Environmental Protection, Public Health and Human Rights
An Integrated Assessment

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Executive Summary

1. Introduction

Until very recently, environmental protection, public health and human rights were viewed as distinct areas of public policy by governmental institutions and non-governmental organizations alike at both the national and international levels. With increasing globalization of trade and commerce in the past few decades, the environmental and public health impacts of rapid industrialization and urbanization in different regions of the world are now being recognized as having major human rights implications by many policy makers.

Human rights in the context of environment and sustainable development recognize that for human communities to survive, they must have an adequate and secure standard of living; they must be protected from harmful substances and unsafe products; they must learn to conserve and equitably share natural resources. Without these environmental and public health policies in place, human rights for respect, dignity, equality, non-discrimination and the ability for the public to participate in decisions that affect their lives cannot be achieved.

This report evaluates the human rights dimensions of significant environmental and public health issues by:

(1) showing linkages between environment, health and human rights within the context of sustainable development;
(2) outlining and assessing environmental and public health problems in various regions of the globe;
(3) examining relevant scientific and technical documents, regulatory standards/ guidelines, and international treaties and conventions.

2. Environment, Sustainable Development and Human Rights

(a) *Brundtland Commission Report*

- As a matter of fundamental human right, the importance of environmental protection and public health in the context of sustainable development was first clearly enunciated in the 1987 Brundtland Commission Report ("Our Common Future"). It defined the concept of sustainable development as follows: "Humanity has the ability to make development sustainable -- to ensure that it meets the needs of the present without compromising the ability of future generations to meet their own needs."

- The Brundtland Commission also included a set of General Principles, Rights and Responsibilities for achieving environmental protection and sustainable development. Its broad first principle of human rights was presented as follows: "All human beings have the fundamental right to an environment adequate for their health and well-being."

(b) *Agenda 21, Rio Declaration and the World Summit on Sustainable Development*

Since the initial publication of the Brundtland Commission Report, global population has increased from 5.0 billion in 1987 to over 6.2 billion in mid-2002, with current estimates of 9 billion people living on earth in 2050. This unprecedented population growth has placed an immense strain on human communities and natural ecosystems around the world. This is especially true in developing countries, where many of its inhabitants continue to reside in abject poverty, where they lack life's basic needs and amenities, such as

adequate shelter and food, clean drinking water, unpolluted air, proper sanitation facilities or access to primary health care.

- At the *United Nations Conference on Environment and Development* (UNCED, also known as the "Earth Summit") held in Rio de Janeiro in June 1992, some 178 countries adopted *Agenda 21*, the centerpiece report of UNCED, which enunciated a detailed road map for achieving a more ecologically sound and economically sustainable future. In its preamble, *Agenda 21* stated that "integration of environment and development concerns and greater attention to them will lead to the fulfillment of basic needs, improved living standards for all, better protected and managed ecosystems and a safer, more prosperous future. No nation can achieve this on its own, but together we can -- in a global partnership for sustainable development."

- In the *Rio Declaration on Environment and Development*, which was also adopted at the 1992 UNCED meeting, representatives from developed and developing countries recognized the right to a clean and healthy environment as an overarching human entitlement: "Principle 1: Human beings are at the centre of concerns for sustainable development. They are entitled to a healthy and productive life in harmony with nature."

- In addition, the *Rio Declaration* explicitly affirmed the rights of indigenous communities in managing their environment in order to preserve their "identity, culture and interests and their effective participation in the achievement of sustainable development" (*Article 22*), and for the protection of the "environment and natural resources of people under oppression, domination and occupation" (*Article 23*).

- The *UN's World Summit on Sustainable Development (WSSD)* held in Johannesburg, South Africa in August-September, 2002, stated in its *Plan of Implementation* (in *Paragraph 5*) that "Peace, security, stability and respect for human rights and fundamental freedoms, including the right to development, as well as respect for cultural diversity, are essential for achieving sustainable development and ensuring that sustainable development benefits all."

(c) *Health and Human Rights: International Declarations, Conventions and Treaties*

A number of international declarations, conventions and treaties have been adopted that incorporate the principle of human rights to life and health. The following is a brief summary of the relevant provisions of these human rights instruments:

- The *Universal Declaration of Human Rights* adopted and proclaimed by the United Nations General Assembly in December 1948. In the Universal Declaration, the right to life is recognized in *Article 3* and the right to health in *Article 25.*

- The *International Covenant on Civil and Political Rights,* adopted in December 1966 (and entered into force in March 1976) protects the right to life in *Article 6(1)*, which is stated as follows: "Every human being has the inherent right to life. The right shall be protected by law. No one shall be arbitrarily deprived of his life."

- The *International Covenant on Economic, Social and Cultural Rights* adopted by the United Nations General Assembly in December 1966 (and entered into force in January 1976), affirms the right to

health in *Article 12*. (1), where " States Parties to the present Covenant recognize the right to the enjoyment of the highest attainable standard of physical and mental health."

- The *World Health Organization's (WHO) Constitution's Preamble* (adopted in 1945 and ratified in April 1948) defines the right to health, and the responsibility of individuals, institutions and governments, which states in part: 'The enjoyment of the highest attainable standard of health is one of the fundamental rights of every human being without distinction of race, political belief, economic or social condition."

- The *International Labor Organization's (ILO) Annex to its Constitution*, "Declaration Concerning the Aims and Purposes of the ILO" (adopted by the General Conference of ILO in May 1944) states in *Section III* , that all nations must achieve: " . . . (g) adequate protection for the life and health of workers in all occupations; (h) provision for child welfare and maternity protection; (i) the provision of adequate nutrition, housing and facilities for recreation and culture."

- The *Convention on the Rights of the Child*, adopted by the United Nations General Assembly in November 1989, states the child's right to health in Article 24, which in part, reads as follow: "States Parties recognize the right of the child of the highest attainable standard of health and to facilities for the treatment of illness and rehabilitation of health. States Parties shall strive to ensure that no child is deprived of his or her right of access to such health care services."

- Other international conventions that explicitly provide right to health include: (a) *International Convention on the Elimination of All Forms of Racial Discrimination,* (b) *Convention on the Elimination of All Forms of Discrimination Against Women,* (c) *Convention Concerning Indigenous and Tribal Peoples in Independent Countries,* and (d) *International Convention on the Protection of the Rights of All Migrant Workers and Members of Their Families*

3. Impact of Environment on Human Health

(a) *Water Resources and Sanitation*

- The lack of clean water resources and sanitation facilities looms as one of the most serious environmental health problems faced today by a large fraction of the world's population, especially those living in developing regions. Around the world, water supply and sanitation facilities are rapidly deteriorating and are operating at a fraction of their installed capacities. This situation is particularly serious in many developing countries of Asia, Africa, and Latin America where the poor have very limited access to clean water supplies and sanitation facilities.

- The World Health Organization (WHO) has estimated that 1.1 billion people do not have access to drinking water resources, and 2.4 billion people have inadequate sanitation facilities, which accounts for many water-related acute and chronic diseases. Some 3.4 million people, many of them young children, die each year from preventable water-borne infectious diseases, such as intestinal diarrhea (cholera, typhoid fever and dysentery), caused by microbially contaminated water supplies that are linked to deficient or non-existent sanitation and sewage disposal facilities.

- Many freshwater streams, lakes and groundwater aquifers around the world are increasingly becoming contaminated with industrial discharges and agricultural runoffs that carry high concentration levels of toxic chemical substances and hazardous wastes. The presence of these chemical substances in surface

and ground water resources is linked to many acute and chronic illnesses, ranging from severe skin and liver disorders to developmental abnormalities, neurological diseases and human cancer.

(b) ***Air Quality and Human Health***

- Air pollution continues to be a major environmental problem in many regions of the world today. In the past two to three decades, increased urbanization and industrialization in developing countries has resulted in a steady decline of air quality that poses a significant threat to health for large segments of human populations. Annually, air pollution accounts for an estimated 3 million deaths, which is about 5% of the 55 million deaths that occur worldwide each year.

- The World Health Organization (WHO) estimates that as many as 1.4 billion urban residents globally are exposed to outdoor polluted air that exceeds WHO air quality guidelines for pollutants such as sulfur dioxide, nitrogen dioxide and particulate matter. In addition, in many heavily populated regions, such as China and India, indoor air pollution (from smoky stoves in poorly ventilated homes) poses an even greater threat to human health, especially for women and children. At present, it is estimated that some 3.5 billion rural residents globally are exposed to high levels of indoor air pollutants, which have been designated by the World Bank as one of the four most critical environmental health problems worldwide.

- In the past several decades, air quality has generally improved in many developed countries in North America and Europe. However, in the United States, air pollution caused principally by gaseous and particulate emissions from a variety of fossil fuel burning sources, continues to account for approximately 60,000 deaths each year. Among the major sources of high levels of airborne fine particulates (less than 2.5 micrometers in diameter) in developed countries are electric power generating plants, metal refining processes and diesel-engine motor vehicles.

(c) ***Toxic Substances, Pesticides and Hazardous Wastes***

- Globally, over 50,000 chemical substances are produced, transported and consumed today, with several thousand new chemicals entering the marketplace each year. A vast majority of compounds have not been adequately tested for their harmful effects on human population. A large number of synthetic pesticides are used in agricultural production and for household purposes. These include insecticides, herbicides and fungicides employed to eradicate harmful insects, weeds, fungi and other microbial agents. By their very intrinsic nature of being chemically toxic to animal and plant species, these pesticide products pose significant health risks to a number of biological organisms, including human beings and domesticated animals.

- The disposal of solid and hazardous waste has also become a major problem in many developed and rapidly developing regions of the world. In a number of regions today, municipal landfills and waste incinerators are almost full and cannot continue to receive any additional supplies of discarded and unwanted materials. In many countries of the developed regions, including the United States and Canada, a large number of underground aquifers and drinking water wells have become seriously contaminated from leakage of hazardous wastes materials that were placed in unlined lagoons, industrial pits and unsecured, open landfills.

- Agricultural runoffs of chemical fertilizers and pesticides have polluted streams and lakes in rural and suburban regions of many developed countries, and this has created health risks to adults and children in these communities. However, contaminated underground water supplies have not as yet been

identified as a public health concern in most developing countries, and it may be several decades before contaminated aquifers may become a critical environmental problem in these regions. This issue will be especially serious in many rapidly developing countries in Asia, Africa and Latin America, because their present means of hazardous waste disposal utilizes the same practices that led to contamination of water supplies in developed countries.

(d) ***Climate Change and Human Health***

- A number of scientific measurements and technical assessment studies have shown how global climate change may have serious impacts on human population within this century. These climate-related effects include the rise of atmospheric concentrations of greenhouse gases, such as carbon dioxide and methane, and the potential global loss of earth's protective ozone layer.

- Many scientific studies indicate that increases of greenhouse gases in the atmosphere will lead to widespread global warming by the middle or latter part of the 21st century. This in turn will result in dramatic changes in local and regional weather patterns, leading to a number of significant environmental and public health impacts. These include increases in heat-related stress, movement of vector-borne diseases (such as malaria and dengue fever) to northern latitudes, higher production of certain allergens and air pollutants, interference with agricultural production, changes in forestry patterns, greater incidences of extreme weather events (such as storms, floods and drought), and uncontrollable sea-level rise in coastal areas.

- With global and regional losses of stratospheric ozone, an increase in ground-level exposure to harmful ultraviolet radiation would ensue, leading to increased incidence of skin cancer, cataracts and suppression of the body's immune system. More importantly, increased UV radiation may have unprecedented impacts on the yields of important agricultural crops, and on the oceanic phytoplankton population, whose loss would significantly decrease global fish and shellfish stocks, since phytoplankton species are at the base of all food chains in the marine and coastal environment.

(e) ***Biodiversity Loss and Ecosystem Disruption***

- While biological species extinction has occurred all through evolutionary history, leading ecologists believe that the rate of biodiversity loss has accelerated by factors of 100 to 1,000 times since human beings first evolved on earth some 120,000 years ago. They estimate that at present rates of biodiversity loss, more than 25% of all species on earth may become extinct within the next half-century. There are multiple causes for the loss of biodiversity: encroachment and destruction of forested areas, savanna grasslands, freshwater wetlands, marine resources and other natural ecosystems; high consumption rates of natural resources; introduction of alien invasive species; global climate change; air pollution and acid precipitation; and widespread use of toxic substances and pesticides.

- The most invidious and irreversible aspects of biodiversity loss result from the intentional and accidental introduction of alien invasive species that severely damage native organisms and local ecosystems of a geographic region. In economic terms, it is estimated that invasive species may account for tens of billions of dollars of loss annually. Alien plant species can drastically reduce crop yields, destroy water catchment areas and adversely impact local freshwater wetlands. New insect pests and pathogens, when accidentally introduced into regions with native plant and animal species, may lead to increased costs of agricultural and livestock production. Invasion of foreign plant pathogens, such as new microbial species may cause a variety of human illnesses in the community.

- Loss of biodiversity has both direct and indirect impacts on human health. The most direct impact is the disruption of natural ecosystems, whereby local and regional food webs are permanently destroyed, leading to decreased forest and agricultural productivity and decline of marine fisheries. Such shortfalls of traditional food resources in many regions of the world could lead to serious malnutrition, illnesses and death among human populations. Indirect impacts to human health occur through loss of many valuable biological organisms, including hitherto undiscovered sources of plant, animal and microbial species that have potentially therapeutic products and medicinal drugs.

- As the global population becomes increasingly urbanized, human beings have become less aware of the central role that natural ecosystems play in their daily lives. This is especially true of persons living in industrialized, developed regions of the world, where urban and town dwellers procure food, water, shelter, clothing, energy and other goods and services without much individual effort. The fact that almost all material and energy resources that human communities depend upon originate in the natural environment is often forgotten by many urban and suburban dwellers, whose daily existence is far removed from the network of ecosystems where food, water, energy and other resources are first obtained.

- In many areas of the world, human beings have drastically transformed the landscape of their natural environment by converting forests into croplands, open spaces into housing subdivisions, free-flowing rivers into water reservoirs, wetlands into industrial parks and shopping malls, and oceans into over-harvested, declining fisheries. While many social and economic benefits have occurred as a result of these human activities, the damaging costs to natural ecosystems have not been fully determined, nor has any detailed scientific assessment been made to study the capacity of seriously altered ecosystems to sustain human communities over the long term.

4. Environmental Protection and Public Health: Major International Treaties and Conventions

- During the past decade, the international community has adopted a series of agreements and conventions that provide regulatory procedures and guidelines to control the global export and shipment of toxic substances and hazardous wastes. In 1995, the *International Code of Conduct on the Distribution and Use of Pesticides* was adopted by the Food and Agriculture Organization (FAO), followed in 1987 by the enactment of the *London Guidelines for the Exchange of Information on Chemicals in International Trade* by the United Nations Environment Programme (UNEP).

- In 1989, an international agreement, known as *Prior Informed Consent (PIC)* (later extended by the Rotterdam Convention in 1998) was adopted to help control the importation of banned or severely restricted products into developing countries. Under PIC, officials in importing countries must be informed by the exporter about the toxicological characteristics and regulatory status of potentially hazardous chemicals before shipment of the product to their region.

- Discarded agricultural chemicals, unused toxic pesticides and hazardous wastes are generally recognized as requiring legal restrictions or regulatory oversight in their international shipments or transfers. Over one hundred countries have banned or severely restricted the import of hazardous materials. However, some developing countries, especially in Asia and Africa, have found an economic niche in importing hazardous wastes from developed nations. The *Basel Convention on the Control of Transboundary Movement of Hazardous Wastes and their Disposal* offers a system by which to regulate transport and disposal of such wastes, but also encourages waste minimization and the implementation of sound environmental management policy.

- A class of toxic chemicals, known as persistent organic pollutants (POPs), is made up of long-lasting, non-biodegradable organic compounds that bioconcentrate in the food chain, posing serious health risks to human populations. The international community recently signed a landmark agreement, the *Stockholm Convention on Persistent Organic Pollutants (POPs Treaty)*, which was adopted with considerable worldwide publicity in December 2000 in Johannesburg. Under the POPs Treaty, the following chemicals are to be globally phased out: polychlorinated biphenyls (PCBs), dioxins and furans, aldrin, dieldrin, DDT, endrin, chlordane, hexachlorobenzene, mirex, toxaphene and heptachlor.

- Global climate change exacerbated by anthropogenic activity may bring about severe weather events and drastic changes in land-use patterns in many regions of the world, leading to a number of significant environmental and public health impacts. The impact of global warming on human communities has several short-term and long-term local and regional environmental consequences. Based on these concerns, the international community drafted the *Kyoto Protocol to the United Nations Framework Convention on Climate Change* in 1998. The Kyoto Protocol calls on ratifying states to reduce atmospheric emissions of greenhouse gases linked to global warming through nationally-based emission-reductions program and the creation of international mechanisms for trading emission credits and for providing technical assistance to developing countries.

- In the mid-1980s, the growing worldwide consensus between research scientists and policy makers that earth's protective stratospheric ozone was being depleted led to the adoption of the landmark *Montreal Protocol on Substances that Deplete the Ozone Layer* in 1987, along with a number of modifying amendments in the 1990s. The Montreal Protocol has led to a worldwide phaseout of stratospheric ozone-depleting substances, including chlorofluorocarbons (CFCs) and other halocarbon compounds.

- Global concerns about the rapid rate of loss and extinction of biological species led to the adoption of the *Convention on International Trade in Endangered Species of Wild Fauna and Flora (CITES)* in March 1973. The international agreement required the listing of "all species threatened with extinction which are or may be affected by trade. Trade in specimens of these species must be subject to particularly strict regulation in order not to endanger further their survival and must only be authorized in exceptional circumstances."

- To preserve and equitably share the genetic resource base of earth's biological diversity, the international community signed the *Convention on Biodiversity* at the 1992 United Nations Conference on Environment and Development in Rio de Janeiro. This international agreement on biodiversity describes its main objectives as: ". . . the conservation of biological diversity, the sustainable use of its components and the fair and equitable sharing of the benefits arising out of the utilization of genetic resources, including by appropriate access to genetic resources and by appropriate transfer of relevant technologies . . ."

5. Concluding Remarks

- It should be apparent that environmental and human rights are inextricably linked -- to talk about the one implies the other. As we increasingly recognize the serious impact of a degraded environment on human health and well being, we are better placed to adjust our policies and cultural practices to reflect our enhanced understanding of the close linkages between environmental protection, public health and human rights. As a result, we should be able to protect human rights and human dignity within its broader social, economic and cultural context by drawing from and contributing to those who are actively engaged in the environmental and public health arenas.

- This new understanding should also allow individuals and organizations working in the environmental, conservation and public health fields to develop better working relationships with and to gain more knowledge of human rights institutions, approaches and instrumentalities. In doing so, we are able to articulate a more integrated approach to dealing with socio-economic and environmental problems that encourages the development of sustainable local communities and the emergence of institutional frameworks and governing structures dedicated to the preservation of biological resources and natural ecosystems.

I. Linkages Between Environment, Health and Human Rights

(A) Overview

Until very recently, environmental protection, public health and human rights were viewed as distinct areas of public policy by governmental institutions and non-governmental organizations alike at both the national and international levels. With increasing globalization of trade and commerce in the past few decades, the environmental and public health impacts of rapid industrialization and urbanization in different regions of the world are now being recognized as having major human rights implications by many policy makers. The concept of human rights entails human responsibilities, which includes leaving the earth a life-sustaining and healthy place for our children and grandchildren. While it may be possible to separate environmental protection, public health and human rights in the abstract, it is not possible to do so in real life. Human rights in the context of environment and sustainable development recognize that for human communities to survive, they must have an adequate and secure standard of living; they must be protected from harmful substances and unsafe products, and they must learn to conserve and equitably share natural resources. Without these environmental and public health policies in place, such basic human rights as respect, dignity, equality, non-discrimination and the public's ability to participate in decisions that affect their lives cannot be achieved.

Today, chronic water shortages and lack of sanitation facilities affect the lives and health of large numbers of people in developing regions, where millions of infants and young children die each year from preventable water-borne infectious diseases. In recent years, oil exploration, drilling and refining in developed and developing countries have threatened the health and well being of human communities, while the production and consumption of large varieties of toxic chemicals and disposal of hazardous wastes create long-term, unhealthy conditions for present and future populations. The destruction of natural resources such as tropical forests, freshwater wetlands, savanna grasslands and marine coastal areas has both immediate and long lasting consequences on local communities, with serious impacts on the livelihood and well being of their inhabitants. At a more global level, anthropogenic activities leading to stratospheric ozone loss and large-scale climate change from emission of greenhouse gases have major regional impacts that impede the right of human communities around the world to a clean, secure and healthy environment.

This report evaluates the human rights dimensions of critical and significant environmental and public health issues by:

> (1) showing linkages between environment, health and human rights within the context of sustainable development;
>
> (2) outlining and assessing environmental and public health problems in various regions of the globe;
>
> (3) examining relevant scientific and technical documents, regulatory standards/ guidelines, and international treaties and conventions.

In a report based on a recent meeting of experts (held in December 2001) jointly convened by the United Nations Commission on Human Rights, the UN High Commissioner for Human Rights (UNHCHR) and the United Nations Environment Programme (UNEP), it was stated that since the 1992 Earth Summit meeting in Rio de Janeiro, important developments have occurred at the national and international levels that "indicate a growing interconnectedness between the fields of human rights and environmental protection. The overall context for these developments is the concept of sustainable development, which requires that

different societal objectives be treated in an integrated manner." In addition, the experts noted in their review of actions of international treaty bodies in the past decade shows that:

> . . . a substantial body of case law and decisions has recognized the violation of fundamental human rights as the cause, or result, of environmental degradation. A significant number of decisions at the national and international levels have identified environmental harm to individuals or communities, especially indigenous people, arising as a result of violations of the rights to health, to life, to self-determination, to food and water, to housing.

