Agricultural Safety and Health Center since 1996. He is a core faculty member of the NIEHS-supported Center for Ecogenetics and Environmental Health. He also served as deputy director of the EPA/NIEHS-supported UW Center for Child Environmental Health Risks Research from 1996 to 2003, and director of the UW Field Research and Consultation Group from 1992 to 1996.

Dr. Fenske has focused his research on the assessment and mitigation of chemical hazards through workplace and community studies. He has introduced novel procedures for the assessment of skin exposure among agricultural workers through the use of fluorescent tracers. He has also contributed to the elucidation of pesticide exposure pathways for children living in agricultural communities and in residential settings. His current research includes studies of pesticide handler exposures, advanced biomonitering techniques, pesticide spray drift, and paraoccupational exposures of children in rural communities. He currently receives research support from the NIOSH Agricultural Centers Program, the EPA/NIEHS Children's Environmental Health Centers Program, and the EPA STAR grant program.

From 1984 to 1990 Dr. Fenske was assistant professor and then associate professor of environmental sciences at Rutgers University and the New Jersey Agricultural Experiment Station. He received his doctoral degree and M.P.H. from the University of California, Berkeley in environmental health sciences. He was also awarded a master's degree in geography from the University of California, Berkeley and a master's degree in comparative religion from Columbia University in New York. His bachelor's degree is in history from Stanford University.

**Lynn R. Goldman, M.D., M.P.H.,** a pediatrician and an epidemiologist, is dean of and professor at the School of Public Health and Health Services at George Washington University (GWU). Prior to her move to GWU, Dr. Goldman was a professor of environmental health sciences at the Johns Hopkins University Bloomberg School of Public Health. Her areas of focus are children's environmental health research, public health preparedness, and environmental health policy. She had joint appointments in the Departments of Health Policy and Management and Epidemiology and in Emergency Medicine at the Johns Hopkins School of Medicine.

From 1993 to 1998, Dr. Goldman served as assistant administrator for the EPA's Office of Prevention, Pesticides and Toxic Substances. In

that position she was responsible for the nation's pesticide, toxic substances, and pollution prevention laws. In this job she was responsible for managing a number of complex regulatory and science issues. Her achievements included expanding the Toxics Release Inventory, reauthorizing the nation's pesticides laws (Food Quality Protection Act of 1996); and development of a framework for the regulation of biotechnology chemical and pesticide products. She led consensual processes that developed frameworks for testing of high-volume industrial chemicals and for identification of chemicals that disrupt endocrine systems.

Dr. Goldman has a B.S. from the University of California, Berkeley; an M.P.H. from the Johns Hopkins University School of Public Health; an M.D. from the University of California, San Francisco; and pediatric training at Children's Hospital, Oakland, California. She has served on numerous boards and expert committees, including the Committee on Environmental Health of the American Academy of Pediatrics and the Centers for Disease Control Lead Poisoning Prevention Advisory Committee. Dr. Goldman is a member of the Institute of Medicine and vice chair of the Institute of Medicine Roundtable on Environmental Health Sciences, Research, and Medicine.

**Bernard D. Goldstein, M.D.,** is professor emeritus in the Department of Environmental and Occupational Health at the University of Pittsburgh's Graduate School of Public Health and a former dean of the graduate school. He served as the director of the Environmental and Occupational Health Sciences Institute, a joint program of Rutgers, The State University of New Jersey, and the University of Medicine and Dentistry of New Jersey (UMDNJ)–Robert Wood Johnson Medical School from 1986 to 2001. He was the chair of the Department of Environmental and Community Medicine, UMDNJ–Robert Wood Johnson Medical School from 1980 to 2001. He was the first principal investigator of the Consortium of Risk Evaluation with Stakeholder Participation. Dr. Goldstein served as acting dean of the UMDNJ–School of Public Health from 1998 to 1999, the first year of its formation. Dr. Goldstein earned his B.S. degree at the University of Wisconsin in 1958 and his M.D. at New York University School of Medicine in 1962. He is a physician, board certified in internal medicine and hematology as well as toxicology.