(B) Environment, Sustainable Development and Human Rights

As a matter of fundamental human rights, the importance of environmental protection and public health in the context of sustainable development was first clearly enunciated in the 1987 Brundtland Commission Report (officially drafted by the World Commission on Environment and Development, which published its final report under the title, *Our Common Future*). It defined sustainable development in its Overview Chapter along the following lines:

> Humanity has the ability to make development sustainable -- to ensure that it meets the needs of the present without compromising the ability of future generations to meet their own needs. The concept of sustainable development does imply limits -- not absolute limits but limitations imposed by the present state of technology and social organization on environmental resources and by the ability of the biosphere to absorb the effects of human activities . . . The Commission believes that widespread poverty is no longer inevitable. Poverty is not only an evil in itself, but sustainable development requires meeting the basic needs of all and extending to all the opportunity to fulfill their aspirations for a better life.

In its proposed legal principles for environmental protection and sustainable development, the Brundtland Commission stated a set of General Principles, Rights and Responsibilities (Annex 1):

> 1. *Fundamental Human Right*: All human beings have the fundamental right to an environment adequate for their health and well-being.
> 2. *Inter-Generational Equity*: States shall conserve and use the environment and natural resources for the benefit of present and future generations.
> 3. *Conservation and Sustainable Use*: States shall maintain ecosystems and ecological processes essential for the functioning of the biosphere, shall preserve biological diversity, and shall observe the principle of optimum sustainable yield in the use of living natural resources and ecosystems.
> 4. *Environmental Standards and Monitoring*: States shall establish adequate environmental protection standards and monitor changes in and publish relevant data on environmental quality and resource use.
> 5. *Prior Environmental Assessments*: States shall make or require environmental assessments of proposed activities which may significantly affect the environment or use of a natural resource.
> 6. *Prior Notification, Access and Due Process*: States shall inform in a timely manner all persons likely to be significantly affected by a planned activity and to grant them equal access and due process in administrative and judicial proceedings.
> 7. *Sustainable Development and Assistance*: States shall ensure that conservation is treated as an integral part of the planning and implementation of development

activities and provide assistance to other States, especially to developing countries, in support of environmental protection and sustainable development.
8. *General Obligations to Co-operate*: States shall co-operate in good faith with other States in implementing the preceding rights and obligations.

Since the initial publication of the Brundtland Commission Report, the world has added another 1.2 billion people, growing from 5.0 billion in 1987 to more than 6.2 billion by mid-2002, with another estimated 3 billion to arrive between now and the middle of the 21st century. Inevitably, to sustain such an unprecedented population growth during this period, an immense strain has been placed on human communities and natural ecosystems around the world. This is especially true in developing countries, where many of the inhabitants continue to reside in abject poverty, where they lack life's basic needs and amenities, such as adequate shelter and food, clean drinking water, unpolluted air, proper sanitation facilities or access to primary health care. The right of humans to health as originally enunciated in Article 25 of the *Universal Declaration of Human Rights*, is quite clearly linked to environmental protection, where clean water, clean air, adequate shelter and food, and primary health care are no longer considered societal privileges but as universal human rights.

At the United Nations Conference on Environment and Development (UNCED, also known as the "Earth Summit") held in Rio de Janeiro in June 1992, some 178 countries adopted *Agenda 21*, the centerpiece report of UNCED that enunciated a detailed road map for achieving a more ecologically sound and economically sustainable future. In its preamble, *Agenda 21* stated that "integration of environment and development concerns and greater attention to them will lead to the fulfillment of basic needs, improved living standards for all, better protected and managed ecosystems and a safer, more prosperous future. No nation can achieve this on its own, but together we can -- in a global partnership for sustainable development." Chapter 6 of *Agenda 21* ("Protecting and Promoting Human Health") begins by stating: "Health and development are intimately interconnected. Both insufficient development leading to poverty and inappropriate development resulting in overconsumption, coupled with an expanding world population, can result in severe environmental health problems in both developing and developed nations."

In the *Rio Declaration on Environment and Development*, which was also adopted at the 1992 UNCED meeting, the Conference representatives from developed and developing countries, stated the right to a clean and healthy environment as an overarching human entitlement: "Principle 1 -- Human beings are at the centre of concerns for sustainable development. They are entitled to a healthy and productive life in harmony with nature." In addition, the Rio Declaration explicitly states the rights of indigenous communities in managing their environment in order to preserve their "identity, culture and interests and their effective participation in the achievement of sustainable development" (Article 22), and for the protection of the "environment and natural resources of people under oppression, domination and occupation" (Article 23).

While progress has been made in implementing some of the provisions of *Agenda 21* during the past decade, it appears that achieving many of the goals and objectives of the UNCED meeting have seriously lagged behind. In assessing how the world community has fulfilled promises made at UNCED, the United Nations Secretary-General, Kofi Annan, in a recent speech (May 14, 2002) presented the following rather discouraging appraisal:

> Ten years ago, the international community gathered for the Earth Summit in Rio de Janeiro. With the conceptual breakthrough of sustainable development, the Summit generated both heat and light. No longer, it was hoped, would environmental protection be regarded as a luxury or afterthought. Rather, environmental factors would be integrated with economic and social issues and become a central part of the

> policy-making process. Developed countries, which had benefited immensely from a wasteful and hazardous path of modernization, would help developing countries combat poverty and avoid the same polluting path. In adopting Agenda 21, a blueprint for sustainable development, rich and poor seemed to have agreed on common vision for growth, equity and conservation over the long-term.
>
> *But progress since then has been slower than anticipated.* The state of the world's environment is still fragile. Conservation measures are far from satisfactory. At discussions on global finance and the economy, the environment is still treated as an unwelcome guest. High-consumption life-styles continue to tax the earth's natural life-support systems. Research and development remains woefully under-funded, and neglects the problems of the poor. *Developed countries in particular have not gone far enough in fulfilling the promises they made in Rio -- either to protect their own environments or to help the developing world defeat poverty*. (emphasis added)

At the recently held United Nations *World Summit on Sustainable Development (WSSD)* Conference in Johannesburg, South Africa in August-September, 2002, the conferees at the meeting agreed to place human rights and ethical considerations within the purview of environmental protection and sustainable development in the *WSSD's Plan of Implementation*:

> *Paragraph 5*. Peace, security, stability and respect for human rights and fundamental freedoms, including the right to development, as well as respect for cultural diversity, are essential for achieving sustainable development and ensuring that sustainable development benefits all.
>
> *Paragraph 5(bis)* We acknowledge the importance of ethics for sustainable development, and therefore we emphasise the need to consider ethics in the implementation of Agenda 21 . . .
>
> *Paragraph 152.* Acknowledge the consideration being given to the possible relationship between environment and human rights, including the right to development, with full and transparent participation of Member States of the United Nations and observer States.

Finally, in a keynote address given by Mary Robinson, UN High Commissioner for Human Rights, at a workshop on human rights and the environment organized at the Civil Society Forum during the World Summit on Sustainable Development Conference on September 1, 2002, she stated the link between environment and human rights as follows:

> The interdependence of human rights, environmental protection and sustainable development has been described using the metaphor of a triangle. Although sustainable development is the overarching goal, it cannot be achieved without also respecting human rights and protecting the environment. Each side is linked to, and mutually supports the others. Without one, effective realization of the other two is not possible . . . Environmentalists must come to realize that the language and framework of human rights provides another tool in their struggle to protect the environment. At the same time, human rights advocates need to look to the significant role that environmental degradation – in all its forms – has on the enjoyment of individual rights not alone for those living today but for future generations.

(C) Health and Human Rights: International Declarations, Conventions and Treaties

A number of international declarations, conventions and treaties have been adopted that incorporate the human rights to life and health. The following is a brief summary of the relevant provisions of these human rights instruments:

(1) The *Universal Declaration of Human Rights*, adopted and proclaimed by the United Nations General Assembly in December 1948. Here the right to life (Article 3) and the right to health (Article 25) are enunciated as follows:

> *Article 3*. Everyone has the right to life, liberty and security of person.
>
> *Article 25.* (1) Everyone has the right to a standard of living adequate for the health and well-being of himself and of his family, including food, clothing, housing and medical care and necessary social services, and the right to security in the event of unemployment, sickness, disability, widowhood, old age or other lack of livelihood in circumstances beyond his control.
> (2) Motherhood and childhood are entitled to special care and assistance. All children, whether born in or out of wedlock, shall enjoy the same social protection.

(2) The *International Covenant on Civil and Political Rights*, adopted in December 1966 (and entered into force in March 1976) protects the right to life in Article 6(1), which is stated as follows: "Every human being has the inherent right to life. The right shall be protected by law. No one shall be arbitrarily deprived of his life." In addition, the right to life is also incorporated in several regional human rights documents of Americas, Europe and Africa, namely: (a) the *American Convention on Human Rights*, (b) the *European Convention for the Protection of Human Rights and Fundamental Freedoms* and (c) the *African Charter on Human and Peoples' Rights*.

(3) Among the most authoritative, comprehensive and legally binding articulations of a right to health (on States Parties that have ratified the agreement) is the *International Covenant on Economic, Social and Cultural Rights.* This convention, which was adopted by the United Nations General Assembly in December 1966 (and entered into force in January 1976), states the right to health as follows:

> *Article 12.* (1) The States Parties to the present Covenant *recognize the right to the enjoyment of the highest attainable standard of physical and mental health*.
> (2) The steps to be taken by the State Parties in the present Covenant to achieve the full realization of this right shall include those necessary for:
>
> (a) The provision for the reduction of the stillbirth-rate and of infant mortality and for the healthy development of the child;
> (b) The improvement of all aspects of environmental and industrial hygiene;
> (c) The prevention, treatment and control of epidemic, endemic, occupational and other diseases;
> (d) The creation of conditions which would assure to all medical service and medical attention in the event of sickness. (emphasis added)

In an important document that interprets the international agreement, the *General Comment* (No. 14, 2000) on Article 12(1) of the above Covenant ("The Right to the Highest Attainable Standard of Health"), the *United Nations Committee on Economic, Social and Cultural Rights* interpreted the *right to health* as "extending not only to timely and appropriate health care but also to the underlying determinants of health,

including access to safe and potable water and adequate sanitation, an adequate supply of safe food, nutrition and housing, healthy occupational and environmental conditions, and access to health-related education and information, including sexual and reproductive health." (Paragraph 11). Additionally, the Committee confirmed that State parties have *core obligations* to provide access to health services, essential drugs, minimum essential food, basic shelter, housing, sanitation and an adequate supply of safe and potable water (Paragraph 43 (a) – (e)). In Paragraph 43 (f), the Committee calls on:

> To adopt and implement a national public health strategy and plan of action, on the basis of epidemiological evidence, addressing the health concerns of the whole population; the strategy and plan of action shall be devised, and periodically reviewed, on the basis of a participatory and transparent process; they shall include methods, such as right to *health indicators and benchmarks*, by which progress can be closely monitored; the process by which the *strategy and plan of action* are devised, as well as their content, shall *give particular attention to all vulnerable or marginalized groups*. (emphasis added)

On November 26, 2002, the United Nations Committee on Economic, Social and Cultural Rights adopted a *General Comment* (No. 15, 2002) that delineated the *human right to water*, in accordance with Article 11 [the right to an adequate standard of living] and Article 12 [the right to the highest attainable standard of health] of the International Covenant on Economic, Social and Cultural Rights. According to *Part II* of the General Comment, which delineates the normative content of the right to water, in *Paragraphs 10* and *16*:

> 10. The right to water contains both freedom and entitlements. The freedoms include the right to maintain access to existing water supplies necessary for the right to water, and the right to freedom from interference, such as the right to be free from arbitrary disconnections or contamination of water supplies. By contrast, the entitlements include the right to a system of water supply and management that provides equality of opportunity for people to enjoy the right to water . . .
>
> 16. Whereas the right to water applies to everyone, States parties should give special attention to those individuals and groups who have traditionally faced difficulties in exercising this right, including women, children, minority groups, indigenous peoples, refugees, asylum seekers, internally displaced persons, migrant workers, prisoners and detainees . . .

(4) The preamble to the *World Health Organization's (WHO) Constitution* (adopted in 1945 and ratified in April 1948) states the definition and right to health, and the responsibility of individuals, institutions and governments in the following manner:

> -- Health is a state of complete physical, mental and social well-being and not merely the absence of disease or infirmity.
> -- The *enjoyment of the highest attainable standard of health is one of the fundamental rights of every human being* without distinction of race, political belief, economic or social condition.
> -- The health of all peoples is fundamental to the attainment of peace and security and is dependent upon the fullest co-operation of individuals and States.
> -- The achievement of any State in the promotion and protection of health is of value to all.
> -- Unequal development in different countries in the promotion of health and control of disease, especially communicable disease, is a common danger.

> -- *Healthy development of the child is of basic importance*; the ability to live harmoniously in a changing total environment is essential to such development.
> -- The extension to all peoples of the benefits of medical, psychological and related knowledge is essential to the fullest attainment of health.
> -- *Informed opinion and active co-operation on the part of the public are of the utmost importance in the improvement of the health of the people*.
> -- Governments have a responsibility for the health of their peoples which can be fulfilled only by the provision of adequate health and social measures. (emphasis added)

(5) The *International Labor Organization's (ILO) Annex to its Constitution*, "Declaration Concerning the Aims and Purposes of the ILO" (adopted by the General Conference of ILO in May 1944) states in *Section III* , in part, that all nations must achieve: " . . . (g) adequate protection for the life and health of workers in all occupations; (h) provision for child welfare and maternity protection; (i) the provision of adequate nutrition, housing and facilities for recreation and culture."

(6) The *Convention on the Rights of the Child*, adopted by the United Nations General Assembly in November 1989, states the child's right to health in Article 24, which reads, in part as follows:

> *Article 24* (1) States Parties recognize *the right of the child to the highest attainable standard of health* and to facilities for the treatment of illness and rehabilitation of health. States Parties shall strive to ensure that no child is deprived of his or her right of access to such health care services.
> (2) States Parties shall pursue full implementation of this right and, in particular, shall take appropriate measures: (a) to diminish infant and child mortality, (b) to ensure the provision of necessary medical assistance and health care to all children with emphasis on the development of primary health care, (c) to *combat disease and malnutrition* including within the framework of primary health care, through inter alia the application of readily available technology and *through the provision of adequate nutritious foods and clean drinking water, taking into consideration the dangers and risks of environmental pollution . . . .* (emphasis added)

(7) Other international conventions that explicitly provide the right to health include:

(a) *International Convention on the Elimination of All Forms of Racial Discrimination* (adopted December 1965; entered into force January 1969) in *Article 5(e)(4)*, stating " The right to public health, medical care, social security and social services",
(b) *Convention on the Elimination of All Forms of Discrimination Against Women* (adopted December 1979; entered into force September 1981) in *Article 12(1)*, stating "States Parties shall take all appropriate measures to eliminate discrimination against women in the field of health care in order to ensure, on a basis of equality of men and women, access to health care services, including related to family planning,
(c) *Convention Concerning Indigenous and Tribal Peoples in Independent Countries* (adopted in June 1989 by the General Conference of the International Labor Organization; not in force as yet) in *Article 7(2)*, which states "The improvement of the conditions of life and work and levels of health and education of the peoples concerned, with their participation and co-operation, shall be a matter of priority in plans for the overall economic development of area they inhabit", and

in *Part V (Social Security and Health), Article 25*, which states in part "Governments shall . . . provide them with resources to allow them to design and deliver such services under their own responsibility and control, so that they may enjoy the highest attainable standard of physical and mental health."

(d) *International Convention on the Protection of the Rights of All Migrant Workers and Members of Their Families* (adopted by the United Nations General Assembly in December 1990; not in force as yet), states in *Article 28*: "Migrant workers and members of their families shall have the right to receive any medical care that is urgently required for the preservation of life or the avoidance of irreparable harm to their health on the basis of equality of treatment with nationals or the State concerned. Such emergency care shall not be refused them by reason of any irregularity with regard to stay or employment."

(D) Environmental Protection and Public Health: Major Conventions and Treaties

(i) Water Resources

Access to safe and clean water is a critical factor in realizing the right to health. Human beings are unable to maintain life without access to clean drinking water for any extended period of time. Thus, a national or local government authority that poorly allocates water resources or fails to regulate water-borne contaminants or industrial discharges in publicly accessible waterways is, in effect, precluding a community's right to life and health. Another important legal principle with respect to the right to water is freedom of information. United Nations background papers on the environment emphasize the relationship between public access, political freedom and public health. Public access to regulatory proceedings affecting the environment and public participation in environmental impact assessments are critical elements in achieving sustainable development in a community. Without public access to information and public freedom to participate in environmental decision-making, especially with respect to a community's water resources, government agencies may find that they have compromised the long-term health and well-being of a community in achieving long-term social and economic development goals.

In the *United Nations Millennium Declaration*, adopted by the General Assembly on September 8, 2000, the need for development of water resources through proper planning strategies was stressed (Section IV):

> To stop the unsustainable exploitation of water resources by developing water management strategies at the regional, national and local levels, which promote both equitable access and adequate supplies.

At the United Nations World Summit on Sustainable Development (WSSD) held in Johannesburg, South Africa (August 26 - September 4, 2002), the *WSSD's Plan of Implementation* (Articles 24 - 28) stated a number of significant goals for developing water resources and sanitation facilities within the next few decades:

> *Article 24*. Launch a programme of action, with financial and technical assistance, to achieve the millennium development goal on safe drinking water. In this respect, we agree to halve, by the year 2015, the proportion of people who are unable to reach or to afford safe drinking water as outlined in the Millennium Declaration and the proportion of people without access to basic sanitation . . .
>
> *Article 25*. Develop integrated water resources management and water efficiency plans by 2005, with support to developing countries, through actions at all levels . . .

> *Article 28*. Promote effective coordination among the various international and intergovernmental bodies and processes working on water-related issues . . . closer coordination should also be promoted to elaborate and support proposals and undertake activities related to the International Year of Freshwater 2003 and beyond.

In many regions of developing countries, several million infants and young children die or become seriously ill each year from exposure to contaminated water, which along with acute respiratory diseases and malaria constitutes the largest causes of childhood mortality and morbidity in the world at present. In Article 24(1) of the *Convention for the Rights of the Child* (adopted in November 1989), children's right to health is presented in the following language: "States Parties recognize the right of the child to the enjoyment of the highest attainable standard of health and to facilities for the treatment of illness and rehabilitation of health. States Parties shall strive to ensure that no child is deprived of his or her right of access to such health care services." In addition, the Children's Convention states in Article 24(2c) "To combat disease and malnutrition, including within the framework of primary health care, through, inter alia, the application of readily available technology and through the provision of adequate nutritious foods and clean drinking-water, taking into consideration the dangers and risks of environmental pollution."

In the *Outcome Document* (*"A World Fit for Children"*) adopted at the United Nations General Assembly's Special Session on Children in May 2002, the conferees at the meeting agreed as follows (Paragraph 36):

> We are determined to break the intergenerational cycle of malnutrition and poor health by providing a safe and healthy start in life for all children; providing access to effective, equitable, sustained and sustainable primary health care systems in all communities, ensuring access to information and referral services; providing adequate water and sanitation services; and promoting a healthy lifestyle among children and adolescents.

At the International Conference on Freshwater in Bonn, Germany (December, 2001), the conferees at the meeting issued twenty-seven specific recommendations, which were organized in three major parts (see *Appendix A*). Integral to the recommendations is the importance of poor peoples' access to clean water in the context of poverty eradication; the need for gender equity in water management, especially in areas where women have few rights to own or control land; and the implied need to consider indigenous people's rights and the right to work, which may be lost if a community's riparian (rivers and streams) rights are arbitrarily appropriated by the state.

(ii) ***Air Quality***

Chemical plants, oil refineries and other manufacturing factories that release large quantities of hazardous substances in their smokestacks are a major cause of air pollution in many urban and inner city areas. The public health consequences that arise from these industrial facilities, including municipal incinerators and toxic dump sites that emit hazardous air pollutants in poor neighborhoods, has recently been brought to the attention of policy makers by advocates of the emerging field of environmental justice. All too often, they have noted, low-income communities -- especially in developed countries (such as the United States) that have high proportions of ethnic minorities as inhabitants -- become victims of inadequate urban planning or faulty residential zoning laws. Moreover, in the past, residents of these low-income areas generally did not have effective political or legal means to stop the siting of polluting factories or the placement of hazardous waste facilities within their neighborhoods.

The *Rio Declaration on Environment and Development* adopted by the UNCED meeting in 1992 broadly outlined general principles that signatory states should consider in implementing basic environmental rights and sustainable development strategies, which encompasses the preservation of air quality in both urban and rural areas. These broad principles included the requirement to enact effective national environmental legislations and standards (Article 11), liability laws and compensation for victims of pollution (Article 13), prevention of relocation and transfer of activities and substances injurious to health (Article 14) and the establishment of the "precautionary principle" in protecting human beings from environmental degradation (Article 15), an important public policy position which precludes relying on scientific uncertainty to avoid taking precautionary measures to safeguard the health of the community.

Poor ventilation in the indoor environment is another cause of death and illness in both developed and developing countries. This problem is exacerbated when persons work a full day and/or night within such poorly ventilated indoor premises. Minimum standards in working conditions are detailed in many of the International Labor Organization (ILO) Conventions, including provisions on the fundamental necessity of proper ventilation. Particularly worrisome are conditions in which workers have little input in developing safety standards in their work environment and thus have little or no control over occupational health issues, such as those related to adequate ventilation systems and indoor air quality standards. More recently, the World Health Organization (through its European Centre for Environment and Health) has recommended a set of nine safety principles related to the right of individuals to breathe safe and clean air within the indoor environment, which states as its first three principles:

> 1. Under the principle of the human right to health, everyone has the right to breathe healthy indoor air.
> 2. Under the principle of respect for autonomy (self-determination), everyone has the right to adequate information about potentially harmful exposures, and to be provided with effective means for controlling at least part of his or her indoor exposures.
> 3. Under the principle of non-maleficence (doing no harm), no agent at a concentration that exposes any occupant to an unnecessary health risk should be introduced into indoor air.

In addition to the first three principles, the WHO's human rights approach to indoor air quality emphatically employs the "precautionary principle" (as enunciated in the *Rio Declaration on Environment and Development*) as follows (Principle 8): "Under the precautionary principle, where there is a risk of harmful indoor air exposure, the presence of uncertainty shall not be used as a reason for postponing cost-effective measures to prevent such exposure."

(iii) *Toxic Substances*

The young, the elderly, and those with compromised health because of underlying illness or living conditions are the most vulnerable groups to poisoning from toxic substances. Children are an especially vulnerable group, with their rapidly developing organs and tissues that incorporate toxic substances more readily than an adult's body. Additionally, children's smaller bodies (based on their body weight and size) can tolerate less toxicity than an adult's. Thus, toxic effects on children are especially swift and severe. In the *Convention on the Rights of the Child*, Article 3 emphasizes the need to safeguard children's health through "institutions, services and facilities" that "conform with the standards established by competent authorities." That is, a state party to this Convention must take steps to ensure reductions in toxic substances affecting children. In matters of human toxicity, the workplace again serves as a useful context in which to examine the issue. Chronic, low-dose exposure of workers to cancer causing compounds is always problematic, but more so because many workers are unaware of their right to a healthy workplace, or are unable to determine workplace causes of illness. In addition, in many regions of the world, workers

as a rule are unable to bring complaints to management or to regulatory bodies to ameliorate unsafe workplace conditions.

Many toxic chemicals today are known as *persistent organic pollutants (POPs)*, since they are long-lasting, non-biodegradable organic compounds that bioconcentrate in the food chain, posing serious health risks to human populations. The international community recently signed a landmark agreement, the *Stockholm Convention on Persistent Organic Pollutants (POPs Treaty)*, which was adopted with considerable worldwide publicity in December 2000 in Johannesburg. Under the POPs Treaty, the following chemicals are to be globally phased out and completely eliminated in the next few years: polychlorinated biphenyls (PCBs), dioxins and furans, aldrin, dieldrin, DDT, endrin, chlordane, hexachlorobenzene, mirex, toxaphene and heptaclor.

During the past decade, the international community has adopted a series of agreements and conventions that provide regulatory procedures and guidelines to control the global export and shipment of toxic substances and hazardous wastes. In 1995, the *International Code of Conduct on the Distribution and Use of Pesticides* was adopted by the Food and Agriculture Organization (FAO), followed in 1987 by the enactment of the *London Guidelines for the Exchange of Information on Chemicals in International Trade* by the United Nations Environment Programme (UNEP). In 1989, an international agreement, called the *Prior Informed Consent (PIC)* (later extended by the Rotterdam Convention in 1998) was adopted to help control the importation of banned or severely restricted products into developing countries. Under PIC, officials in importing countries must be informed by the exporter about the toxicological characteristics and regulatory status of potentially hazardous chemicals before shipment of the product to their region.

Discarded agricultural chemicals, unused toxic pesticides and hazardous wastes are generally recognized as requiring legal restrictions or regulatory oversight in their international shipments or transfers. Though over one hundred countries have banned or severely restricted the import of hazardous materials, some developing countries, especially in Asia and Africa, have found an economic niche in importing hazardous wastes from developed nations. The *Basel Convention on the Control of Transboundary Movement of Hazardous Wastes and their Disposal* offers a system by which to regulate transport and disposal of such wastes, but also encourages waste minimization and the implementation of sound environmental management policy. Workers in the country of import who directly receive and recycle the waste materials, however, may not (and often do not) know of the Basel Convention and whether their country is party to its provisions. Thus, human rights education is strongly implicated here. The Basel Convention is useful and protects member states to a large extent, but full protection of peoples' human rights cannot be fulfilled without widespread knowledge of the existence of these rights.

(iv) *Climate Change*

Global climate change exacerbated by anthropogenic activity (i.e., not caused by natural events) may bring about severe weather events and drastic changes in land-use patterns in many regions of the world, leading to a number of significant environmental and public health impacts. These climate-related effects have been linked to the rise of atmospheric concentrations of greenhouse gases, such as carbon dioxide and methane, which are emitted from fossil fuel combustion sources and through agricultural production. At present, there is a growing consensus among leading scientists around the world that current increases of greenhouse gases in the atmosphere may lead to widespread global warming by the middle or latter part of this century.

The impact of global warming on human communities has several short-term and long-term local and regional environmental consequences. It would increase the movement of vector-borne diseases (such as malaria and dengue fever) to northern latitudes, cause higher levels of air pollution, severely change

agricultural and forestry patterns, lead to greater incidences of storms, floods and drought, including causing extensive sea-level rise along low-lying coastal areas. Based on these concerns, the international community adopted the *Kyoto Protocol to the United Nations Framework Convention on Climate Change* in 1998. The Kyoto Protocol calls on ratifying states to reduce atmospheric emissions of greenhouse gases linked to global warming through nationally-based emission-reductions program and the creation of international mechanisms for trading emission credits and for providing technical assistance to developing countries.

Since the mid-1970s, there has been increasing scientific evidence that worldwide production and use of chlorofluorocarbons (and related compounds) could cause significant loss of earth's protective ozone layer. Loss of stratospheric ozone would in turn cause increases in harmful ultraviolet radiation on earth's surface, leading to higher incidences of skin cancer, cataracts and immune system disorders. More importantly, increased UV radiation may have unprecedented impacts on oceanic phytoplankton yields, whose loss would significantly decrease global fish and shellfish stocks, since phytoplankton species are at the base of all food chains in the marine and coastal environment. By the mid-1980s, the growing worldwide consensus between research scientists and policy makers led to the adoption of the landmark *Montreal Protocol on Substances that Deplete the Ozone Layer* in 1987, along with subsequent modifying amendments in the 1990s. The Montreal Protocol has led to a worldwide phase out of stratospheric ozone depleting substances, including chlorofluorocarbons (CFCs) and other ozone-depleting compounds.

(v) ***Biodiversity and Ecosystem Disruption***

Of the estimated half billion biological organisms that are believed to have existed over the past 600 million years, only a fraction (1-10%) of these species still exist on earth today. Current estimates of species extinction are around 100 to 1,000 species per year, considerably greater than rate of biodiversity loss over most of earth's evolutionary history. At this rate of species extinction, more than 25 % of all biological organisms on earth today, will become extinct in the next fifty years. At present, the largest repository of biodiversity is in tropical rainforests in the equatorial belt, where it is believed more than 50% of all biological species reside. At current trends of deforestation, however, it is believed that by the end of this century, most of the primary tropical forestlands in Asia, Africa and Latin America will be lost.

Global concerns about the rapid loss and extinction of biological species led to the adoption of the *Convention on International Trade in Endangered Species of Wild Fauna and Flora (CITES)* in March 1973. The international agreement required the listing of "all species threatened with extinction which are or may be affected by trade. Trade in specimens of these species must be subject to particularly strict regulation in order not to endanger further their survival and must only be authorized in exceptional circumstances." Following the adoption of this convention, the United States Congress enacted the *Endangered Species Act of 1973,* which provides broad authority to the federal government to conserve ecosystems where endangered or threatened animal or plant species are known to exist. The act authorizes the determination, listing, possession, sale or transport of endangered species be regulated by government agencies, and allows the acquisition of land for the conservation of the listed endangered species.

At present, over 1.75 million biological species have been scientifically identified and catalogued, out of an estimated total of 3 million (or as much as 100 million) species that, according to conservation biologists, probably exist on earth's lands and oceans today. To preserve and equitably share the genetic resource base of earth's biological diversity, the international community signed the *Convention on Biodiversity* at the 1992 United Nations Conference on Environment and Development in Rio de Janeiro. This international agreement on biodiversity establishes its main objectives in the following terms: ". . . the conservation of biological diversity, the sustainable use of its components and the fair and equitable sharing of the benefits

arising out of the utilization of genetic resources, including by appropriate access to genetic resources and by appropriate transfer of relevant technologies . . ."

(vi) *Concluding Remarks*

It should be apparent that environmental and human rights are inextricably linked -- to talk about the one implies the other. As we increasingly recognize the serious impact of a degraded environment on human health and well being, we are better placed to adjust our policies and cultural practices to reflect our enhanced understanding of the close linkages between environmental protection, public health and human rights. As a result, we should be able to protect human rights and human dignity within its broader social, economic and cultural context by drawing from and contributing to those who are actively engaged in the environmental and public health arenas.

This new understanding should also allow individuals and organizations working in the environmental, conservation and public health fields to develop better working relationships with and to gain more knowledge of human rights institutions, approaches and instrumentalities. In doing so, we are able to articulate a more integrated approach to dealing with socio-economic and environmental problems that encourages the development of sustainable local communities and the emergence of institutional frameworks and governing structures dedicated to the preservation of biological resources and natural ecosystems.

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II. Water Resources and Sanitation

(A) Overview

The lack of clean water resources and sanitation facilities looms as one of the most serious environmental health problems faced today by a large fraction of the world's population, especially those living in developing regions. Around the world, water supply and sanitation facilities are rapidly deteriorating and are operating at a fraction of their installed capacities. This situation is particularly serious in many developing countries of Asia, Africa, and Latin America, where the poor have very limited access to clean water supplies and sanitation facilities. This poses serious and life-threatening diseases to the population, especially among infants and young children. The situation is even more pronounced in rural areas of developing regions, where the problems of water resources and inadequate sanitation facilities largely remain unresolved for a large majority of the population. Added to this is the rapid industrialization and urbanization of a number of highly populated developing countries (such as China, India, Brazil, and Mexico) where in the past few decades, water contamination by a variety of toxic chemicals and hazardous wastes has aggravated an already serious water pollution problem related to microbial diseases.

The World Health Organization (WHO) has estimated that 1.1 billion people lack basic access to drinking water resources, while 2.4 billion people have inadequate sanitation facilities, which accounts for many water-related acute and chronic diseases. Some 3.4 million people, many of them young children, die each year from water-borne infectious diseases, such as intestinal diarrhea (cholera, typhoid fever and dysentery), caused by microbially contaminated water supplies that are linked to deficient or non-existent sanitation and sewage disposal facilities. In addition, many freshwater streams, lakes and groundwater aquifers around the world are increasingly becoming contaminated with industrial discharges and agricultural runoffs that carry high concentration levels of toxic chemical substances and hazardous wastes. These contaminated water sources contain a number of highly toxic heavy metals, pesticides, fertilizers and other agricultural chemicals, along with a variety of persistent organic pollutants (POPs) and disinfection by-products, many of which remain intact in the environment for long periods of time and bioaccumulate in the food web. The presence of these chemical substances in surface and ground water resources is linked to many acute and chronic illnesses, ranging from severe skin and liver disorders to developmental abnormalities, neurological diseases and human cancer.

Broadly speaking, the global problem of water resources and sanitation may be generally looked upon as consisting of: (1) increasing scarcity of water supplies with rising population, (2) uneven and inequitable distribution of water resources and sanitation facilities, (3) high water pricing rates and charge schedules, (4) prohibitive costs associated with operating and maintaining sanitation facilities, (5) insufficient funds available for building water treatment and sewage disposal facilities, (6) lack of availability of appropriate and innovative water treatment technologies, (7) failure to implement water conservation programs, (8) poor management in protecting aquatic ecosystems, (9) inadequate prevention of microbial and chemical contamination of surface and ground water resources from human activities.

(B) Infectious and Vector-Borne Diseases

(i) *Microbial Diseases in Developing Regions*

According to WHO and the US Centers for Disease Control and Prevention (CDC), over 2 billion people, mostly living in developing countries, are at elevated risk to water-related bacterial diseases.

While there are many illnesses in this category, the major water-borne diseases include acute dehydrating diarrhea (*cholera*), abdominal illness (*typhoid fever*), bacterial enteritis (*salmonellosis*), acute diarrhea (*dysentery*) and chronic diarrhea (*Brainerd diarrhea*). One of the main modes of transmission of these diseases is from drinking bacterially infested water from poorly maintained municipal distribution systems. This happens either as a result of lack of chlorination at the drinking water source or through cross-contamination of the disinfectant-treated piped water by underground sewage wastes. Another mode of microbial infections from water sources occurs through occasional phytoplankton blooms. Such a bloom episode, in which pathogenic bacteria survive and spread widely, was associated with a major cholera outbreak in Bangladesh in 1994.

Proper means to address these water-related environmental health problems in developing regions requires simple point-of-use disinfection methods and availability of clean storage vessels. At present this may be achieved relatively inexpensively in many rural areas by the use sodium hypochlorite as a disinfectant, which is produced from salt water by means of simple electrolytic devices. However, the widespread use of sanitary latrines in rural areas, along with the introduction of sewage treatment systems in urban areas of developing regions, is necessary if long-term solutions to water pollution problems are to be achieved.

(ii) *Cryptosporidiosis and Giardiasis*

In many regions of the world, including the United States, a common water-related diarrheal disease that has been recognized as a major public health problem is *cryptosporidiosis*, which is caused by a microscopic parasite (Cryptosporidium). This parasite is generally found in drinking water, swimming pools and recreational streams that are contaminated by human fecal wastes. Since Cryptosporidium has a strong protective outer shell, it survives outside the human body for long periods of time, thus making it difficult to destroy by using conventional disinfectants such as chlorine. Additionally, this highly contagious disease can be transmitted by raw, uncooked food or by oral contact of bacterially-contaminated objects by young children. For these reasons, thorough washing of hands with soap and water after using the toilet (or changing diapers) and before eating a meal is highly recommended. Furthermore, the importance of restricting the use of inside recreational waters (pools, jacuzzis, hot tubs) and outdoor streams by individuals who have been recently been infected with this bacterial disease needs to be widely communicated to the general public.

Another increasingly common water related diarrheal disease around the world, including the United States, is *giardiasis*, which is caused by a one-celled microscopic parasite (Giardia). Similar to the spread of cryptosporidium in the environment, giardia is transmitted by discharges of fecal wastes into water, food, soil and other surfaces. Therefore the preventative hygienic measures that is recommended to lower the overall incidence of cryptosporidiosis apply to giardiasis as well.

(iii) *Malaria*

One of the most serious vector-borne diseases in the world today is *malaria*. It occurs in many warm, tropical regions of the world, such as Central and South America, Hispaniola, the sub-Saharan region of Africa (where the largest annual incidences are reported), the Indian subcontinent, Southeast Asia, the Middle East and Oceania. Malaria is a water-related disease, since it is caused by four subspecies of microscopic parasites (Plasmodium) carried by female Anopheles mosquitoes that breed their larvae in stagnant pools and water storage reservoirs in warm climates. Each year, 300 to 500 million people contract malaria worldwide, of which some 1.5 to 2.7 million people die from the disease. The overwhelming majority (90%) of fatal cases are children below the age of 5 years. Since the 1970s, there has been a resurgence of malaria in many regions of the world, partially due to the rapid formation of

parasites that are resistant to malaria preventing drugs, such as chloroquine and other quinoline products. In addition, significant increases in the incidence of malaria in recent years have been caused by the construction of dams, intensified irrigation systems and other water-related projects, accounting for a large number of new mosquito breeding sites in many developing regions.

In general, prevention and control of malarial diseases is quite complex and multifaceted. Though relatively expensive, the use of wire screens in houses and other buildings is an effective way to keep infectious mosquitoes out of indoor premises. The use of mosquito fish in small ponds and water tanks for reducing larval populations has met with success in some communities. Insect repellent treatments of home walls, bednets, mats and coils are also recommended in severely affected areas. It should be noted, however, that in many regions of the world, some strains of mosquitoes have become highly resistant to frequently used insecticides, such as DDT and pyrethroids. For travelers who plan to visit areas of the world where malarial diseases are endemic, it is important to take antimalarial prescription drug (whose non-resistant properties have been well established) in advance (generally 4 - 6 weeks before traveling) and to maintain a strict dosage regimen. Moreover, use of insect repellents is advisable, along with wearing clothing that covers the body and sleeping under mosquito bednets treated with insecticides.

(iv) *Schistosomiasis and Trachoma*

It is estimated that 200 million people worldwide are infected with *schistosomiasis*, with another 2 billion people in some 74 countries at elevated risk from this debilitating water-borne disease. Schistosomiasis (sometimes known as bilharzia) is caused by parasitic worms (Schistosoma) when human beings come into contact with certain types of snails that harbor these parasites in contaminated fresh water. The main factor in the proliferation of this disease is dumping human fecal wastes to fresh water sources. While 20 million people suffer from severe consequences of this disease, the World Health Organization states that better latrines and sanitation facilities could significantly reduce the incidence of schistosomiasis by as much as 77%. Prevention of schistosomiasis can be achieved by avoiding swimming or wading in contaminated streams and lakes, by drinking properly boiled water, and bathing or showering in water heated to 66 degrees C (150 degrees F) for 5 minutes.

Improved water sanitation and hygienic conditions could also reduce the worldwide incidence of *trachoma*, a serious chronic eye disease, which is caused by an infectious bacterial agent (*Chlamydia trachomatis*). This diseases is spread by person to person contacts and by insect vectors such as house flies. The infection begins by irritation of the cornea (*trichiasis*), which increases the risk of ulceration of the cornea, resulting in reduced vision and blindness. At present, it is estimated that 500 million people are at risk to this disease, while 146 million people are threatened with irreversible blindness. The World Health Organization estimates that trachoma results in 6 million cases of blindness each year, and that the prevalence of this disease in children is 10 - 40% in some African countries. Recently, WHO initiated a global campaign to eliminate trachoma, which consists of a combined strategy of: (1) monitoring and conducting surveillance for the disease, (2) improving community water supplies and introducing sanitation facilities, (3) encouraging individual hygiene programs, (4) prescribing the use of antimicrobial drugs, and (5) eye surgery to correct the onset of trichiasis.

(C) Naturally Occurring Water Contaminants

(i) *Arsenic*

An environmental health problem of enormous proportion has arisen in a number of regions of the world where naturally occurring arsenic found in subsoil layers has contaminated underground drinking water sources. The most severe cases of *arsenic poisoning* have occurred in Bangladesh, where it is estimated

that between 35 and 77 million people (in a country of 125 million people) were exposed to this toxic chemical substance by ingesting drinking water from underground aquifers. Today, 97% of the population in Bangladesh drinks water drawn from underground aquifers. These underground drinking water sources were tapped through installation of tube wells under an extensive World Bank assisted program during the 1980s when it was recognized by local authorities that surface water sources in the country had become too contaminated for human consumption. At present, in many rural areas of the country arsenic is found in drinking water above WHO's recommended level of 10 parts per billion (ppb). To confront this public health crisis, a combination of remediation, clinical and educational programs have been undertaken by the national government and by a number of international agencies. Three types of action programs have been identified to address this problem: (1) enabling people in the community to have access to arsenic-free drinking water, (2) providing financial assistance and medical treatment to those suffering from arsenic poisoning, and (3) conducting an extensive study of underground water sources to understand the overall hydro-geological nature of the problem.

Toxicological studies show that ingestion of arsenic may lead to thickening of the skin, nervous system disorders, digestive problems, diabetes, liver disease, and cancer. Treatment for arsenic poisoning range from changes in dietary habits (e.g., eating more high sulfur-containing foods, such as eggs, onions and garlic, and those food products with high fiber content) to medical treatments (oral ingestion of charcoal tablets or intravenous injection of metal binding agents). Other countries of the world where arsenic in drinking water from underground sources (and in some cases from surface mine tailings and agricultural runoffs) has also been identified as an environmental health risk include Argentina, Chile, China, India, Mexico, Thailand and the United States.

(ii) *Fluoride*

In several regions of the world, unsafe levels of naturally occurring fluoride, which is present abundantly in the earth's crust, are found in drinking water. Excessive level of fluoride ingestion causes a chronic disease known as *fluorosis*, which is a serious bone disease that discolors teeth (dental fluorosis), and causes stiffness of joints and other skeletal deformations. According to UNICEF, fluorosis is endemic in at least 25 countries across the globe, whereas WHO estimates that in China alone some 30 million people suffer from chronic fluorosis. In 1993, fluorosis was reported to be endemic in 15 out of 32 states in India and an estimated 5 million people in Mexico were affected by high levels of fluoride from exposure to underground drinking water. In areas of the world where high levels of fluoride occur in groundwater, surface water sources need to be developed that are free of bacterial and chemical contaminants. Another approach is to remove fluoride from groundwater sources by employing either flocculation (solid precipitation) or adsorption (chemical binding) treatment procedures. Currently, in many developed countries, fluoride is added intentionally in drinking water -- at a presumed safe concentration level of around 1 part per million (ppm) -- as a preventative measure against dental decay. However, WHO has recommended that in warmer climates, fluoride in drinking water be kept below the 1 ppm concentration level, since individuals in hot weather ingests greater quantities of water daily than those living in more temperature regions.

(D) Water-Related Toxic Substances and Hazardous Wastes

Increasingly, many surface and underground drinking water sources around the world have become severely polluted by a variety of toxic chemical substances and hazardous wastes. These sources of water contamination include manufacturing, refinery and municipal effluent discharges, leachates from landfills and hazardous waste sites, agricultural runoffs, mining operations, and other commercial and

recreational activities. Among the more common toxic substances found in drinking water are (i) heavy metals, (ii) toxic organic compounds, (iii) pesticides and fertilizers, and (iv) disinfection by-products.[1]

The major identifiable or "point" sources of heavy metal contamination of waterways are from the mining, metal smelting, electroplating and chemical manufacturing industries, whereas "non-point" sources of heavy metals are mainly from agricultural runoffs (containing mineral fertilizers, sewage sludge and certain types of pesticides) and from urban/suburban runoffs, along with atmospheric fallout linked to road traffic and emissions from power plants and waste incinerators. Major sources of toxic organic compounds in surface and ground water are from chemical, pharmaceutical, synthetic polymer (plastic/rubber) and fossil fuel refining industries, while most pesticide contamination of drinking water originates from agricultural and domestic uses.

Disinfectant by-products are formed in waterways and reservoirs when chlorine -- used as a bactericidal agent in many water treatment plants -- chemically reacts with naturally occurring organic compounds (e.g., soil-bearing humic acids) to form a number of halogenated organic compounds, such as chloroform and bromoform. In addition, agricultural runoff of nitrogen fertilizers in many rural areas of the world contaminates rivers, lakes and underground aquifers leading to excessive levels of dissolved nitrates in drinking water that may cause "blue baby syndrome", an acute and serious life-threatening disease among infants and young children.