Dr. Goldstein was assistant administrator for research and development at the EPA from 1983 to 1985. His past activities include

serving as member and chairman of the NIH Toxicology Study Section and the EPA's Clean Air Scientific Advisory Committee; chair of the Institute of Medicine (IOM) Committee on the Role of the Physician in Occupational and Environmental Medicine; chair of the National Research Council Committees on Biomarkers in Environmental Health Research and Risk Assessment Methodology; and chair of the Industry Panel of the World Health Organization Commission on Health and Environment. He is a member of the IOM where he has co-chaired the member section on Public Health, Biostatistics, and Epidemiology and he has been a member of the IOM Committee on Environmental Justice: Research, Education, and Health Policy Needs. Dr. Goldstein is also president-elect for the Society for Risk Analysis, vice president of the Scientific Committee on Problems of the Environment, and a member of the National Advisory Environmental Health Sciences Council. He is the author of more than 200 articles and book chapters related to environmental health sciences and to public policy.

**Richard J. Jackson, M.D., M.P.H.,** is professor and chair of the Department of Environmental Health Sciences in the School of Public Health at the University of California, Los Angeles. A pediatrician and public health leader, he recently served as a professor at the University of Michigan, Ann Arbor, and at the University of California, Berkeley. He served in many leadership positions with the California Health Department, including the highest, state health officer. For 9 years he was Director of the Centers for Disease Control and Prevention's (CDC's) National Center for Environmental Health in Atlanta. In 2005 he was recognized with the highest civilian award for U.S. government service, the Presidential Distinguished Executive Award.

While in California his work led to the establishment of the California Birth Defects Monitoring Program and state and national laws that reduced risks, especially to farm workers and to children, from dangerous pesticides. While at CDC he established the national asthma epidemiology and control program, and advanced the childhood lead poisoning prevention program. He instituted the current federal effort to "biomonitor" chemical levels in the U.S. population. He was the U.S. lead under several U.S. government efforts around health and environment in Russia, including radiation threats. In the late 1990s he was the CDC leader in establishing the U.S. National Pharmaceutical Stockpile to prepare for terrorism and other disasters—which was activated on September 11, 2001. In 2006 he received the Breast Cancer

Fund's Hero Award, and at the University of California, Berkeley, 2007 commencement, the School of Public Health graduate students recognized him as the Distinguished Teacher and Mentor of the Year. Dr. Jackson coauthored *Urban Sprawl and Public Health*, a 2004 book from Island Press. He has served on many environmental and health boards, as well as the board of directors of the American Institute of Architects.

**Wilfried Kreisel, Ph.D.,** holds a doctorate degree in physical chemistry from the University of Heidelberg, Germany. Before joining WHO in 1977, he was a research fellow at the University of Dortmund, Germany (1974–1977) where he conducted interdisciplinary research on the effects of environmental determinants on health. As WHO adviser for environmental health, Dr. Kreisel spent 8 years in the Republic of Korea and Malaysia (1977–1985) and 1 year as regional adviser in the Western Pacific Regional Office in Manila, Philippines (1985–1986). In 1986 he was reassigned to WHO Headquarters in Geneva as director, Division of Environmental Health (1986–1993). Subsequently, he was appointed executive director, Health and Environment (1993–1998). In this capacity, Dr. Kreisel was responsible for planning, developing and implementing global policies and programs in public health with a focus on environmental health.

Among important functions, Dr. Kreisel was WHO's officer-in-charge of the preparatory process and follow-up to the Rio Summit in 1992, and was the chairman of various interagency programs and committees, and international conferences on public health and environment issues. From 1998 to 2002, he served as executive director at the WHO Office at the European Union (EU) in Brussels, Belgium, to build up and reinforce WHO's relations with EU institutions and other organizations such as the OECD (Paris) and the Council of Europe (Strasbourg). In 2004–2005 he was Director of the WHO Centre for Health Development in Kobe, Japan, where he, among others, developed a research framework for the center's future work focusing on selected social and environmental determinants of health in urban areas. He is currently a freelance consultant and specializes in policies and programmatic issues related to health and environment, with emphasis on energy and health and climate change and health.

**David M. Michaels, Ph.D., M.P.H.,** is an epidemiologist and a nationally recognized leader in the scientific community's efforts to protect the integrity of the science on which public health and regulatory

policies are based. Before joining the Occupational Safety and Health Administration (OSHA) within the U.S. Department of Labor, he was professor of environmental and occupational health at the George Washington University School of Public Health.

From 1998 to 2001, Dr. Michaels served as assistant secretary of energy for environment, safety, and health. In that position, he was the chief architect of the Energy Employees Occupational Illness Compensation Program, the historic initiative to compensate nuclear weapons workers who contracted occupational illnesses as a result of exposure to radiation, beryllium, and other hazards. The program has provided more than $6 billion in payments to sick workers and the families of deceased workers. In 2006 Dr. Michaels was awarded the American Association for the Advancement of Science's Scientific Freedom and Responsibility Award, and, in 2009, the John P. McGovern Science and Society Award given by Sigma Xi, the Scientific Research Society, for his work in scientific integrity and for gaining compensation for nuclear weapons workers.

Dr. Michaels is the author of studies examining the health of construction workers, printers, bus drivers and other occupations, as well as of numerous publications on science and regulatory policy, including *Doubt Is Their Product: How Industry's Assault on Science Threatens Your Health* (Oxford University Press, 2008). He is a graduate of the City College of New York, and holds M.P.H. and Ph.D. degrees from Columbia University.

**Daniel P. Schrag, Ph.D.,** is the director of the Harvard University Center for the Environment, the Sturgis Hooper Professor of Geology, and professor of environmental science and engineering at Harvard University. Dr. Schrag studies climate and climate change over the broadest range of Earth's history. He has examined changes in ocean circulation over the last several decades, with particular attention to El Niño and the tropical Pacific; he investigates Pleistocene ice-age cycles over the past million years; he studies the warm climates of the Eocene, 50 million years ago; and, with colleagues from Harvard, he helped to develop the Snowball Earth hypothesis that explains extreme glacial events that occurred more than 600 million years ago. Currently he is working on the early history of Mars and Earth, trying to understand the environmental conditions around the time of the origin of life. He is also working on new technological approaches to mitigating future climate change, including advanced energy technologies for low-carbon

transportation fuel and carbon sequestration. Dr. Schrag received a B.S. from Yale and a Ph.D. in geology from the University of California, Berkeley. He taught at Princeton before moving to Harvard in 1997. Among various honors, he was named a MacArthur Fellow in 2000. He currently serves on President Obama's Council of Advisors for Science and Technology.

**Kirk R. Smith, Ph.D.,** is professor of global environmental health and is also founder and coordinator of the campus-wide Masters Program in Global Health and Environment. In addition to his work at the University of California, Berkeley, Dr. Smith is the chair of the National Research Council Committee on Environmental Exposure Science for the 21st Century and lead author in the health chapter of the Intergovernmental Panel on Climate Change's (IPCC's) Fifth Assessment. Previously, he was founder and head of the Energy Program of the East-West Center in Honolulu, where he still holds appointment as adjunct senior fellow in environment and health after moving to Berkeley in 1995. He serves on a number of national and international scientific advisory committees, including the Global Energy Assessment, the National Research Council's Board on Atmospheric Science and Climate, the Executive Committee for WHO Air Quality Guidelines, and the International Comparative Risk Assessment. He participated along with many other scientists in the IPCC's third and fourth assessments and thus shared the 2007 Nobel Peace Prize. He holds visiting professorships in India and China and bachelor's, master's, and doctoral degrees from the University of California, Berkeley. In 1997 he was elected a member into the National Academy of Sciences, one of the highest honors awarded to scientists by their peers. In 2009 he received the Heinz Prize in Environment.