The presence of toxic chemical substances and hazardous waste materials in drinking water pose a large spectrum of human health risks to the general population. They range from simple ailments such as short-term skin rashes, nose and eye irritation, gastrointestinal distress, numbness in fingers and toes, to a variety of serious acute and chronic diseases. For instance, a number of heavy metals cause long-term liver and kidney damage, nervous system disorders, loss of fingernails and hair, blood pressure changes and circulatory problems. Many persistent organic pollutants (POPs) found in drinking water, such as aromatic and halogenated hydrocarbons, cause developmental and nervous system disorders, reproductive difficulties, liver and kidney problems, several types of cardiovascular disorders, increased risks of childhood and adult cancer and potential genetic damage to future generations. The chief characteristic of POPs is their long-lasting presence in the environment, where they can exert their adverse toxicological effects on human and animal populations for many years or even decades.

The human health risks associated with ingesting heavy metal and toxic organic substances in drinking water over a prolonged period of time often occurs at relatively low concentration levels, generally in the range of parts per million (ppm) or below. For these reasons, prevention and/or removal of trace amounts of these water-borne contaminants in drinking water sources is considered a matter of high priority by regulatory agencies in many industrialized and rapidly developing countries. In addition to prohibiting or severely restricting the discharge of toxic effluents and hazardous wastes into surface and ground water sources, a number of technological solutions may be employed to remove chemical contaminants in drinking water. These include the use of activated charcoal filters (and other chemical adsoption devices) at the water tap to remove persistent organic pollutants and disinfectant by-products in homes and office buildings.

[1] Examples of *heavy metals* in water resources consist of such chemical substances as beryllium, cadmium, chromium, lead, mercury, nickel; *toxic organic compounds* such as benzene, dichloroethylene, dioxin, ethylene dibromide, MTBE, phthalates, PCBs, toluene, xylenes; *pesticides* such as alachlor, atrazine, DDT, dalapron, hexachlorobenzene, lindane, permethrin, 2,4-D; and *disinfection by-products* such as bromates, chlorophenols, chloroform, bromoform, halogenated acetic acids and acetonitriles (For more explanatory information on these chemical substances, see Section III-B).

In some areas of developed countries, such as the United States and Canada, where ground water has been severely polluted with heavy metals or toxic organic compounds, an entire aquifer that serves a community may have to undergo extensive remediation, such as by pumping out and treating the underground contaminated drinking water source. At present, the treatment technologies to remove drinking water contaminants employ a variety of approaches, including chemical adsorption technique, biological degradation, air stripping of volatile compounds and metallic precipitation. However, such a remediation procedure would be prohibitively expensive and difficult to carry out in less developed regions of the world, and is not recommended as the method of first choice in most cases.

(E) Distribution of Water Resources and Water Quality Standards

At present, drinking water is not available at sufficient amounts needed for daily human consumption in many regions of the world for the simple reason that the global supply of freshwater is unevenly distributed. For instance, some arid and semi-arid regions on the earth's surface receive only about 2% of the global flow of fresh water, while they account for 40% of the total land mass of the world. On the other hand, some major river basins may carry enormous quantities of fresh water, such as the Amazon River (accounting for 16% of the global water run-off) or the Congo River basin, which accounts for one-third of all fresh water flow on the African continent. For these reasons, in many regions of the world more than half the population, especially those living in rural areas, obtain their drinking water supplies from shallow wellwaters and underground aquifers.

In addition to providing drinking water that is free from pathogenic microbial contaminants that cause water-borne infectious diseases, special steps must be taken to keep toxic substances (such as industrial chemicals, urban/suburban stormwater effluents and agricultural runoffs) from polluting downstream water resources. These measures include protecting watersheds and aquatic recharge areas from a variety of human activities, such as dumping of human wastes, mining operations, manufacturing discharges and excessive use of agricultural fertilizers and pesticides. Groundwater sources of drinking water must be protected from surface drainage and flooding, with rainwater recharge areas kept free of garbage and toxic waste disposals, agricultural husbandry and land clearance activities.

An important factor in achieving clean water supplies for the community is the development of health-based water quality standards and indicators that should be accompanied by frequent monitoring to ensure compliance with safe drinking water guidelines and regulations. WHO has issued *Guidelines for Drinking Water Quality*, a set of recommendations whose primary goal is to safeguard human health and which were intended for the development of national water quality standards. Its health-based guidelines for chemical substances are divided as follows: (i) inorganic compounds (including heavy metals and anions), (ii) organic compounds, (iii) pesticides, and (iv) disinfectants/disinfectant by-products. The WHO guidelines provide recommended maximum acceptable concentration levels for each water-borne contaminant in order to ensure the safety of drinking water sources. However, these guidelines are not envisioned to be a mandatory limit, since the water quality guidelines are to be viewed "in the context of local or national environmental, social, economic and cultural conditions."

Under the U. S. Safe Drinking Water Act, the United States Environmental Protection Agency (USEPA) has issued legally enforceable drinking water standards known as *National Primary Drinking Water Regulations* (NPDWRs), which are divided into the following broad categories: (i) microorganisms (including bacteria and viruses), (ii) disinfectants/disinfectant by-products, (iii) inorganic chemicals (including heavy metals and anions), (iv) organic chemicals (including pesticides), and (v) radionuclides (including alpha and beta particles). In addition, the USEPA has published non-enforceable guidelines -- the *National Secondary Drinking Water Regulations* (NSDWRs) -- on a number of physical/chemical factors and chemical substances that cause cosmetic or aesthetic effects in drinking water. These include

items such as corrosivity, odor, color, foaming agents, pH (acidity), total dissolved solids and the non-health impacts of a number of metal cations and anions (aluminum, chloride, copper, fluoride, iron, manganese, silver, sulfate and zinc). However, each state in the U. S. has the regulatory discretion to adopt the federal NSDWRs as enforceable drinking water standards.

(F) International Approaches to Water Resources Management

At the International Conference on Freshwater (ICF) held in Bonn, Germany on 3 - 7 December, 2001, a set of recommendations was proposed by government ministers from 46 countries in order to achieve sustainable management of water resources and sanitation facilities. They identified five key elements in reaching such a broad objective:

1. meeting the water security needs of the poor,
2. delegating water resource management to local authorities,
3. developing new partnerships with community organizations,
4. creating more integrated water management programs within watersheds and river basins, and
5. maintaining better governance structures for water resource management.

In addition, they stated the importance of mobilizing financial resources and global investments in water-related infrastructures. Though at present, it is estimated that $70 - 80 billion worldwide is being invested annually in such infrastructure programs, only $10 billion of these available funds are being allocated for water supply and sanitation programs that meet basic needs. They recommended that future expenditures for water resource management and sanitation facilities be doubled annually from a variety of public and private funding sources in the next few years on a priority basis (See *Appendix A* for more detailed information on the conference's recommendations.)

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Appendix A: International Conference on Freshwater Recommendations: The International Conference on Freshwater (ICF) in Bonn, Germany on December 3 - 7, 2001 issued a set of 27 specific recommendations that are briefly summarized in three parts as follows:

A. *Governance*: (i) *secure equitable access to water for all people*, with the participation of all stakeholders who use or protect water resources and ecosystems, (ii) *ensure that water infrastructure and services are delivered to poor people*, with programs linked to poverty eradication and economic growth, along with the target of halving the proportion of people lacking proper sanitation by 2015, (iii) *promote gender equity* to allow men and women to have equal involvement in managing water resources, along with ensuring that women's role be further strengthened and broadened, (iv) *appropriately allocate water among competing demands* -- to meet basic human needs first and then to ensure ecosystem functioning and encourage economic uses, including food security, (v) *share benefits* of watersheds, river basins, lakes and aquifers by cooperation on water management at the regional level that goes beyond traditional provincial and national boundaries, (vi) *promote participatory sharing of benefits from large projects*, especially in water-scarce countries, where new water sources and infrastructure (such as dams) should be developed only after an integrated assessment of the community's needs and options is undertaken, (vii) *improve water management*, taking into account the impact of trade in water-intensive goods on water resources and ecosystem integrity, with encouragement being given to growing drought resistant crops in water scarce regions, (viii) *protect water quality and ecosystems*, to safeguard human health and preserve the integrity of surface and ground water sources, including rivers, lakes, wetlands and coastal zones, along with the development of programs on pollution prevention and municipal water treatment, using both public and private means to achieve such goals, (ix) *manage risks to cope with variability and climate change*, identifying trends and developing early warning systems into order to anticipate floods and droughts, (x) *encourage more efficient service provision* by use of different and innovative forms of service delivery, including setting up self-help programs and cooperative societies, accompanied by effective regulation, benchmarking and monitoring, (xi) *manage water at the lowest appropriate level*, with local stakeholders participating in collaborative management of resources built around a decentralized process of decision making,

implementation and operation of services, (xii) *combat corruption effectively*, along with awareness building programs and maximizing transparency in the decision making process;

(B) Mobilizing Financial Resources: (xiii) *ensure significant increases in all types of funding* for water resource and sanitation projects, including greater allocation from national general budget revenues, water tariffs and charges, external assistance and private investment, (xiv) *strengthen public funding capacities*. Public funding has remained the largest source of investment in water resources, and subsidies will further increase by improved water management and sanitation programs that promote the health and welfare of the community, (xv) *improve economic efficiency to sustain operators and investment* by receiving income from water customers to finance operations, maintenance and capital costs, ensuring that such cost recoveries do not become as barriers to serving the needs of the poor, who should receive a greater percentage of public subsidies and cross-subsidies from other customers, (xvi) *make water attractive to private investment* as a means to augment public expenditures on water management and sanitation programs, especially for capital costs associated with water utilities, waste water treatment plants, irrigation projects, etc, (xvii) *increase development assistance to water* from the international donor and lending community, especially to developing and transition countries to serve in a catalytic role, to build capacity and in helping local and regional institutions to develop their own water management solutions and models, (xviii) *focus education and training on water wisdom* by integrating local and traditional knowledge with that of different professionals, disciplines and hands-on practitioners, while building human resources development through primary/secondary schools, vocational training, university education, continuing education and strengthening research capacity, (xix) *focus research and information management on problem solving*, with the sharing of knowledge and information on water management on a interdisciplinary basis and by the development of indicators and benchmarks for assessing progress made in achieving relevant targets and national goals, (xx) *make water institutions more effective*, by encouraging capacity building and providing technical assistance to develop integrated water management programs and to bring about successful institutional changes and governance structures at the community level, (xxi) *share knowledge and innovative technologies* by incorporating appropriate technologies for a whole range of water resources management and service delivery that is made available on an equitable basis, along with reviving traditional and indigenous water related knowledge around the world;

(C) Sectoral Roles: (xxii) *Governments* – especially local governments should play a more active role in water management and governance, applying internationally recognized principles, legislations and regulatory standards, while keeping local and regional social, economic and cultural differences in mind, (xxiii) *Local Communities* – are better equipped to understand and manage water resources issues in their community, so that concerted efforts should be made to enhance local capacities and knowledge, secure rights, develop leadership, decrease inequalities and provide access to appropriate technologies and financial resources, (xxiv) *Workers and Trade Unions* – should be included in the decision making process, especially in joint advisory and governance committees, along with the adoption and implementation of core labor standards, (xxv) *Non-Governmental Organizations* – should continue to participate in the policy making and implementation process, to represent the interests of stakeholder and advocacy groups on a variety of issues that hold government institutions and decision makers accountable to the community, (xxvi) *Private Sector* – ranging from multinational companies to small local providers and financial institutions, who should contribute actively to sustainable governance, financial resources, service provision and capacity building in water management, carried out in a socially, environmentally and ethically acceptable manner, (xxvii) *International Community* – including the United Nations and other multilateral agencies, which should strengthen their commitment to developing sustainable water management programs around the world, while playing a catalytic role for reform, poverty eradication and capacity building by mobilizing technical knowledge and financial resources in an open and inclusive manner.

II. Air Quality and Human Health

(A) Overview

Air pollution continues to be a major environmental problem in many regions of the world today. In the past two to three decades, with increasing urbanization and industrialization in developing countries, the steady decline of air quality poses a significant threat to health for large segments of human populations. In many urban areas of Asia, Latin America and Africa, deteriorating air quality has been associated with rapidly rising population growth and increased use of motor vehicles, coupled with inadequately regulated emissions of air pollutants from industrial plants and power generating facilities. Annually, air pollution accounts for an estimated 3 million deaths, which is about 5% of the 55 million deaths that occur worldwide each year.

The World Health Organization (WHO) estimates that as many as 1.4 billion urban residents globally are exposed to outdoor polluted air that exceed WHO air quality guidelines, including sulfur dioxide, nitrogen dioxide and particulate matter. In addition, in many heavily populated regions, such as China and India, indoor air pollution poses an even greater threat to human health, especially among household women and children who tend to spend more time at home. Indoor air pollution often occurs when residents living in poorly ventilated homes are exposed to excessive smoke and a variety of airborne pollutants that arise from fuel burning sources, such as cook-stoves and other heat producing devices. It is estimated that some 3.5 billion rural residents globally are exposed to high levels of indoor air pollutants, which have been designated by the World Bank as one of the four most critical public health problems worldwide (the other three are waterborne diseases, HIV/AIDS and tobacco use and smoking.)

In the past several decades, air quality has generally improved in many developed countries in North America and Europe. However, the continuing elevated levels of certain air pollutants in urban and industrial areas still remain a major public health problem in developed regions, especially among young children, the elderly and other vulnerable segments of the population. For instance, in the United States, air pollution continues to account for approximately 60,000 deaths each year, caused principally by gaseous and particulate emissions from motor vehicles and other fossil fuel burning sources. In developed countries, greater attention has been paid by regulatory agencies in recent years to reduce the concentration of fine particulate matter and photochemical oxidants in the atmosphere, which cause a number of serious acute and chronic respiratory diseases. Among the major sources of high levels of airborne fine particulates (less than 2.5 micrometers in diameter) in developed countries are electric power generating plants, metal refining processes and diesel-engine motor vehicles.

B. Clean and Degraded Air

(i) *General Characteristics of Earth's Atmosphere*

The earth's lower atmosphere (known as the troposphere) is principally comprised of oxygen (21%) and nitrogen (78%), along with trace amounts of other airborne substances, such as argon (0.93%) and carbon dioxide (0.03%). In addition, the amount of water vapor present in the atmosphere (as high as 4% by volume) varies by place and time. Oxygen, nitrogen and carbon dioxide in the atmosphere are part of a vast global and regional bio-geochemical nutrient cycle, whereby these naturally occurring gaseous compounds are produced, dispersed, exchanged and re-absorbed by plant, animal and microbial species on earth's oceanic and land surfaces. Atmospheric water vapor results from gaseous evaporation and windborne transport from oceans, lakes and streams, which in turn is condensed back to earth's surface

in the form of precipitation (rain, hail and snow), forming a large global and regional hydrological cycle. Water vapor is also formed by respiration of living organisms and through other biochemical reactions.

In addition to the gaseous substances and water vapor that are part of earth's nutrient and hydrological cycles, small amounts of naturally occurring chemical substances are often found in the atmosphere of certain regions. These include certain airborne inorganic and organic substances, such as radioactive radon gas (through underground soil seepage), metal mercury (from rock erosions and volcanic eruptions) and plant-based terpenoids (from tree and shrub leaf dispersals). While the background concentrations of these airborne compounds may be harmful to human health in some instances (e.g., high exposure levels to radon gas in home basements in certain regions), they generally do not constitute a major environmental health risk to human populations.

(ii) ***Degradation of Air Quality***

Air pollution was recognized as a major public health problem in the 1940s and 1950s when large numbers of individuals in industrial or urban centers in North America and Europe became seriously ill or died from exposure to a variety of toxic air pollutants that were emitted from manufacturing and domestic sources. In 1948, a severe air pollution episode occurred in a small steel mill town of Donora, Pennsylvania (on the outskirts of Pittsburgh), which resulted in acute respiratory illnesses among a large fraction of the population and in the deaths of scores of inhabitants. In 1952, an estimated 4,000 deaths were attributed to the dense "killer fog" that blanketed London, England for several days, most of it caused by emissions from numerous commercial and residential fossil fuel combustion sources within the city.

Since these well-publicized air pollution episodes, many developed countries have adopted stringent air quality standards to safeguard the public from the most commonly occurring and widespread airborne pollutants. These include sulfur dioxide, nitrogen dioxide, particulate matter, carbon monoxide, ground-level ozone (photochemical oxidants) and lead. In the United States, under its air quality regulatory framework, these commonly found airborne gaseous substances and particles are collectively known as "*criteria air pollutants*", to distinguish them from other atmospheric pollutants that are found in specific industrial or urban locations. Other non-criteria or "*toxic air pollutants*", which are present at high concentration levels in specific regions, consist of heavy metals (cadmium, chromium, mercury, etc) volatile organic compounds (VOCs, such as benzene, methylene chloride, perchloroethylene, etc) and other toxic airborne substances (asbestos, pesticide vapors, etc.).

(C) Criteria Air Pollutants

As mentioned above, the class of air pollutants known as "criteria air pollutants", which are ubiquitous and commonly found in the atmosphere in almost all regions of the globe, are airborne substances that have adverse acute and/or chronic impacts on human health. The emission sources, physical-chemical characteristics and human health effects of each of the criteria air pollutants are discussed below.

(i) ***Sulfur Dioxide***

As one of the most common and ubiquitous air pollutants that originate from industrial, commercial and residential sources, sulfur dioxide (SO_2) is formed by the combustion of fossil fuels that have high sulfur content, such as certain grades of oil and coal. Sulfur dioxide can be further oxidized to sulfur trioxide (SO_3), which rapidly reacts with atmospheric water vapor to form airborne sulfuric acid (H_2SO_4). The formation of sulfuric acid results in the secondary formation of acid aerosols, which is the main cause of acid precipitation (such as acid rain or acid snow) in certain parts of the industrialized world, especially

in northeastern United States and Canada and in northern continental Europe and the Scandinavian countries.

Health effects associated with sulfur dioxide exposure include interference with normal breathing, alteration of pulmonary defense mechanisms and the aggravation of existing cardiovascular diseases. These health effects are more pronounced in young children and the elderly, and in those individuals who suffer from asthma, chronic bronchitis and emphysema. Short term exposure to high levels of sulfur dioxide in a population may lead to increased hospitalization and excess incidence of deaths from a variety of respiratory and cardiovascular diseases. Since sulfur dioxide is often secondarily oxidized to acid aerosols, it is difficult at times to separate its overall health effects from those associated with exposure to fine particulate matter that contain hydrated aerosol particles.

While in recent years the concentration of sulfur dioxide has declined in North America and Western Europe, it still remains high in Eastern Europe and in many urban and industrialized centers of Asia and Latin America. For instance, in a number of industrial centers and major cities of India and China, the ambient (i.e., the surrounding atmosphere's) annual average concentration levels of sulfur dioxide are two- to six-fold above the WHO's SO_2 air quality guidelines of 50 micrograms per cubic meter. The United States Environmental Protection Agency (USEPA) has established a national ambient air quality standard for sulfur dioxide at an annual arithmetic mean of 80 microgram per cubic meter, along with short term air quality standards for 24-hour and 3-hour averages (365 and 1,300 micrograms per cubic meter, respectively.)

(ii) ***Particulate Matter***

Traditionally, particulate matter as a criteria air pollutant was considered as a dispersed mixture of:: (a) the heavier, coarse-sized solid or liquid particles that are derived mainly from naturally occurring sources, such as wind-blown dust, sea sprays, plant particles, etc., and (b) the lighter, fine particulate fraction, which is principally a product of human activity, such as industrial processing and fossil fuel combustion. Generally speaking, fine particles have aerodynamic diameters less than 2.5 micrometers in size (approximately, $1/30^{th}$ the size of a human hair) and remain in the atmosphere for relatively long periods of time and are transported over long distances, while airborne solid matter or liquid droplets above 5 to 10 micrometers in diameter quickly settle out by gravitational sedimentation near the emission source.

Fine particles constitute the most respirable and harmful fraction of atmospheric particulate matter, since they are small enough to evade the respiratory system's clearance mechanism for removing coarser particles, allowing them to penetrate and deposit into the deeper (alveolar) regions of the lung. Fine particles consist of a variety of toxic vapors, liquids and gases that are either absorbed on solid particulate surfaces or are embedded in liquid aerosols. Thus, they contain a mixture of heavy metal ions, hazardous organic vapors and acid aerosols, with the relative proportions of these chemical substances varying from region to region. For instance, in areas that are downwind from electric power generating plants and metallic ore processing operations, atmospheric fine particles generally contains a higher proportion of sulfuric and nitric acids, formed by the secondary oxidation and hydration of sulfur dioxide and nitrogen dioxide.

A large body of scientific studies has shown the linkage between fine particulate matter exposure and a variety of respiratory diseases, including shortness of breath, bronchitis, asthma and premature deaths. Young children, who breathe 50% more air per body weight than an adult, are especially vulnerable to the environmental impacts of particulate matter. Several acute and chronic respiratory illnesses, including childhood asthma, have been attributed to exposure to fine particles. High levels of

atmospheric fine particles also seriously affect the elderly, particularly those with immune system deficiencies or those who have underlying respiratory or cardiovascular diseases.

Until ten or fifteen years ago, most countries only used a total suspended particle (TSP) air quality standard to regulate the levels of atmospheric particulate matter. Unfortunately, the use of TSP to monitor the level of atmospheric fine particles had been demonstrated to be misleading, especially in regions of the world where there were high levels of naturally occurring coarser particles, such as windblown dust or sea sprays. In recent years, a number of regulatory agencies have moved to adopt new health-based air quality standards on particulate matter. For example, the U.S. Environmental Protection Agency in 1987 revoked its TSP standard and enacted instead a PM10 national ambient air quality standard (at an annual arithmetic mean of 50 micrograms per cubic meter), which required specific monitoring of particulate matter below 10 micrometers in diameter.

In 1997, to provide additional protection of the general population, the USEPA proposed a fine particulate matter national ambient air quality standard of PM2.5 (at an annual arithmetic mean of 15 micrograms per cubic meter), whereby the air monitoring of fine particles below 2.5 micrometer was required. This is based on recognition by the public health community that current particulate matter standards (TSP or PM10) are not sufficiently protective of human health. Moreover, the USEPA has issued a short-term PM10 air quality standard (at a 24-hour average of 150 micrograms per cubic meter) and proposed a short-term PM2.5 air quality standard (at a 24-hour average of 65 micrograms per cubic meter). At present, both WHO and the European Commission are reviewing the replacement of TSP air quality guidelines by establishing a health-based fine particle guideline and recommending a monitoring system of using PM10 and/or PM2.5 as appropriate public health yardsticks.

(iii) ***Nitrogen Dioxide***

Nitrogen dioxide (NO_2) is a gaseous compound, which is an oxidation by-product of naturally occurring atmospheric nitrogen and oxygen, formed during high temperature combustion processes. Thus, it is a result of a variety of industrial, commercial and residential activities, such as production of steam in electric power generating and manufacturing plants and the use of gasoline products in internal combustion engines of motor vehicles. Since nitrogen dioxide is a dark colored gas, its presence at high levels in the atmosphere is often noted in industrial and urban areas by the familiar brown haze that tends to hover over the region. During the combustion process, nitrogen dioxide is initially formed from its precursor compound, nitrogen oxide (NO), and therefore it is often found in a mixture of various oxidized states of the compound, known collectively as nitrogen oxides (NO_x). Further chemical oxidation and hydration of nitrogen oxide compounds produces atmospheric nitric acid (HNO_3), which is a major aerosolized component (droplets of air/liquid mixtures) of particulate matter that form acid precipitation in a number of regions of the world.

The environmental impact of nitrogen dioxide on human health may be viewed both directly and indirectly. At relatively high concentrations, nitrogen dioxide causes direct acute effects on respiratory tracts and mucous membranes of both adults and children, such as nose, throat and eye irritations. However, its main long-term health impacts are largely indirect, since it participates in the formation of ground level photochemical smog by reacting with volatile organic compounds, and in the formation of highly corrosive nitric acid which then becomes part of the fine particulate fraction in the atmosphere. At present, the WHO health-based air quality guideline for nitrogen dioxide is 40 micrograms per cubic meter (annual average), while the USEPA has established an annual (arithmetic mean) average of 100 micrograms per cubic meter as its national ambient air quality standard for nitrogen dioxide.

(iv) *Ozone (Photochemical Oxidants)*

As a gaseous substance, ozone (O_3) contains three atoms of oxygen (arranged in an unstable, ring structure) and is a highly reactive chemical compound found in the atmospheric smog of many regions of the world. In the stratosphere (a region some 10 to 30 miles above the earth's surface), ozone is found as a naturally occurring substance that forms a protective layer against the sun's harmful ultraviolet radiation. However, in the lower atmosphere at the earth's surface, ozone -- along with other photochemical oxidants -- are a product of a number of anthropogenic activities. They are formed by photochemical oxidation (i.e., atmospheric chemical reactions that are catalyzed by sunlight) of a variety of airborne compounds, such as: (a) hydrocarbon gases that are emitted from power plants, oil refineries, chemical plants, motor vehicles, etc, and (b) nitrogen oxides that are produced from similar industrial and residential sources. While there are many different kinds of reactive chemical substances found in smog, ozone is generally chosen as a surrogate measure of the levels of photochemical oxidants in the lower atmosphere.

At a general rule, atmospheric ozone levels reach their highest concentration during daytime hours and during the summer months when sunlight is at its brightest. High levels of ambient ozone concentration in a community have been correlated with increased incidence of respiratory illnesses and elevated hospital admission rates. Short-term exposure to elevated levels of ozone causes upper respiratory tract irritation and uncomfortable chest distress that may last for several hours. Increased ozone levels may interfere with overall lung function, especially among athletes and those who work outdoors. High levels of ozone may increase the incidence of asthma in a population and may make individuals more susceptible to a variety of allergens, such as exposure to dust mites, cockroaches, pets, fungus, pollen, etc. Other health impacts of ozone include long-term damage to lung linings and the aggravation of other lung diseases, such as chronic bronchitis and emphysema. It is believed that repeated short-term exposure to elevated levels of ozone and other photochemical oxidants may lead to permanent health damage, especially among young children whose lungs are still not fully developed.

At present, the WHO air quality guideline on ozone is 120 micrograms per cubic meter for an 8-hour exposure period. The USEPA has adopted 1-hour average at 235 micrograms per cubic meter (0.12 ppm) as its national ambient air quality standard for ozone. In recent years, the U.S. EPA has also proposed an 8-hour average of 157 micrograms per cubic meter (0.08 ppm) as an additional national ambient air quality standard for ozone.

(v) *Carbon Monoxide*

Carbon monoxide (CO) is a highly toxic, colorless and odorless gas. It is principally formed as an incomplete combustion product of carbon-based sources (gasoline and diesel fuels) used in motor vehicles. In many urban environments, as much as 95% of carbon monoxide present in the atmosphere comes from motor vehicle exhausts. Thus, its atmospheric concentration levels are especially high in heavily used roadways and during morning and evening rush hours. Other significant emission sources of carbon monoxide are the boilers and incinerators employed in industrial and fuel combustion processes.

Over the years, the health impacts of carbon monoxide have been well characterized. Carbon monoxide enters the bloodstream through inhalation and reduces the amount of oxygen that is delivered to organs and tissues of the body. Physiologically, carbon monoxide binds to hemoglobin (Hb), an oxygen-binding protein found in the bloodstream, by displacing oxygen to form carboxyhemoglobin (Hb-CO). Thus, carbon monoxide decreases the ability of hemoglobin to carry fresh, inhaled oxygen to other parts of the body. Exposure to elevated levels of carbon monoxide may therefore affect capacity to work, impair

manual dexterity, reduce learning ability and cause visual impairment. In addition, acute health effects of carbon monoxide exposure at even moderate amounts may be serious to individuals with underlying cardiovascular diseases.

WHO has recommended several health-based short-term air quality guidelines for carbon monoxide – at 10, 30, 60 and 100 milligrams per cubic meter for 8-hour, 1-hour, 30-minute and 15 minute averages, respectively. On the other hand, the U.S.EPA has only two short term national ambient air quality standards for carbon monoxide: 10 and 40 milligrams per cubic meter for 8-hour and 1-hour averages.

(vi) ***Lead***

Lead is a naturally occurring metallic substance that has been incorporated into a variety of handicrafts, water pipings, ceramic glazes, household paints and other manufactured products over two or three thousand years. However, its toxic effects on human populations have only been recognized fully in the past 50 to 100 years. Today, lead is present in many old housing structures and contaminated industrial sites, and it continues to be used in many consumer products, such as paints and ceramic glazes. The main source of lead in the atmosphere is exhaust from motor vehicles that employ lead compounds as an antiknock additive in gasoline products. While in recent years lead additives in gasoline have been phased out in many developed countries in North America and Western Europe, it is still being used in many Eastern European countries and in most developing regions of the world.

The health effect of lead has been well documented in both adults and children. Its impacts are especially severe on young children, since it is a neuro-toxic agent that impairs the normal development of the central nervous system. At relatively low exposure levels, lead has been shown to affect the cognitive skills of children – a 10 micrograms per deciliter increase in blood lead level caused a decline of about 2.5 IQ points in lead-exposed children. Chronic lead exposure may also result in decreased growth, hyperactivity and impaired hearing in children. Short-term high levels of lead exposure may cause permanent brain damage in children and on occasion result in death. At present, in many regions of the developing world, blood lead levels in children below five years old continue to exceed 10 micrograms per deciliter, which is the health advisory guideline established by the U.S. Centers for Disease Control and Prevention (USCDC) for safeguarding children from long-term ill effects of lead exposure.

The current WHO health-based air quality guideline for lead is an annual average of 0.5 microgram per cubic meter. The USEPA has adopted a national ambient air quality standard for lead of 1.5 microgram per cubic meter averaged quarterly each year.

(D) Toxic Air Pollutants

Toxic air pollutants are a large and diverse class of hazardous airborne substances that range from heavy metals, volatile organic compounds, and other atmospheric suspended substances, including a number of insecticide and herbicide vapors, inorganic mineral fibers and radionuclides.

(i) ***Heavy Metals***

While a number of toxic heavy metals are found in the atmosphere, their airborne concentration levels vary markedly from region to region. Airborne heavy metals consist of arsenic, beryllium, cadmium, chromium, copper, lead, mercury, nickel, selenium, vanadium and zinc. Heavy metals are emitted into the atmosphere ore smelters, ferrous and non-ferrous industries, coal-fired power plants, metal foundries and a variety of manufacturing facilities. Each heavy metal -- and their various compounds -- has

different physical and chemical properties and thus possesses diverse toxicological characteristics. For instance, both mercury and lead are well known neurotoxic agents, while arsenic, beryllium and chromium VI are potent carcinogens. Exposure to airborne cadmium has been associated with kidney disorders, chronic bronchitis, emphysema and lung cancer. Nickel fumes cause eye and skin irritation and can lead to pneumonia-like symptoms, while chronic exposure to nickel is associated with nasal, throat and lung cancer. On the other hand, low concentration levels of copper, selenium and zinc have important nutritional value to animals and humans, but at higher exposure levels they can exhibit quite toxic effects. Therefore, it is not possible to generalize about the health effects of heavy metals as a group, since their risk profiles are assessed on an individual basis in order to determine their specific toxic impact on human populations.

(ii) ***Volatile Organic Compounds***

This group of toxic air pollutants constitutes a vast number of organic chemical substances that range from highly volatile solvents (such as benzene, methylene chloride, perchloroethylene, etc.) to complex polyaromatic compounds (multiple-cyclic organic chemicals, such as dioxins and furans). The chief emission sources of these volatile organic compounds (VOCs) are petroleum refineries, coke ovens, chemical manufacturing and processing plants, motor vehicle exhausts, municipal and hazardous waste incinerators and a number of industrial facilities and commercial outlets, such as tanning factories, dry cleaning establishments and gasoline stations. Short-term exposure to high levels of VOCs may cause headaches, dizziness, nausea and abdominal distress, while long-term chronic exposure may lead to an array of neurological diseases, reproductive failures, developmental abnormalities, genetic damage and cancers.

(iii) ***Other Air Toxics***

A number of insecticides and herbicides used in agriculture, forests and domestic settings can remain airborne for considerable periods of time and thus adversely affect animal and human populations that live in proximity to commercial and residential spraying. At present, in many developed countries, a number of non-biological degradable pesticides (such as DDT, aldrin, dieldrin, chlordane, etc) have been phased out for their long-term chronic impact on human populations, while under a new international treaty (the recently signed Persistent Organic Pollutants (POPs) Treaty) a worldwide campaign has been launched to discard the remaining stockpiles of POPs and rapidly phase out the commercial and residential use of these toxic substances.

Another common hazardous airborne substance is asbestos fiber, whose microscopically small aerodynamic diameter allows it to penetrate deeply into the alveolar region of human lungs. In the past, asbestos was used extensively in many commercial and residential applications, mainly as an acoustical and thermal insulator (in floor and ceiling tiles, cement pipes, etc.) and as a fire proofing material in building structures. Over time, asbestos fibers in these buildings became frayed and loose, thus allowing them to become airborne in both the interior and exterior of human dwellings. Chronic exposure to airborne asbestos fibers has been conclusively linked in many occupational health studies to a variety of diseases, including asbestosis (a debilitating respiratory disease), mesothelioma (abdominal carcinoma) and lung cancer .

Finally, certain biologically harmful radionuclides (such as Iodine-131, Cesium-137, Polonium-210, Strontium-90, etc) are released into the atmosphere in trace amounts from nuclear power plants and uranium processing facilities, and in considerably higher amounts during above ground nuclear weapons testing. On the other hand, the radionuclide gas, radon (which is a potential carcinogen) is present in the

interior air of buildings and residences in certain geographical regions where it occurs naturally at high concentrations in the underlying soil substratum.

(E) Indoor Air Pollution

(i) *Developing Regions*

In recent years, there has been a growing recognition that in addition to deteriorating outdoor air quality in many parts of the world, indoor air pollution is a major public health problem, especially in rural populated areas of developing regions. A significant factor here is the almost exclusive reliance of rural populations on traditional forms of energy sources, such as biomass fuels that produce high levels of harmful air pollutants in indoor environments, e.g., gaseous fumes, smoke and fine particulate matter emitted from cooking stoves and other heat producing devices. It is estimated that currently 2 billion people around the world use biomass fuels (such as firewood, dung and crop residues), and other fossil fuel products (such as low grade coal and charcoal), to cook their meals and heat their homes. Recent studies have shown that in developing countries such as India and China, indoor air pollution poses a major risk factor on their national burden of disease. For example, using conservative assumptions of use patterns in the rural sector of India, it was determined that between 400,000 and 550,000 premature deaths annually may be attributed to the use of biomass fuels. Employing the World Bank's disability-adjusted lost life-year (DALY) approach, between 4 and 6 percent of India's burden of disease is linked to the use of biomass fuels in the country. Earlier studies had shown that particulate matter concentration levels (monitored as PM10) of over 2,000 micrograms per cubic meter (averaged over a 24-hour period) were measured in indoor dwellings among the rural population, with short-term PM10 levels rising considerably higher during cooking periods. This should be compared to the annual average atmospheric concentration levels of PM10 ranging between 90 and 600 micrograms per cubic meter (with a population mean of 200 micrograms per cubic meter) in the outdoor air of many Indian cities and urban areas.

In addition to the use of traditional biomass fuels, coal is still widely used in many regions of Eastern Europe, China and South Africa. While coal products are easier to obtain, transport and store, they are a considerably less clean source of fuel than firewood. For the past twenty years, a number of national and international programs have been initiated to introduce clean fuels and cooking stoves around the world. Since the early 1980s, China has embarked on a major national effort to introduce improved cooking stoves to over 175 million rural households. A similar effort in India, under the aegis of National Programme on Improved Chulhas (cooking stoves), has led to distribution of 30 million improved stoves. Unfortunately, in a follow-up survey, it was found that less than one-third of such stoves were still in use in India. It now appears that many former recipients in rural areas remained unconvinced of the stove's overall energy efficiency and its ability to produce less smoke. The greater success of this approach in China may be attributed to superior program design and implementation, such as better education and training, less bureaucratic interference, with more user involvement in the construction of stoves for convenience, attractiveness and longevity.

(ii) *Developed Regions*

Indoor air pollution has also been recognized as an environmental health problem in many developed countries. Myriad air pollution sources reside in the interiors of buildings and residential homes, including gas-, coal-, wood- and kerosene-based stoves (buildup of carbon monoxide and nitrogen dioxide), building materials (asbestos floor and ceiling tiles), furnishings (volatile chemicals used in carpeting, drapes, upholstery), furniture and paneling (urea-formaldehyde resins used in pressed wood), household products (toxic chemicals used in cleaners, paints, solvents, insect sprays), household

allergens (dust mites, molds, mildew, pet and insect residues), humidifiers (use of ultrasonic and impeller units), central heating and cooling systems, second-hand tobacco smoke, and radon gas seepage in residential basements. With buildings and homes now being built with more tightly sealed interiors, acute and chronic exposure to these indoor air pollutants has increased in recent years. This factor coupled with inadequate ventilating systems in the workplace and residential homes has enhanced the potential for serious respiratory illness for adults and children. Practical solutions to these problems include eliminating (where possible) the sources of indoor air pollutants, increasing the dwelling's air exchange rate with the outdoors (opening windows, unblocking air supply vents), cleaning humidifiers and ventilation systems, and installing air cleaning devices.

A number of physical symptoms and diseases have been associated with indoor air pollution in the working environment of office buildings in developed countries. These include serious illnesses such as asthma, hypersensitivity pneumonitis, humidifier fever and Legionnaire's disease. More often, individuals working or residing in poorly maintained or inadequately ventilated buildings may not manifest any specific pattern of disease, but suffer from a variety of physical symptoms, collectively labeled as the "sick building syndrome". Such persons may experience a variety of different symptoms: headaches; dizziness; nausea; dryness or burning sensation in their eyes, nose or throat; a general sense of lethargy or fatigue; frequent sneezing; stuffy or runny nose; irritability; and forgetfulness. Frequently, these symptoms may affect workers when they enter a building and then dissipates when they leave the premises. WHO has estimated that as many as 30% of new or remodeled buildings today may have occupants who suffer from physical symptoms associated with poor indoor air quality.

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III. Toxic Substances, Pesticides and Hazardous Wastes

(A) Overview

Since the beginning of the industrial revolution in Europe in the late 18th century, there has been a dramatic increase in the synthesis, production and use of chemical substances that were incorporated into numerous industrial, commercial and consumer products of modern society. Over 50,000 chemical substances are produced, transported and consumed today, with several thousand new chemicals entering the marketplace each year. While the acute and chronic toxicological properties of these commercially useful chemical substances have been identified in some instances, the vast majority of these compounds have not been adequately tested for their harmful effects on human population. In addition, a large number of synthetic pesticides are used in agricultural production and for domestic purposes, such as insecticides, herbicides and fungicides, whose primary purpose is to eradicate harmful insects, weeds, fungi and other microbial agents. However, by their very nature of being chemically toxic to animal and plant species, these pesticide products often pose unnecessary health risks to other biological organisms, including human populations and domesticated animals.

One of the unfortunate byproducts of the large production and use of chemical substances in modern society is the growing problem of solid and hazardous waste disposal in many developed and rapidly developing regions of the world. In a number of regions today, municipal landfills and waste incinerators have reached peak capacities and cannot continue to receive further supplies of discarded and unwanted materials. It is now apparent that without concerted public and private programs to reduce today's solid waste stream, through innovative industrial process design and by the introduction of wide-scale recycling of household materials, many regions will soon be unable to handle the solid and hazardous wastes of an increasing global population whose annual consumption rates continue to grow. Even in many European countries where such innovative industrial and residential programs has been in use for several decades, the amount of solid waste increased by 10 percent in the first five years of the 1990s, accounting for the production of 5 metric tons of waste material per person per year.

In many countries of North America and Europe, including United States and Canada, a large number of underground aquifers and drinking water wells have become seriously contaminated from leakage of hazardous wastes materials that were once placed in unlined lagoons, industrial pits and unsecured, open landfills. In addition, agricultural runoffs of chemical fertilizers and pesticides have polluted streams and lakes in many rural and suburban regions of developed countries, posing further health risks to both adults and children in these communities. While contaminated underground water supplies have not been identified as a major public health problem in most developing countries as yet, in a few decades this may also be recognized as a critical environmental issue. This problem will be especially serious in many developing countries in Asia, Africa and Latin America, since their means of hazardous waste removal have followed similar land use disposal patterns that were carried out in industrialized countries of North America and Europe.

(B) Toxic Substances

(i) *Production and Consumption of Chemical Substances*

Currently, a large number of inorganic and organic chemical compounds are produced, processed, transported, consumed and disposed of through a chain of manufacturing and processing plants, oil refineries, commercial outlets, agricultural farmlands and residential homes. They include a variety of industrial chemicals and polymers, petroleum distillates, pharmaceuticals, pesticides, synthetic fertilizers and a vast cornucopia of consumer products. Chemical compounds are incorporated into an almost

infinite array of human-made products -- ranging from earth circling satellites, warships and airplanes to laptop computers, cellular phones, diesel fuel, car seats, nylon stockings, prescription drugs, insect sprays, fat-free beverages, vitamins and food supplements, floppy disks and CDs, books and magazines, etc. Nothing bought or sold in modern society has escaped the almost ubiquitous impact that chemical substances have had on our consumer-based economies. However, the price for the introduction of such a limitless number of chemical substances, petroleum byproducts and synthetic polymers is their overall environmental health impact on human populations.

(ii) ***Toxicological Characteristics***

To begin with, all chemical substances have potential toxic ill effects on animals and humans, depending on the mode of ingestion, the concentration level and duration of exposure, and the sensitivity of the exposed individual. For example, even pure water can be fatal if directly injected into the bloodstream at sufficient amounts, since it would cause widespread destruction of red blood cells by critically diluting the salt concentration of blood plasma. Many heavy metals, such as copper and zinc, are nutritionally beneficial for humans, but if ingested in high doses may have serious toxicological side effects. Similarly, naturally occurring fat-soluble vitamins that are necessary in human diets may have ill effects when taken in artificially large doses for extended periods of time.

Individual susceptibility to chemical substances is a common observation in human clinical drug trials and in laboratory toxicity tests conducted on animals. While some adults are able to tolerate the harmful effects of a chemical substance at high doses, others become acutely ill even when exposed to small amounts of the compound. For these reasons, when defining the harmful properties of chemical substances, toxicologists generally identify their ill effects by developing a percentile basis for assessing the acute effects of a specific compound. For example, a frequently used measure of the acute effect of a toxic substance is given by its "Lethal Dose 50" (LD50), which indicates the orally ingested dose at which 50% of the tested laboratory animals died after a single, short-term exposure. Thus, assuming that laboratory animals and humans have similar toxicological profiles, the LD50 provides a common scale by which the relative toxicities of different chemical substances may be compared.

The toxicological test results, which are basically designed to determine the toxic ill effects on normal, healthy adults, do not necessarily apply to more vulnerable populations, including young children, the elderly and the chronically sick, and therefore can be highly misleading. For instance, the standard toxicological profile of a chemical substance for an adult should not be used to assess health risks of infants, toddlers and children below the age of five years. At this stage of a young child's life, the organs and tissues of its body are neither physiologically nor biochemically fully established, but are undergoing rapid growth and development. Thus, the child is highly vulnerable to the ill effects of a variety of chemical substances, especially on its lungs, brain and central nervous system. Moreover, on a per body weight basis, the child inhales more air and ingests more water and food than an adult, and therefore its ability to detoxify harmful chemical substances in its body is significantly diminished. Similarly, the elderly or the chronically sick have reduced capacity to withstand the ill effects of toxic substances, since they may have immune system deficiencies and/or underlying respiratory, cardiovascular, liver or kidney disorders that may be aggravated by exposures to relatively low concentrations of harmful materials.

Another important toxicological aspect of a toxic substance is its ability to cause chronic health effects when individuals are exposed to long-term, repeated low doses of a chemical compound. For instance, cancer-causing substances (known as carcinogens) may cause the formation of malignant tumors after long latency periods, some lasting as long as several decades. For instance, the latency period for the development of lung cancer and mesothelioma (cancer of the lung or abdominal lining) from chronic

exposure to asbestos fibers is typically between 15 and 30 years. Similarly, cancer-causing organic compounds found in occupational settings, such as vinyl chloride and acrylonitrile, have reported latency periods in plant workers ranging from 20 to 40 years.