Dr. Smith's research focuses on environmental and health issues in developing countries, particularly those related to health-damaging and climate-changing air pollution from household energy use, and includes field measurement and health-effects studies in India, China, Nepal, Mexico, and Guatemala as well as development and application of tools for international policy assessments. He also develops and deploys small, smart, and cheap microchip-based monitors for use in these settings.

**David J. van Hoogstraten, Esq.,** is the director of policy and regulatory affairs for BP Wind Energy, North America, Inc. Mr. van Hoogstraten has also served as counsel in Hunton & Williams' International Environmental Practice, and has served for the past 15 years as a senior

U.S. government lawyer and policy maker at the State Department, White House Council on Environmental Quality, and the EPA, where he has worked on a wide range of international environmental issues that significantly affect U.S. businesses. These include the relationship between global environmental health and safety agreements and other arrangements, and international trade laws.

His international environmental law practice focuses on the impact on businesses of global and regional environmental, health, and safety legal and regulatory regimes dealing with industrial chemicals and pesticides, climate change, ozone depletion, the transboundary movement of hazardous chemicals, electronic and other wastes, nanotechnology, biotechnology and biosafety, and other biodiversity challenges. It further concentrates on how regulatory restrictions in overseas markets impact clients' ability to compete effectively in a global economy. Mr. van Hoogstraten is proficient in the provisions and implementation of the major global environmental agreements and with conflicts between international trade law and environmental, health, and safety laws.

**Paul Wilkinson, F.R.C.P., M.P.H.,** studied medicine at Oxford University and then spent several years in hospital medicine in London before taking up an epidemiological research post at the UK National Heart & Lung Institute. From there he moved to the London School of Hygiene and Tropical Medicine (LSHTM) in 1994, where he first began research into the links between the environment and health, initially studying hazards arising from localized chemical contamination of the environment—pollution of the air and from industrial emissions. Such hazards have been the focus of much international research effort in recent years reflecting the problems associated with industrialization and urban living in both the developed and the developing world.

More recently, Dr. Wilkinson has been part of a research team that has begun to focus on the health impacts of global environmental change. There is now increasing recognition of the growing threats to human health from large-scale environmental changes—threats arising from our profligate consumption of the Earth's resources and from pollution of the environment on a global scale. One of those threats is climate change and its potential impacts on health. Dr. Wilkinson's research in this field was developed initially through a cooperative research group on climate change, ozone depletion, and health sponsored by the Medical Research Council and the Natural Environment Research Council, a collaboration

between the London School and the Tyndall Centre for Climate Change Research at the University of East Anglia. He is codirector at LSHTM of the WHO Collaborating Centre on Global Change and Health. In 2009 he was a key member of the Task Force on Climate Change Mitigation and Public Health. He currently leads a major European Commission–funded project on the public health impacts in urban environments of greenhouse gas emissions reduction strategies in Europe and Asia.

**Lauren Zeise, Ph.D.,** is chief of the Reproductive and Cancer Hazard Assessment Section in the Office of Environmental Health Hazard Assessment at the California Environmental Protection Agency. She oversees a variety of risk assessment and public health activities, including development of approaches for assessing cumulative impacts, green chemistry and safer alternatives, susceptible populations, cancer and reproductive toxicants, and health risks for environmental media, food, and consumer products. Her group also conducts the department's biomonitoring activities and the science for California's Proposition 65 statute. Dr. Zeise has served on numerous advisory boards and committees addressing issues of risk, chemicals policy, and public policy. This includes boards and committees of the EPA, WHO, NIEHS, and the National Academy of Sciences' Institute of Medicine and National Research Council. Recent National Academy of Sciences reports she coauthored include *Toxicity Testing in the 21st Century: A Vision and a Strategy* (2009) and *Science and Decisions: Advancing Risk Assessment* (2007). She is a member, fellow, and past councilor of the Society of Risk Analysis and received the society's Outstanding Risk Practitioner Award in 2008. Dr. Zeise received her Ph.D. from Harvard University.