It is now recognized that cancers with long latency periods undergo a multi-step process in the progression of the disease: (a) the *initiation* step, where the carcinogen causes a biochemical change or lesion in the genome of a target cell, (b) the *promotion* step, where under repeated exposure to another chemical substance -- called a "promoter" -- the initiated cell forms other cloned cells in the form of benign tumors (papillomas, polyps, etc), and (c) the *progression* step, where the non-cancerous clonal cells progress into rapidly dividing malignant cells, which allows them to metastasize into the bloodstream, that is, they spread and embed themselves in other organs and tissues of the body. The body has a natural immune defense mechanism against these malignant cells, such as T-lymphocytes, macrophage cells and bloodstream substances called interleukin-2 (or interferon). However, in individuals with severe immune system disorders (such as HIV/AIDS), the defense mechanism is highly compromised and is thus unable to stop the malignancy from spreading to other vital organs and tissues of the body.

(iii) ***Health Effects of Toxic Substances***

In general, the health effects of toxic substances may be divided into two broad categories: (a) *acute effects* -- denoting short-term exposure to chemical compounds at relatively high doses, ranging from a one-time exposure to daily exposures not exceeding two weeks (i.e., sub-acute effects), and (b) *chronic effects* – denoting long-term exposure to chemical compounds at lower doses, ranging from several months (i.e., sub-chronic effects) to a lifetime of cumulative exposure. In other words, the terms "acute" and "chronic" are defined in terms of length of time and concentration levels of exposure, rather than to the severity of the health effects of toxic substances on animals or human beings.

Acute effects may range from temporary discomfort from high dose, short-term exposures (such as headaches, shortness of breath or intestinal disorders) to severe neurological damage (e.g., acute childhood lead poisoning), life-threatening respiratory distress (e.g., onset of asthma from organic solvent fumes), allergic responses (e.g., hypersensitivity to toxic agents) and death (e.g., severe organophosphate pesticide poisoning). Similarly, chronic health effects of toxic substances, in which low dose exposure occurs over several months or even years, may range from relatively mild physical symptoms (such as skin rashes or eye irritations) to a variety of serious, debilitating diseases (such as reproductive failures, developmental abnormalities, kidney and liver disorders, chronic pneumonitis and cancer).

In recent years, a considerable amount of regulatory attention in developed countries has been placed in preventing and controlling health risks associated with carcinogenic or mutagenic (i.e., genetic or developmental) impacts of toxic substances, since their chronic effects are not immediately manifested because of their long latency periods or over a multi-generational time frame. This includes assessing health risks from trace amounts of cancer-causing substances found in air, water, soil, food and other consumer products. Thus, regulatory agencies in many developed countries have established fairly stringent health safety standards for potentially carcinogenic substances. Many of these toxic chemicals are *persistent organic pollutants (POPs)*, such as those found in a number of widely used pesticides and chlorinated hydrocarbons. The major characteristic of POPs is their long-term chemical stability, i.e., they do not break down to form less toxic chemical substances in the environment. Moreover, POPs as a class of compounds do not readily dissolve in water. Thus, they tend to bioconcentrate in the food chain, especially in the fatty tissues of fish and livestocks, posing serious health risks to human populations. Under the recently signed international agreement, the *Stockholm Convention on Persistent Organic*

Pollutants (POPs Treaty), which was adopted in December 2000 in Johannesburg, the following 12 chemicals are to be phased out and eliminated: polychlorinated biphenyls (PCBs), dioxins and furans, aldrin, dieldrin, DDT, endrin, chlordane, hexachlorobenzene, mirex, toxaphene and heptaclor.

More recently, another class of toxic substances, known as *endocrine disrupters*, has been brought to the attention of regulatory agencies in developed countries for its potentially severe long-term impact on both animals and human populations. These toxic substances contain organo-chlorine pesticides, polychlorinated biphenyls, dioxins and furans, and a number of plant-based and synthetic estrogens. By interfering with the endocrine system, these estrogen-mimicking compounds have been associated with developmental disorders and reproductive failures in wildlife animal and fish species, stunting their normal growth and their ability to produce healthy offspring. While the toxicological impact of endocrine disruptors on human populations has not been thoroughly determined, preliminary studies have shown significant declines in the male sperm production in the past few decades. In addition, some researchers believe that recent increases in breast, testicular and prostate cancer, along with increased behavioral disorders in children in many developed countries, may be associated with long-term, chronic exposure to endocrine disruptors, which are found in trace amounts in many fresh water sources and food products. At present, a number of multilateral agencies (for example., WHO, Organization for Economic Cooperation and Development (OECD)), and national regulatory agencies (including U.S. Environmental Protection Agency, the U.S. Department of Agriculture, and Environment Canada) have embarked on a concerted effort to assess the potentially serious harmful effects of endocrine disruptors on human populations.

While the health impact of toxic substances varies from compound to compound, they all possess acute and chronic effects above specific threshold levels of exposure. However, only a small number of chemical compounds have been fully evaluated for their health impacts on human populations. In most cases, only the acute lethal dose of a chemical compound (LD50) is evaluated, but their longer term, sub-chronic or chronic effects are largely unknown. In order to evaluate the overall toxicity of a given compound, a health risk assessment is carried out, which generally follows a four-step approach: (a) *hazard identification*, which determines acute and chronic effects of a substance by conducting animal toxicity tests and/or clinical studies, and by carrying out epidemiological studies to assess health impacts on human population; (b) *dose-response assessment*, which quantifies the health effects by determining the range of exposure levels at which the harmful effects of a toxic substance are observed in animal and human populations; (c) *exposure assessment*, which identifies the route of exposure and the actual concentration levels of a toxic substance in an occupational setting or in the general community; (d) *risk characterization*, which estimates the magnitude and importance of the public health problem associated with the exposure of a toxic substance to human population from a policy or regulatory point of view.

In order to obtain the toxicological profiles of specific chemical compounds, the following comprehensive websites of international organizations and national government agencies are now available to access such information:

(a) *The International Programme on Chemical Safety (IPCS)*, which is a joint activity of the World Health Organization, the United Nations Environment Programme and the International Labor Organization. It was established in 1980 in order to "establish the scientific basis for safe use of chemicals, and to strengthen national capabilities and capacities for chemical safety."

(b) *IARC Monographs Programme on the Evaluation of Carcinogenic Risks to Humans*, is published by the International Agency for Research on Cancer (IARC), a division of the World Health Organization. It is an "authoritative independent assessments by international experts of

the carcinogenic risks posed to humans by a variety of agents, mixtures and exposures." The technical monographs are an important source of information on cancer causing substances for both scientific researchers and regulatory authorities.

(c) *Chemicals Programme* of the Organization for Economic Cooperation and Development (OECD) assists its 30-member countries, primarily in North America and Europe (which includes other developed countries, such as Japan, Australia and New Zealand) in the improvement of chemical safety, and to "make chemical control policies more transparent and efficient" and "prevent unnecessary distortions in the trade of chemicals and chemical products.

(d) *Risk Assessment Information System (RAIS)*, which is managed by the U.S. Environmental Protection Agency (USEPA) by combining information gathered from other agency databases (such as the Integrated Risk Information System (IRIS) and Health Effects Assessment Summary Tables (HEAST)). It contains individual toxicological profiles and literature references for specific chemical substance in complete (formal) and condensed versions.

(e) *Toxicological Profile Information Sheet*, which is produced by the U.S. Agency for Toxic Substances and Disease Registry (ATSDR) for a list of 275 hazardous substances found at National Priorities List (NPL) sites in the United States. At present, 261 toxicological profiles have either been published or are being developed.

(C) Pesticides and Hazardous Wastes

Although there are many different pesticide products available in today's marketplace, their major uses generally fall under the following categories: insecticides, rodenticides, herbicides, fungicides and antimicrobials that are employed to control insects, rodents, weeds, fungi, and bacteria/viruses, respectively. Other minor categories of uses include chemical agents that control algae, mites, nematodes, insect eggs, or those that disrupt insect mating behavior (pheromones), or inhibit insect or plant growth. Chemical substances that are active ingredients of pesticide products are divided into the following categories: (a) *organo-chlorine compounds*, such as DDT, aldrin, endrin, and lindane, which have relatively low acute toxicity, but are often found to be cancer-causing substances that bioaccumulate in the environment (as persistent organic pollutants), (b) *organophosphate compounds*, such as malathion, parathion, methylparathion, which generally possess high acute toxicity as nerve agents (as chemical inhibitors of nerve transmssions), but do not appear to pose cancer risks and are much more biodegradable, (c) *carbamate compounds*, such as carbaryl, carbofuran, thiodicarb, which generally have high acute toxicity and may pose cancer risks, but do not as a rule bioaccumulate in the environment, (d) *metal-based compounds*, such as arsenic, copper, zinc, mercury, lead oxides and their salts, that have the acute and chronic toxicological profiles associated with heavy metals.

At present, large volumes of chemical pesticides are produced and sold globally for agricultural production, forest management and household use. It is estimated that worldwide industrial sales of pesticides were about $33 billion in 1996, while the export of pesticide products from developed to developing countries continues to increase substantially each year. However, the volume of discarded and obsolete pesticide products in many developing regions has skyrocketed in recent years. These include such non-biodegradable organo-chlorine pesticides (such as aldrin, dieldrin, DDT, endrin, HCH, lindane) and the acutely toxic organophosphate pesticides (such as malathion and parathion). The UN's Food and Agriculture Organization has likened the current situation to a "time bomb" and has urgently called upon industry and governments to increase the pace of clean-up of contaminated storage sites. Several hundred thousand metric tons of banned or unwanted pesticides are now stockpiled in waste storage sites around the world awaiting proper treatment and disposal.

Throughout the 1970s and 1980s, while industrialized countries in North America and Europe began to impose stricter controls on their domestic production, use and disposal of toxic substances, pesticides and hazardous wastes, there was a dramatic increase in the export of banned and severely restricted products from developed to developing regions of the world. This led the international community to adopt a series of agreements and conventions that provided voluntary guidelines and regulatory procedures to control the global shipment of toxic substances and hazardous wastes. In 1995, the *International Code of Conduct on the Distribution and Use of Pesticides* was adopted by the Food and Agriculture Organization (FAO), followed in 1987 by the enactment of the *London Guidelines for the Exchange of Information on Chemicals in International Trade* by the United Nations Environment Programme (UNEP).

In 1989, an international regulatory procedure, called the *Prior Informed Consent (PIC)* was adopted to help control the importation of banned or severely restricted products into developing countries, to be jointly implemented by UNEP and FAO. Under PIC, officials in importing countries are required to be informed by the exporter about the toxicological characteristics and regulatory status of potentially hazardous chemicals before shipment of the product to their region. In 1998, the *Rotterdam Convention* was adopted, extending the PIC regulatory procedure to hazardous pesticide products on the list of toxic substances requiring prior informed consent. The Rotterdam Convention provides legally binding assurances that all shipments of dangerous chemicals and pesticides be subject to authorization by importing countries, including provisions for obtaining adequate product labeling and toxicological information on imported goods.

By the late 1970s and early 1980s, most industrialized countries had recognized the serious environmental health problems associated with hazardous waste disposal and had enacted stringent laws to mitigate and/or control the potential contamination of soil and underground aquifers in their regions. Unfortunately, this regulatory move was followed by the proliferation of hazardous waste exports to many countries in developing regions and Eastern Europe. This international trade in toxic substances led to the adoption in 1989 of the *Basel Convention on the Control of Transboundary Movement of Hazardous Wastes and their Disposal.* During the first decade of its enactment, the Basel Convention was mainly used to set up a framework for controlling the shipment of hazardous wastes across international borders and to drafting criteria for “environmentally sound management”. More recently, it has begun to implement and enforce the provisions agreed to under the Convention. It has also encouraged the concept of waste minimization (through an “integrated life-cycle approach”) and the use of cleaner technologies, while developing specific monitoring procedures to reduce the illegal shipment and trafficking in hazardous wastes.

Since the late 1970s in the United States, the industrial, commercial and residential movement of solid and hazardous wastes has been regulated by a comprehensive set of federal and state legislative mandates and regulatory requirements, which encouraged a "cradle to grave" (i.e., production, distribution, use and disposal of commercial products) approach at the local and regional levels. In addition, a national "Superfund" legislation was enacted in 1980, which created a dedicated tax fund on the chemical and petroleum industries to financially assist federal and state governments in the cleanup and remediation of abandoned or uncontrolled hazardous waste disposal sites. Under the "Superfund" regulatory scheme, the U.S.EPA places hazardous waste sites on a National Priority List (NPL) using a Hazard Ranking System (HRS), which is a quantitative screening mechanism for determining which sites to designate on the NPL. However, high HRS scores and placing of a hazardous waste site on NPL of a hazardous waste site does not automatically determine priority funding for cleanup, which generally requires further health-based risk assessment, remedial investigation and technical feasibility studies. At present, the Agency for Toxic Substances and Disease Registry (ATSDR) of the U.S. Department of

Health and Human Services (HHS) provides background fact sheets and technical summary reports, including acute and chronic toxicity data on the list of toxic substances that have been identified at hazardous waste sites. In addition, ATSDR provides health-based assessments of hazardous waste sites, responds to emergency releases of hazardous substances, conducts education and training programs and disseminates information to the general public.

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IV. Climate Change and Human Health

(A) Overview

In recent years, a number of scientific measurements and technical assessment studies have shown how global climate change within this century may have potentially serious impacts on human population. These climate-related effects include the rise of atmospheric concentrations of greenhouse gases, such as carbon dioxide and methane, and the possible loss of stratospheric ozone. It is currently believed that increases of greenhouse gases in the atmosphere may lead to widespread global warming by the middle or late part of the 21st century, which could drastically change local and regional weather patterns, leading to a number of significant environmental and public health impacts. These include increases in heat-related stress, movement of vector-borne diseases (such as malaria and dengue fever) to northern latitudes, higher production of certain allergens and air pollutants, interference of agricultural production, changes in forestry patterns, greater incidences of extreme weather events (such as storms, floods and drought), and uncontrollable sea-level rise on coastal populations.

With global and regional losses of stratospheric ozone, an increase in ground-level exposure to harmful ultraviolet radiation would ensue, leading to increased incidences of skin cancer, cataracts and probable suppression of the body's immune system. In addition, increased ultraviolet radiation on the earth's surface from the depletion of stratospheric ozone would lead to increased levels of ground-level ozone and other photochemical oxidants, which have a variety harmful effects on human health.

(B) Greenhouse Gases and Global Warming

(i) *Causes and Extent of Global Warming*

Since the beginning of life on earth, the lower atmosphere (troposphere) has essentially functioned as a natural "greenhouse", by trapping infrared-absorbing gases -- such as carbon dioxide, methane, nitrous oxide, halocarbons and water vapor -- and preventing them from dissipating into outer space or rapidly recycling back to the land or oceanic surface of the earth. Because of the presence of these heat-trapping gases, the average surface air temperature of the earth is approximately 15 degrees Celsius, significantly higher than the projected freezing temperature of (minus) 18 degrees Celsius, which would have occurred in the absence of greenhouse gases. However, since the start of the industrial revolution in Europe in the late 17th century, emissions of these greenhouse gases have risen exponentially to the present unprecedented levels. For instance, atmospheric levels of carbon dioxide (which is the major component of greenhouse gases that cause global warming) have increased 31% since the mid-1700s. This air concentration of carbon dioxide (over 360 ppm) is considerably higher than at any period in the earth's history for at least the past 160,000 to 420,000 years, when human beings first appeared on the globe.

According to the Intergovernmental Panel on Climate Change (IPCC) Third Assessment Report (2001), at current trends of annual increases in greenhouse gas emissions, the average surface temperature of the earth could increase between 1.4 and 5.8 degrees Celsius by the end of 21st century as compared to temperature levels in the 1990s. The Panel concluded that the global average surface temperature has increased around 0.6 degrees Celsius over the last century. By 2100, the range of temperatures on the earth's surface would be as high as it has been in the last 10,000 years. Such a dramatic increase in earth's surface temperature would significantly affect the global climate system, causing potentially catastrophic environmental and public health impacts at the local and regional level in many parts of the globe. The IPCC Assessment projects that by the middle of the next century, precipitation levels over the

mid to high latitudes in the northern hemisphere will most likely increase, while other regions of the globe, such as Asia and Africa, may experience widespread droughts.

The global climate phenomenon known as El Nino -- a periodic warming of oceanic waters off the South American Pacific coastline -- will be more frequent and of greater intensity than has been recorded in recent years. The cyclical appearance of El Nino (occurring every two to seven years) has major impacts on the regional variation of precipitation and temperatures over the tropical and mid-latitudinal regions of the world. For instance, in recent years it has caused increased rainfall in southern parts of United States and the western coast of South America, while leading to severe droughts and uncontrollable brush fires in Australia. Another aspect of global warming relates to snow cover and sea-bound ice (such as in Greenland), which are projected to decrease, with widespread retreat of glaciers and ice caps during the 21st century. The projected level of global mean sea level rise from thermal oceanic expansion by the end of this century would range between 9 and 88 centimeters, which would make low lying land areas of the world (such as the Nile and Ganges-Brahmaputra delta regions and small islands in the Indian and Pacific Oceans) particularly vulnerable to coastal flooding and oceanic inundation. Among the impact on human societies, global climate change would seriously affect the availability of fresh water supplies due to decreased precipitation, leading to reduction of food production, and the spread of infectious diseases and would cause major dislocations of human populations.

The IPCC Assessment estimates that approximately three-quarters of the anthropogenic sources (i.e., not caused by natural events) of atmospheric carbon dioxide in the past twenty years are due to fossil fuel combustion, the rest arising chiefly from clearing of forested lands. Other important greenhouse gases that cause global warming (i.e., participate in positive "radiative forcing" of the global climate system) are methane (which increased 151% since the mid-1700s), nitrous oxide (N_2O), and halocarbons (such as the ozone depleting compounds called chlorofluorocarbons, and sulfur hexafluoride, SF_6). Atmospheric agents that caused net global cooling effects (i.e. negative "radiative forcing") include aerosol particles from fossil fuel combustion and biomass burning, non-anthropogenic sources such as volcanic eruptions (especially during 1960s through 1990s) and the presence of water vapor cloud cover.

Based on the assessment of general circulation models of global climate change, the IPCC had previously (in its Second Assessment Report, 1996) concluded that "[t]he balance of evidence suggests a discernible human influence on global climate." In its most recent findings (presented in its Third Assessment Report, 2001) the IPCC concluded: "In light of new evidence and taking into account the remaining uncertainties, most of the observed warming over the last 50 years is likely to have been due to increase of greenhouse gas concentrations. Furthermore, it is likely that the 20th century warming has contributed significantly to the observed sea level rise through thermal expansion of sea water and widespread loss of land ice."

In view of these scientific studies and technical assessments, the international community adopted the *Kyoto Protocol to the United Nations Framework Convention on Climate Change* in 1998. The Kyoto Protocol calls on ratifying states to reduce atmospheric emissions of greenhouse gases linked to global warming through nationally-based emission-reductions program and the creation of international mechanisms for trading emission credits and for providing technical assistance to developing countries.

(ii) ***Health Impacts of Global Warming***

(a) ***Heat-Related Impacts:*** With the onset of global warming, severe fluctuations in temperatures, wind speeds and relative humidity will occur in many regions of the world. In geographical areas where modern air conditioning is not widely available, even short-term heat waves in a closed, urban environment can lead to acute health effects, such as heat-strokes and/or heat-exhaustions that require

hospital admission, along with noticeable rise of mental stress, depression and sudden deaths. Increased mortality rates are linked to rising cardiovascular and respiratory disorders that occur in stressful weather conditions such as high temperatures and humidity. For instance, during the heat wave in July 1995 in Chicago, Illinois, some 465 people (many of them sick and elderly) died from heat-related causes. Similarly, in recent years heat-related mortality rates have risen in other urban areas of United States, Canada, Greece, Germany, the Netherlands, and the Middle East. In 1987, after the third day of a heat wave in Athens, Greece, hospital admission rates increased five-fold, illustrating a strong correlation between acute illness and the duration of heat exposure in a population. A number of studies project that by the middle of the 21st century, significant increases in summer temperature (with periods of extremely hot days) may become a common experience in many temperate-zone cities and urban areas of North America and Europe. Similar scenarios of global warming show that mid-latitude cities in China, such as Shanghai and Guangzhou, may experience excess mortality of different magnitudes from heat and humidity-related stress.

(b) ***Air Pollution Impacts:*** While the combustion of fossil fuels leads to the formation of carbon dioxide as a major greenhouse gas, the same energy-producing sources also form a number of air pollutants, such as sulfur dioxide and particulate matter, which significantly impact human health. Of the fossil fuels used in industrial processing today, coal combustion emits twice as much carbon dioxide into the atmosphere as oil or gas for each unit of energy produced. Many energy experts have concluded that this factor alone makes coal the least desirable fossil fuel option for power production at the present time. However, in addition to contributing excessively to global warming, coal combustion produces high atmospheric levels of sulfur dioxide, along with secondary formation of acid aerosols and fine particulate matter (PM10 or PM2.5, see Chapter III). This negative feature of coal combustion becomes even more serious when little or no air pollution control measures are employed at the emission source. At the present time, coal is the primary fossil fuel used in several rapidly industrializing countries, such as China and India, where it is employed for electric power production, with inadequate controls for reducing the emission of sulfur dioxide or particulate matter into the atmosphere. Thus, public policy measures that phase out the use of coal as a primary energy source would not only contribute to reducing the amount of carbon dioxide emitted to the atmosphere, they would directly improve public health by decreasing the levels of hazardous air pollutants in many highly populated regions of the world.

A recent study by the World Resources Institute (WRI) estimated that, globally, 700,000 deaths per year (with 80% in developing countries) would be avoided if worldwide carbon dioxide emission levels were reduced 15% below 1990 levels by the year 2010. Such a reduction in carbon dioxide emission levels had been recommended by European Union countries during the negotiations leading to the adoption of the 1997 *Kyoto Protocol to the UN Framework Convention on Climate Change*. The WRI study had compared the public health consequences from exposure to projected atmospheric particulate matter (PM10) concentration levels in different regions of the world under two climate scenarios to reduce global carbon dioxide emission levels: "business as usual" against the European Union's "climate policy" recommendations.

With rising temperatures or increased ultraviolet radiation on earth's surface, chemical reactions that lead to the formation of photochemical oxidants (such as ground level ozone caused by human activity) would be greatly enhanced. Thus, one of the consequences of global warming would be increased levels of ozone in the lower atmosphere, which has acute effects on the respiratory tract and interferes with normal physical activities of both adults and children (see Section II-C(iv)). Another lesser known aspect of global climate change is the way weather modifications can interfere with the dispersal of air pollutants at the local and regional level. For instance, increases in stagnant atmospheric conditions, such as during regional "air inversion" episodes (when hot air at higher altitudes traps cooler air below) may cause pollutants to linger longer at the ground level, causing severe air pollution problems for local

communities. In such situations, air pollutants emitted from industrial and commercial sources (such as sulfur oxides and particulate matter) and from motor vehicles in urban areas (such as carbon monoxide and hydrocarbons) would exert greater severity of health impacts on the general population. Warm weather also increase microbial spores and pollen releases into the atmosphere, causing a variety of fungal infections and allergies. Furthermore, preliminary studies on the combined effects of warm temperature and increased air pollution have shown that significant interactions may exist in certain regions. For example, synergistic effects of exposure to air pollutants on high temperature days were shown to be correlated in the Los Angeles and Philadelphia metropolitan areas with increased mortality rates.

(c) ***Vector-Borne and Infectious Diseases:*** In general, climate changes leading to higher surface temperatures accelerate the rate at which a variety of microbes, fungi and insects breed and proliferate. Increased temperature and humidity levels lead to enhanced metabolic rates in vector organisms (e.g., disease-transmitting insects, ticks, water snails and crustacea) resulting in increased nutritional requirements of the parasitic species and thus more frequent feeding on host organisms. Many disease-carrying vector organisms have greater breeding and survival rates in warmer climates, whereas increased precipitation in other regions would allow aquatic-based vector organisms, such as the mosquito and blackfly, to lay more eggs in stagnant pools and increase the overall insect population. Additionally, as temperate-zone annual mean surface temperature rises, there will be greater migrations of tropical, warm weather vector organisms to mid-latitude regions.

Recent studies on the consequences of global warming have concluded that increases in vector-borne diseases would be a public health problem of enormous magnitude. The likeliest impact would be in the spread of malaria to regions of the world where it has long been eradicated. Today, more than 2 billion people in the world are still at risk to malaria, with an estimated 300 to 500 million new cases of malaria and 2 million deaths occurring each year. Modeling studies have shown that by 2100, an increase in global mean temperature of 3 degrees Celsius would result in an additional 50 to 80 million cases of malaria worldwide – a 10 to 16% projected increase over baseline estimates.

Vector borne diseases that would also most likely be affected by global warming are: dengue fever (mosquito-borne), schistosomiasis (caused by water snails) and leishmaniasis (caused by the phlebotomine sandfly), with global annual increases in new cases of 50 - 100 million, 200 million and 500,000, respectively. Of particular concern is the potential spread from the tropics of dengue fever, which is characterized by high fever, severe headache and muscular pain, to mid-latitude regions of the globe where the disease in well contained at present. Other vector borne diseases that have been linked to global warming include yellow fever (mosquito), African trypanosomiasis (tsetse fly), dracunuliasis (crustacean), onchocerciasis (blackfly) and American trypanosomiasis (triatomine bug).

Global climate change could have a major impact on water and sanitation, especially in regions of the world where lowered precipitation levels are projected. As water becomes less available, rivers and streams will become more contaminated with bacterial and viral organisms, leading to increased incidences of diarrheal diseases in the general population. These disease-causing organisms include bacterial species, such as Salmonella and Shigella, and protozoan species, such as Giardia and Cryptospiridia. Another bacterial disease of concern is cholera, which is a water borne illness associated with episodes of floods and droughts, which could occur more frequently with global warming.

(C) Stratospheric Ozone Depletion

(i) ***Causes of Ozone Depletion and Antarctic Ozone Hole***

The stratosphere is a region of the upper atmosphere that lies around 10 to 17 kilometers (6 to 10 miles) above the earth's surface and extends upwards to about 50 kilometers (30 miles). At these high altitudes, the stratosphere contains naturally occurring ozone (O_3), a tri-atomic molecule that forms a protective layer against sunlight's harmful ultraviolet (UV) radiation. The formation of stratospheric ozone occurs when high frequency UV radiation photochemically splits an ordinary oxygen molecule (O_2) in the atmosphere to produce two atoms of oxygen ions (O). Since oxygen ions (O) are highly reactive chemical agents, they undergo a series of catalytic reactions with other oxygen molecules (O_2) to produce ozone molecules (O_3) in the stratosphere. At the same time, high frequency UV radiation, along with other reactive ionic species – such as hydroxyl and chlorine radicals -- convert newly formed ozone molecules back into oxygen molecules through a reverse set of chemical reactions. Thus, the net formation of the protective ozone layer is in a state of chemical equilibrium, in which the amount of ozone molecules in the stratosphere is balanced between its overall rates of formation and destruction.

In the early and mid-1970s, a number of pioneering scientific studies indicated that a group of halogenated organic compounds (i.e., those substances containing chlorine, bromine or fluorine atoms), known as chlorofluorocarbons (CFCs), could significantly destroy the ozone layer by undergoing a series of photochemical reactions in the stratosphere. Since CFCs remain chemically inert in the lower atmosphere, they are physically transported into the stratosphere, where it chemically decomposes into highly reactive chlorine radicals (Cl) under the influence of intense UV radiation. In fact, it is the photochemical formation of the chlorine radicals from CFCs that catalyzes the breakdown of ozone molecules in the stratosphere.

Since the 1930s, CFCs as a class of chemical substances were extensively used in commercial and consumer products -- as non-toxic refrigerant fluids in air conditioners and refrigerators, and as relatively safe propellants in many aerosol products (CFC-11, CFC-12 and CFC-113 were the most commonly used compounds). For many years, CFCs were regarded as "miracle" compounds, since they had excellent physical and chemical properties and had not been linked to any known acute or chronic health effects. Because of their low chemical reactivity, CFCs and other halogenated chemical compounds have long atmospheric residence times, with lifetimes on the order of 60 to 400 years. Based on scientific studies and technical assessments that were carried out at leading research centers around the world on the ozone depleting potential of CFCs, by the late 1970s many regulatory agencies in developed countries, including the United States, Canada and Western European countries (where CFCs had been primarily manufactured and used) began phasing out the non-essential uses of CFCs, such as aerosol propellants, cleaning fluids, etc.

In the early 1980s, the first reported observation was made of an annual springtime phenomenon in the southern hemisphere -- the so-called Antarctic ozone hole. It appears that each year, during the months of September, October and November, a sharp decline in stratospheric ozone concentration occurs (as much as 60%) over the Antarctic polar region. It is now believed that this phenomenon is related to the formation of “ice clouds” that reside in the stratospheric polar vortex during the cold, dark winter months in the Antarctica when temperature can reach (minus) 80 degrees Celsius. The Antarctic polar vortex is an elongated air mass formed by the earth’s diurnal rotation, which becomes essentially isolated from other parts of the global atmosphere during the winter months. A number of potentially reactive chemical species, such as nitrogen, chlorine and bromine containing compounds, become trapped on ice particles in these high altitude stratospheric clouds. During the seasonal warming period with the return of sunlight that begins in September of each year in the Antarctica, these ice-trapped

halogenated chemical compounds are released into the polar stratosphere. They undergo a series of sunlight-mediated photochemical reactions resulting in the formation of large amounts of highly reactive chlorine and bromine ions, which in turn cause massive destruction of stratospheric ozone layer in the Antarctic polar region.

After the initial discovery of the Antarctic ozone hole, a series of intergovernmental negotiations began toward the global control and phase out of CFCs and other chlorinated and brominated hydrocarbon compounds that were linked to stratospheric ozone depletion. In 1985, the *Vienna Convention for the Protection of the Ozone Layer* was adopted, followed by the signing of the landmark *Montreal Protocol on Substances that Deplete the Ozone Layer* in 1987. The Montreal Protocol – which was later amended at subsequent international meetings held in London (1990), Copenhagen (1992), Montreal (1997) and Beijing (1999) -- called for the elimination of the production and consumption of ozone depleting chemicals – CFCs, brominated hydrocarbons (halons), carbon tetrachloride and methyl chloroform, while allowing a grace period for developing countries to phase out the use of these chemical substances.

(ii) ***Impact of UV Radiation on Human Health and Biotic Resources***

Sunlight that reaches the earth's surface consists of visible light (40%), infrared (IR) radiation (55%) and ultraviolet (UV) radiation (5%). The potentially harmful UV radiation spectrum is further classified into three subdivisions: (i) *UV-A radiation* (315 – 400 nanometers in wavelength), (ii) *UV-B radiation* (280 – 315 nanometers), and (iii) *UV-C radiation* (100 – 280 nanometers). The ozone in the stratosphere essentially absorbs all the most harmful, short wavelength (or high frequency) UV-C radiation, while allowing almost all the least harmful, long wavelength (or low frequency) UV-A radiation to enter the lower atmosphere. However, stratospheric ozone allows approximately 25% of the intermediate wavelength UV-B radiation (with its propensity to damage cellular DNA and protein molecules) to penetrate to the surface of the earth, which can seriously affect human health and cause significant damage to other biological organisms.

The most direct health impact of UV-B radiation is its ability to damage human skin, causing mild to severe sunburns, loss of dermal (skin cell) elasticity, darkened pigmentation, increased photo-allergies (sunlight-mediated skin reactions) and premature aging. It is estimated that for each 1% decline in stratospheric ozone, the UV-B radiation levels on earth's surface increase by 2%. In turn, each 1% increase in UV-B radiation could result in a 2% – 5 % increase in the incidence of non-melanoma skin cancer. At present, there is strong evidence that links the cumulative amount of sunlight exposure to elevated incidences of basal cell and squamous cell carcinomas -- both relatively benign, non-lethal forms of skin cancer. However, in recent years there has been a significant increase in the global incidence of malignant melanoma (a less common, but frequently fatal type of skin cancer), which has been chiefly attributed to lifestyle changes, especially among individuals in northern latitudes who have increased their exposure to sunlight during the warm summer months. The U.S. EPA has estimated that if CFC use continues to increase at the rate of 2.5% per year till the year 2050, an additional 150 million cases of skin cancer (along with 3 million deaths) may result among light-skinned individuals in the United States. In addition to a rise in skin cancer rates, increased levels of UV-B radiation may cause suppression of human immune systems -- resulting in greater susceptibility to a variety of infectious diseases -- and to an increase in the number of eye disorders, including chronic retinal damage, cataract and blindness.

Among the most serious indirect health effects of increased UV radiation is long-term decreases of important food sources and the lowered nutritional status of human populations. Increases in UV-B radiation can significantly affect terrestrial and aquatic organisms, since most biological species evolved

on earth after the protective ozone layer was well developed. Recently conducted experimental and field studies have shown that UV-B radiation interferes with photosynthetic activity of many plant species, affecting their overall growth rates and making them more susceptible to diseases. Preliminary studies on agriculturally important crop species -- such as maize, rye, soybeans, peas, sunflowers, melons and cabbages -- show them to be adversely affected by exposure to high frequency UV-B radiation. Similarly, concern has been expressed about the impact of increased UV-B radiation on other plant-based ecosystems, such as forests and grasslands. At present, however, there is considerable uncertainty as to the exact magnitude of the impact of UV-B radiation on agricultural productivity and forest growth rates.

The most serious biological aspect of increased UV radiation on earth's surface is its potential impact on oceanic phytoplankton species, which is the primary base organism of all food chains in the marine and coastal environments. The loss of major phytoplankton species would affect the productivity of all global fish and shellfish stocks. Recent studies have shown that during the appearance of the Antarctic ozone hole, phytoplankton yields in the polar oceanic region were reduced by as much as 6 to 12%, with a net reduction of 1% over the entire year. In addition to loss of marine organisms, significant loss of phytoplankton species from stratospheric ozone depletion would lead to a reduced uptake of atmospheric carbon dioxide. For instance, it has been projected that a 10% loss of global phytoplankton yield would result in lowered absorption of atmospheric carbon dioxide into the ocean -- in an estimated amount equal to the total amount of CO_2 that is annually released from fossil fuel combustion into the environment. The net result would be further increases in the concentration levels of atmospheric carbon dioxide, a major greenhouse gas that is closely linked to potential global warming and climate change.

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V. Biodiversity Loss and Ecosystem Disruption

(A) Overview

While biological species extinction has occurred throughout evolutionary history, it is now believed that the rate of biodiversity loss has accelerated by factors of 100 to 1,000 times since human beings first evolved on earth some 120,000 years ago. Leading ecologists now estimate that at present rates of biodiversity loss, more than 25% of all species on earth may become extinct within the next half-century. There are multiple causes for this loss of biodiversity: rapid population growth with its accompanying destruction of forested areas, savanna grasslands, freshwater wetlands, marine resources and other natural ecosystems; high consumption rates of natural resources; introduction of alien invasive species; global climate change; air pollution and acid precipitation; and widespread use of toxic substances and pesticides.

One of the most invidious and irreversible aspects of biodiversity loss is the intentional or accidental introduction of alien invasive species, which severely damage native organisms and local ecosystems in a geographic region. At present, this phenomenon is worldwide in scope, made even more serious by globalization of trade and commerce, which introduced alien species to regions of the world once believed to be isolated and relatively unaffected by biological invasion. In economic terms, it is estimated that invasive species may account for billions of dollars of loss annually. For instance, alien plant species can drastically reduce crop yields, destroy water catchment areas and adversely impact local freshwater wetlands. New insect pests and pathogens, when accidentally introduced into regions with native plant and animal species, may lead to increased costs of agricultural and livestock production. In addition, invasion of foreign plant pathogens, such as new species of viruses and fungi, can drastically reduce forest yields in many regions of the world and cause a variety of human illnesses in the community.

Loss of biodiversity has both direct and indirect impacts on human health. The most direct impact is the disruption of natural ecosystems, whereby local and regional food webs are permanently destroyed, leading to decreased forest and agricultural productivity and decline of marine fisheries. Such shortfall of traditional food resources in many regions of the world could pose serious malnutrition, illnesses and death among human populations. Indirect impacts to human health occur through loss of many medicinally valuable biological organisms, including hitherto undiscovered sources of plant, animal and microbial species that have potentially therapeutic products, medicinal drugs and antibiotics.

(B) Biodiversity, Natural Resources and Sustainable Development

(i) *Biodiversity, Population Growth and Consumption Rate*

(a) *Global and Regional Population Trends*: In the past half-century, rapid human population growth and increasing per capita consumption rates have had significant impacts on earth's biodiversity and natural ecosystems. In 1950, the world's population stood at 2.5 billion, increasing to 3 billion in 1960, 3.7 billion in 1970, 4.4 billion in 1980, 5.2 billion in 1990, 6.0 billion in 2000, and is currently (mid-2002) about 6.2 billion. Based on these demographic data, during the past fifty years, between 500 - 800 million people per decade were added to the world's total population. The world's population growth rate was about 2% per year in the 1950s and 1960s, and declined to 1.52% per year during the decade of the 1990s. The United Nations Population Division estimates that the world's population growth rate should further decline to around 0.53% per year by mid-21st century. However, if current trends continue, the UN projects that the earth's population may reach around 9.3 billion people in 2050 (estimates range between 7.8 and 10.9 billion), which is an increase of more than 3 billion people in the next fifty years. Thus, while the global

population growth rate appears to be decreasing, the number of human beings living on earth may increase by another 50% or more.

The trends in population growth rates show dramatic differences among various regions of the world during the past fifty years. In the 1950s, the highest annual growth rates were recorded in the Latin America and Caribbean region, with a growth rate of more than 3% per year, followed by Africa and Asia, at 2.5% and 2.15% per year, respectively. During the same time period, population growth rates were about 1% per year in European countries and around 1.9% per year in the North American region. By contrast, in the past decade (1990 - 2000), the fastest growing region of the world was the African continent, where the annual population growth rate was around 2.8% per year, while the growth rates have significantly declined in both the Latin American/Caribbean and Asian regions, to approximately 1.8% and 1.6% per year, respectively. The population growth rate in North America was reduced by nearly half, reaching a rate of 1.1 % per year in the past decade, while the growth rate in European countries was reduced to below 0.01 % per year, with an actual decline in its overall population at the beginning of the new millennium.

Other important demographic indicators of measuring how humans have stressed natural systems in the past few decades include examining trends in population density and degree of urbanization in different regions of the world. Fifty years ago, over 30% of the world's population resided in the industrialized, developed countries of Europe and North America (as well as Japan, Australia/New Zealand). This figure has now declined to around 20% (1.2 billion in 2000). In the meantime, the numbers of people living in developing regions of Asia, Africa and Latin America have risen to over 80% of the world's population (4.9 billion in 2000). While population density figures may not give a full picture of the impact of human societies on the natural environment because there may be vast uninhabitable areas in a country or region (such as mountain ranges, sandy deserts, arctic tundra, etc), it nevertheless indicates the degree to which certain parts of the world may undergo major demographic transitions related to future population growth. For instance, the population density of Asian countries is projected by the United Nations to grow nearly four-fold between 1950 and 2030, from 44 to 156 persons per square kilometer in the eighty-year period. By the year 2030, the population densities of several major Asian countries -- China, Pakistan, India and Bangladesh -- are expected to reach 155, 343, 429, and 1,546 persons per square kilometer, respectively. By comparison, the current population density of Western European countries is around 165 persons per kilometer, which is not projected to increase significantly in the next few decades.

In 1950, over 70% of the world's population lived in rural areas, especially in Asian and African countries, where the relative proportion of people living in cities, towns and other urban areas was only around 17% and 15%, respectively. By the beginning of the new millennium, this was no longer the case. At present more than a third of the Asian population live in urban areas, and this figure is now projected to reach more than 50% in the next 25 to 30 years. If current trends remain unchanged, in some Asian countries with high population density, such as Bangladesh, more than 95% of the population is expected to live in closely contiguous urban areas by 2030, while maintaining its mixed "urban-rural" South Asian character. At present, over three-quarters of the population in Europe, North America and the Latin America/Caribbean region live in urban areas, with many cities surrounded by large suburban populations. This is currently projected to rise to about 80 - 85% by 2030. The United Nations Population Division has projected that in the next quarter century, nearly 60% of the world's population will be living in highly crowded urban and suburban areas. In the developing world, it is believed that 90% of the projected population growth in the next few decades will occur in the urban sector, with only marginal growth projected in rural areas.

At present, there are over 20 cities in the world that have in excess of 10 million inhabitants in their metropolitan area -- described by some demographers as "megacities" -- with Tokyo, Japan (26.4 million), Mexico City, Mexico (18.1 million), Mumbai (Bombay), India (18.1 million), Sao Paulo, Brazil (17.8 million), New York City, USA (16.6 million), Lagos, Nigeria (13.4), Los Angeles, USA (13.1 million),

Calcutta, India (12.9 million), Shanghai, China (12.9 million), Buenos Aires, Argentina (12.6 million), Dhaka, Bangladesh (12.3 million) and Karachi, Pakistan (11.8 million) in the top twelve list. In 1975, 195 cities had an urban population greater than 1 million inhabitants, but in the next fifteen years 564 cities are expected to reach the 1 million population mark. In contrast, sub-Saharan Africa has not yet experienced the same global trend toward urbanization and rapid population growth in the cities and towns. Even so, because of deteriorating municipal infrastructure and services, many urban areas in African countries now require major improvements in water resources and sanitation facilities and in the construction of public roads and transportation systems.

While the demographic transition from a largely rural to a more urbanized environment in many developing countries may bring about reduced birth rates, improved living standards, higher incomes, longer life expectancies and more accessible social services, it also places enormous stress on local services and the resources of cities, towns and their surrounding areas. It also means more people living in crowded and unsanitary conditions, producing more solid and sewage wastes, putting more demands for adequate housing, drinking water, energy supplies, transportation systems, food, clothing, education and other social services and resources. Without close attention to proper urban planning and the adoption of viable governance structures, with the goal of achieving long-term, sustainable communities, most cities and towns in developing countries may risk becoming effectively uninhabitable, offering a degraded and unhealthy environment in which to live, work or raise a family.

(b) ***Consumption Rates of Developed and Developing Regions*****:** At present, rich countries in the industrialized, developed regions of North America, Europe, Japan, Australia/New Zealand, with 20% of the world's total population, consume over 85% of the globe's natural resources. By contrast, the poorest 20% of world's population, residing in the least developed countries, consume less than 2% of the globe's natural resources. Many developmental economists and policy makers consider such indicators of socio-economic discrepancy and lack of equity between the developed and developing regions of the world to be a likely source of long-term political instability, if not downright a socially and morally reprehensible state of affairs. In most developing regions, environmental degradation mainly results from the daily activities of poor and often marginalized people, struggling to find barely adequate amounts of food, water, shelter and fuel to meet their basic human needs. The unfortunate consequences of these foraging and food growing activities, along with recent increases of population in developing regions, have led to significant changes in land-use patterns, with expanding agricultural production and deforestation causing greater and more frequent incidences of soil erosion, floods and widespread loss of animal and plant habitats. In addition, increased use of agricultural chemicals and pesticides has contaminated surface and groundwater, posing severe health risks to local inhabitants and those that live downstream from polluting sources.

The inhabitants of developed countries, on the other hand, with their high standards of living and affluent lifestyles, continue to produce and consume vast quantities of materially wasteful and energy-intensive products and services. One indicator of such intensive energy use, which has been employed as a surrogate measure for overall resource consumption rate, is the commercial energy-use per capita. In the United States in 1999, this energy-use rate was 8,159 kilogram oil equivalent per person (koe/p), which represents the highest energy consumption rate in the world. Other high energy-consuming countries in the developed world are Canada (7,929 koe/p), Finland (6,461 koe/p), Norway (5,965 koe/p), Australia (5,690 koe/p), New Zealand (4,770 koe/p), Netherlands (4,686 koe/p), France (4,351 koe/p), Russia (4,121 koe/p), Germany (4,108 koe/p), Japan (4,070 koe/p), and the United Kingdom (3,871 koe/p). By contrast, the per capita energy consumption rates in several heavily populated Asian countries are relatively low -- e.g., China (868 koe/p), Indonesia (658 koe/p), India (482 koe/p), Pakistan (444 koe/p), Bangladesh (139 koe/p). Thus, an average person in the United States consumes energy 9 times more than an inhabitant in China, and 17 to 18 times more than people in India or Pakistan. Another means of assessing the intensity of energy use in the United States is to state it in terms of the total energy consumption of the population. At

the beginning of the new millennium, with only 4.7% of the globe's population, the United States consumed nearly 23 % of the world's total energy resources.

Another measurement of overall resource consumption rate is to examine the relative amounts of carbon dioxide currently being emitted from fossil fuel combustion sources among developed and developing countries. Again, United States with its large gross national income per capita of $34,100 (given in terms of Gross National Income/Purchasing Power Parity, GNI/PPP), had the highest amount of carbon dioxide emissions per capita, at about 19.8 metric tons per person (mt/p) in the late 1990s. By contrast, many industrialized country in Western Europe, with comparable gross national incomes, emitted *considerably lower amounts* of carbon dioxide per capita -- e.g., Switzerland (with GNI/PPP of $30,450), emitted carbon dioxide per capita at 5.9 mt/p (i.e., at 3.3 fold lower levels than the US). Similarly, France (6.3 mt/p), Norway (7.6 mt/p), United Kingdom (9.2 mt/p) and Germany (10.1 mt/p) emitted carbon dioxide per capita at levels 2 to 3 fold lower than the United States (the corresponding GNI/PPP for these European countries are $24,420, $29,630, $23,550 and $24,920, respectively). Thus, high energy consumption in a country or region does not *ipso facto* correlate with increased levels of carbon dioxide emission per capita.

Current carbon dioxide emission levels per capita are even lower in developing regions. For example, in Mexico, China, Brazil, and India, the average person emits carbon dioxide around 3.9 mt/p, 2.5 mt/p, 1.8 mt/p, and 1.1 mt/p, respectively (the corresponding GNI/PPP for these Latin American and Asian countries is $8,790, $3,920, $7,300 and $2,340, respectively). Thus, the average individual in the United States emits between 5 to 18 times more carbon dioxide than individuals in the most rapidly industrializing countries of developing regions. The per capita carbon dioxide emission levels in African countries today are, for the most part, very low. They range between low estimates of 0.1 mt/p (for example, in Burkina Faso, Congo, Malawi, Tanzania, etc. with GNI/PPP generally between $500 and $1,000) and high estimates for a few countries, such as South Africa (8.3 mt/p), Algeria (3.6 mt/p) and Tunisia (2.4 mt/p) (the corresponding GNI/PPP for these high carbon dioxide emitting African countries is $9,160, $5,040 and 6,070, respectively). However, in terms of *total* carbon dioxide produced by each country, China emitted the second largest amount into the atmosphere, at 3.36 billion metric tons in 1996, next to the United States at 5.36 billion tons per year, while India produced nearly 1 billion metric tons of carbon dioxide annually. Recent projections on future global energy use from fossil fuel combustion indicate that within the next fifty years, the total amount of carbon dioxide emitted from all developing regions will begin to equal or exceed the amount of carbon dioxide emitted by industrialized, developed countries. This projection is based on present population increases, industrial growth rates and energy use patterns of many rapidly developing countries, such as China, India, Brazil and Mexico.

(ii) ***Biodiversity Loss and Species Extinction***

Of the estimated half billion biological organisms that are believed to have existed on earth over the past 600 million years, only 1 - 10% of this evolutionary pool of species still exist today. It is thus estimated that the natural average background rate of species extinction is about one species per year. Current estimates of species extinction are around 100 to 1,000 species per year, considerably greater than the rate of biodiversity loss over most of the earth's evolutionary history. While past periods of major species extinction were mainly due to natural causes, today's loss of biodiversity is almost all anthropogenic in origin. At this rate of species extinction, more than 25 % of all biological organisms on earth today will become extinct in the next fifty years.

At present, the largest repository of biodiversity is in tropical rainforests in the equatorial belt, covering some 7% of the globe's total land area, where it is believed that more than 50% of all biological species reside. Of the 9 million square kilometers of tropical forests that remained intact in the late 1970s, forest lands were being destroyed at a annual rate of 70,000 - 90,000 square kilometers, with an additional

100,000 square kilometers being seriously encroached upon each year. This translates to a tropical deforestation and encroachment rate of approximately 1 - 2 % per year. If current trends continue, it is estimated that by the end of this century, most of the primary tropical forest lands in Asia, Africa and Latin America will be lost, except for two large remaining forested areas – one in the Congo basin and the other in the western Amazon River watershed. Based on present annual rates of deforestation, along with the accompanying agricultural settlements and other infrastructure activities, it is difficult to estimate accurately the rate of species extinction in a tropical forested region. However, based on the current abundance of flora and fauna known to exist in warm, tropical regions, it is believed that in the past 20 - 25 years, tens of thousands of biological species may have become extinct in many areas of the world.

Although the temperate and boreal zones in the northern hemisphere do not harbor the enormous variety of biological species found in the tropics, loss of important habitats of plant and animal species in northern latitudes may occur with greater swiftness and severity as a result of changes in temperature regimes and weather patterns. Thus, impacts are likely to occur at an earlier date and with greater consequences in colder regions, where for instance, seasonal changes in permafrost thawing and ice melts, along with the drying of wetlands and other freshwater systems, may seriously disrupt annual movements and mating habits of land-based animals and migratory birds. Studies have shown that in the Arctic region, permafrost melting causes plant diseases and die-backs (decline of tree growth) in northern boreal forests. With increased global warming, many species of trees in the colder regions may not be able to move further north, since large stands of trees are needed to seed, germinate and mature together at greatly accelerated migration rates. At present, high migration rates of plant species will be required in many areas of the Northern Hemisphere, especially in regions of Canada, Russia and Scandinavia, with the highest rates needed for the temperate evergreen and boreal coniferous forests. With increasing warming trends expected in northern latitudes, it is projected that more than half the existing habitats of vulnerable biological species in large regions of Russia, Canada, Iceland, the Balkan States and the Central Asian republics may be lost irretrievably. In the United States, the most likely regions for plant species loss will be in the New England states, the Pacific northwest, the Mountain states and in areas of Arizona, Kansas, Oklahoma and Texas.

In the past few decades, overall global concerns about the loss and extinction of biological species led to the adoption of the *Convention on International Trade in Endangered Species of Wild Fauna and Flora (CITES)* in March 1973. The international agreement required the listing of "all species threatened with extinction which are or may be affected by trade. Trade in specimens of these species must be subject to particularly strict regulation in order not to endanger further their survival and must only be authorized in exceptional circumstances." Following the adoption of this convention, the US Congress enacted the *Endangered Species Act of 1973*, which provides broad authority to the federal government to conserve ecosystems where endangered or threatened animal or plant species are known to exist. The act authorizes the determination, listing, possession, sale or transport of endangered species to be regulated by the government, and allows the acquisition of land for the conservation of endangered species.

At present, over 1.75 million biological species have been scientifically identified and catalogued, out of an estimated total of 3 to 100 million species that, according to conservation biologists, probably exist on earth's lands and oceans today. This vast genetic resource resides in a variety of natural ecosystems and human settlements -- forests, wetlands, grasslands, mountains, deserts, oceans, coastal areas, coral reefs, lakes, rivers, agricultural lands, pastures, urban and suburban areas, recreational parks, beaches and shopping malls, etc. Yet, biological species within such natural ecosystems and human settlements cannot thrive in isolation but are linked to one another through a web of interconnections, without which no life-form could survive beyond one or two generations. To preserve and equitably share the genetic resource base of earth's biological diversity, the international community signed the *Convention on Biodiversity* at the 1992 United Nations Conference on Environment and Development in Rio de Janeiro. The international agreement on biodiversity establishes its main objectives in the following terms: ". . . the conservation of

biological diversity, the sustainable use of its components and the fair and equitable sharing of the benefits arising out of the utilization of genetic resources, including by appropriate access to genetic resources and by appropriate transfer of relevant technologies . . ."

(iii) *Biodiversity Loss and Invasive Species*

Many wildlife biologists and ecologists believe that one of the major causes of biodiversity loss today is the threat of invasive species on the native fauna and flora in a geographic region. For example, in the United States, the adverse effects of invasive species rank next to loss of habitat as the main cause of placement of animals and plants on the endangered species list. According to the United States Fish and Wildlife Service, a total of 985 biological species (388 animals, 597 plants) are currently on the endangered list, with another 276 species (129 animals, 147 plants) on the threatened list. On a worldwide scale, the total number of biological species that are presently on the endangered or threatened list (as recorded on July 31, 2002) is believed to be around 1,819, including 342 mammals, 273 birds, 115 reptiles, 126 fish, 48 insects and 1,074 flowering plants.

An invasive species is defined as a biological organism that is: (a) non-native or alien to an ecosystem under consideration, and (b) likely to cause harm to the environment, human health or economy of a region. Invasive species may range in size from large marine or land-based mammals, tall trees or leafy shrubs to small, microscopic organisms, such as fungi, bacteria or viruses. They may be deliberately introduced, such as when predatory animals, ornamental trees or drought-resistant plants are imported into a region, or they may brought into a region accidentally, such as when disease-causing insects or pathogenic microbial species are inadvertently spread around by carrier organisms. Yet, invasive species have been transported by human beings for thousands of years, mostly by explorers, settlers and traders, in the form of crops and livestock. These imported plants and animals also brought with them many new species of alien weeds, insects and microorganisms. However, with modern means of transportation and the globalization of trade and commerce, the movement of non-native species has accelerated at an unprecedented pace. For instance, one of the major non-intentional means of spreading non-native aquatic species today is through the ballast water of freight-carrying ships, which discharge their load of water-containing invasive species into hundreds of bays, estuaries and marine coastal areas around the world.

Generally speaking, most newly introduced non-native species to region do not survive, since they compete with native species that have evolved over a long period into well-established ecological niches. Nevertheless, invasive species find certain geographic regions, such as relatively isolated islands and lakes, with their smaller number of competing organisms, to be more hospitable to their survival. In the 1960s, the introduction of Nile perch into Lake Victoria led to the extinction of 200 species of local native fish (such as cichlid). This event on the African continent is now regarded as one of the major extinction episodes of modern natural history. Similarly, the island of Hawaii has been subjected to repeated invasion of alien species, through importation of domesticated animals (such as pigs and goats) from continental America or through the introduction the rosy wolf snail, which caused the extinction of about two dozen native snail species on the island. Another well-documented invasive species is the brown tree snake, which was introduced into Guam in the 1950s. Within a ten-year period, this alien snake species completely destroyed nine bird species, five lizard species and two bat species on the island, dramatically illustrating the severity of biodiversity losses by invasive species in isolated geographic regions.

While some alien or exotic species were originally imported for commercial reasons, the consequences of introducing new biological organisms can be quite destructive to both the natural environment and the economic well-being of a region. In 1993, the US Office of Technology Assessment (OTA) estimated that the introduction of invasive plants into the United States had directly contributed to financial losses in the country ranging between $3.6 and $5.4 billion per year. This estimate has been considered to be low by a

number of observers, since it did not factor in the indirect costs of damages to the environment or human health, or to the increased costs of using herbicides to control the invasive plant species. Additionally, the OTA estimated that the cumulative costs from just 79 of the more than 4,500 alien species found in the United States accounted for $96 billion in financial losses in the overall national economy between 1905 and 1991.

While calculated costs of invasive species damages in various regions of the world differ between conservation biologists and resource economists, some idea of their overall magnitude may be garnered by examining some current impact estimates: (a) $41 billion annually from newly introduced pathogenic disease organisms in the United States, (b) $7 - 16 billion in lost ecosystem services over 55 years from the invasive salt cedar in the western United States, (c) $0.75 - 1 billion cumulative damages (1998 - 2000) to European and United States industrial plants from zebra mussels, (d) $105 million per year on Australian ecosystems by six invasive weed species, (e) $267 - 602 million impact from invasive varroa mites on New Zealand's beekeeping business, (f) $28 - 45 million per year by golden apple snails on rice production in the Philippines, and (g) $20 - 50 million per year by alien water hyacinths on the economy of seven African countries.

The cost-benefit advantages of restoring native species to a region may be graphically illustrated by looking at an example of removing alien vegetation and plant species in an area around the Cape Province of South Africa. In this region, the native fynbos (a fine-leaved, woody shrub) had been seriously displaced over many years by importation of high water-consuming, non-native plant species, such as European pines and Australian acacia plants. It has been estimated that over the years, some $2 billion in cumulative damages was incurred in the local economy as a result of displacement of fynbos vegetation by the imported alien species. Not only did the restoration of the fynbos vegetation by systematic removal of invasive species in the region bring about improvement in stream flow in the mountainous water-catchment area, it contributed to the overall economy of the Cape Province by providing livelihoods for 20,000 - 30,000 people by creating low skill jobs for tree-clearance labor and through the harvesting and sale of locally-grown flowers and thatching materials.

(iv) ***Biodiversity Loss and Human Health***

The most direct impact on human health from biodiversity loss is linked to damage to local and regional ecosystems. For instance, in many developing regions of the world, loss of forests, grasslands, freshwater sources, arable land and coastal areas can result in serious decline of food, fiber, potable water, fuel wood and other natural resources. Such biodiversity loss manifests itself in immediate and/or long-term human health impacts as a result of hunger, malnutrition, dehydration, and lack of shelter, protective clothing and energy resources in the community. Hungry and malnourished adults and children are especially vulnerable to bacterial, viral and parasitic diseases because of lowered immunity to pathogenic agents. In addition, such individuals are more susceptible to adverse health impacts from chemical contaminants present in food, water and air, and from exposure to pesticides and other hazardous materials in their environment.

The Global Burden of Disease study conducted by the World Health Organization and the Harvard School of Public Health in 1996 showed that the single largest cause of disease in the world was malnutrition, which accounted for 11.7 % of total deaths and 15.9 % of DALYs (Disability-Adjusted Life Years, which not only reflected number of life-years lost, but also adjusted for "healthy life-years" lost from non-fatal illnesses or injuries). In this study, two major causes of death and disability were identified globally -- acute respiratory illnesses and intestinal diarrhea -- which were clearly linked to large fraction of human populations living in poverty in a highly degraded environment. These two diseases alone accounted for over 21% of the burden of diseases in developing regions of the world, compared with malaria (2.6%) and other tropical infectious diseases (0.87%). Poor water quality and lack of sanitation facilities were

identified as major risk factors in the study, accounting for 5.3% of total deaths and 6.8% of DALYs, with a higher regional burden of diseases in developing regions -- sub-Saharan Africa (10%), India (9.5%) and Middle East (8.8%). Finally, the study found that outdoor air pollution contributed 1.1% of total deaths and 0.5% of DALYs at the global level.

An indirect and potentially significant impact from biodiversity loss is related to the decline in animal and plant species containing unidentified number of new therapeutic agents and pharmaceutical products to combat human diseases, especially those that could be derived from the abundant fauna and flora of tropical forests. At present, many biological organisms in the equatorial rain forests provide valuable human drugs, such as *d*-tubocurarine (from the chondodendron vine), quinine (from the chinchona tree) and a cluster of well-known antibiotics, including erythromycin, neomycin and amphotericin, which all originate from microorganisms in tropical soil. Similarly, plant-derived pharmaceutical products, such as digitalis (extracted from the foxglove plant), vinblastine (extracted from rosy periwinkle), morphine (extracted from poppy plants) and other plant-based remedies that originate from in non-tropical forest areas are extensively used in modern medicine. The use of plant-based or herbal remedies is especially widespread in several Asian countries, such China, Japan and the Indian subcontinent, where traditional medicine depend on a large variety of plant-derived medicinal products and therapeutic agents for treating human illnesses and ailments.

In a recent survey, it was determined that 57% of the most frequently prescribed human drugs in the United States either contained or were chemically based upon natural substances found in animal or plant species. At present, an estimated $14 billion in plant-based drug products is sold annually in the United States, with a worldwide sale of about $40 billion per year for such pharmaceutical products. Thus, in determining the overall economic value of the biodiversity of forest lands and other natural ecosystems where medicinally useful plants are presently found, the opportunity cost of not being able to identify and develop curative agents and essential human drugs in the future as a result of biodiversity loss should be seriously considered by policy makers.

(C) Ecosystems Disruptions, Human Communities and Public Health

> "Try to imagine Earth without ecosystems. Ecosystems are the productive engine of the planet – communities of species that interact with each other and with the physical setting they live in. They surround us as forests, grasslands, rivers, coastal and deep-sea waters, islands, mountains – even cities. Each ecosystem represents a solution to a particular challenge to life, worked out over millennia; each encodes the lessons of survival and efficiency as countless species scramble for sunlight, water, nutrients, and space. Stripped of its ecosystems, Earth would resemble the stark, lifeless images beamed back from Mars by NASA cameras in 1997. . . The fact is, we are utterly dependent on ecosystems to sustain us. From the water we drink to the food we eat, from the sea that gives up its wealth of products, to the land on which we build our homes, ecosystems yield goods and services that we can't do without. Ecosystems make the Earth habitable: purifying air and water, maintaining biodiversity, decomposing and recycling nutrients, and providing myriad other critical functions."
> -- *World Resources, 2000 – 2001*

With increasing urbanization of the world's population, human beings have become less and less aware of the central role that natural ecosystems play in their daily lives. This is especially true of people who reside in industrialized, developed regions of the world, where those living in large cities and towns procure food, water, shelter, clothing, energy and other goods and services without much individual effort. The fact that

almost all the material and energy resources that human communities depend upon originate in the natural environment is often conveniently forgotten by many urban and suburban dwellers, whose daily existence is far removed from the network of ecosystems where food, water, energy and other resources are first obtained. In many areas of the world, human beings have drastically transformed the landscape of their natural environment by converting forests into croplands, open spaces into housing subdivisions, free-flowing rivers into water reservoirs, wetlands into industrial parks and shopping malls, and oceans into over-harvested, declining fisheries. While many social and economic benefits have resulted from these human activities, the damage to natural ecosystems has not been fully determined, nor has any detailed scientific assessment been made of the capacity of seriously altered ecosystems to sustain human communities over the long term.

In recent years, poor planning and bureaucratic disregard for local and regional natural ecosystems have resulted in unprecedented ecological disasters and economic dislocations in different regions of the world. For instance, the precipitous lowering of water levels and decline of fisheries in the Aral Sea, a major inland freshwater lake in Central Asia, was entirely due to drawing excessive amounts of water from its watershed for large-scale cotton and other agricultural production in the region. Here the waters of the two main rivers (Amu Darya and Syr Darya) that drained into the Aral Sea were diverted for irrigation purposes, which consumed as much 90 % of their annual flow into the lake between 1981 and 1990. In China, the destruction of upland forests, along with lack of soil conservation practices and drainage of wetlands around the Yangtze River basin in the late 1990s led to the loss of 2.4 billion metric tons of topsoil and a significant loss of agricultural productivity. In 1998, when heavy rains arrived, severe widespread flooding occurred along the Yangtze River, leaving 3,600 people dead and 14 million people homeless, with an estimated economic loss of some $36 billion.

What is generally missing from today's debate on environment, health and sustainable development is an integrated approach to link the understanding and deep concerns of natural scientists, wildlife specialists and public health experts with the accumulated knowledge of social scientists, urban planners and resource economists. All too frequently, individuals who work on pressing problems related to the natural environment have little or no opportunity to take into account or listen to critical issues that social planners and developmental experts bring to the attention of policy makers. By the same token, many specialists on economic, social and cultural issues frequently ignore or are unaware of environmental problems identified by conservation biologists or take time to consider how the serious implications of anthropogenic activities on natural ecosystems have serious implications on the long-term health and well-being of human communities. In the following sections, an effort is made to bridge this gap by outlining some salient examples of how adverse impact on earth's natural ecosystems has had, or may have in the future, profound consequences for the survival of human beings and all living forms on the planet.

(i) Freshwater Ecosystems

Of the total amount of water on earth (1.4 billion km^3 (kilometer-cubed)), 97.2% is in the form of saltwater in the oceans and 2.8% is in freshwater on the globe's landmass. However, most of the freshwater is trapped in icecaps and glaciers (2.38 %), which leaves only a small fraction in ground water (0.397%) and in surface water (0.022%) that settles into a network of interlinked ecosystems consisting of aquifers, rivers, lakes, reservoirs and wetlands. Freshwater ecosystems are part of the vast global hydrological cycle, whereby water that evaporates from oceans, rivers and lakes is incorporated into earth's lower atmosphere in the form of water vapor, low-lying fog and higher-altitude clouds. Upon condensation, atmospheric water returns to earth's surface through precipitation as rain, hail or snow. Each year, more than 500,000 km^3 of water becomes part of the global hydrological cycle, of which 74,000 km^3 originates from freshwater ecosystems on earth's surface. About 120,000 km^3 of atmospheric water falls on the land

surface, providing a net increment of around 46,000 km^3 of freshwater in surface and ground water sources each year.

Human communities today consume more than half of the accessible freshwater resources, and this is projected to rise to 70% by 2025. Nearly three-quarters of the earth's freshwater is used in agricultural irrigation, significantly depriving downstream users of their daily need for water resources. In addition, many freshwater ecosystems are polluted with a variety of agricultural chemicals and pesticides, which pose serious health risks to those who drink, cook or bathe in the contaminated water. It is estimated that globally, 1.5 billion people rely on ground water sources (mostly from shallow aquifers), drawing up to 700 km^3 of freshwater annually. While ground water is an important source of freshwater in many rural areas of the world, contamination of aquifers can have more serious long-term consequences for human health than those related to surface water pollution. Unlike rivers, streams and lakes that are continually replenished with new freshwater supplies, clean-up of polluted ground water becomes technologically difficult and economically prohibitive once high concentrations of chemical contaminants seep into the underground water sources.

During the early 1990s, worldwide consumption of freshwater increased six-fold, which was greatly in excess of the global population growth rate. With the already high demand for freshwater growing each year, the availability of water resources has become one of the most challenging problems for achieving sustainable development goals in the next few decades. In a recent study, it was determined that over 40% of the world's population (2.3 billion people) live in areas where there is a chronic shortage of freshwater; some 1.7 billion of them receive less than an annual amount of 1,000 m^3 (meter-cubed) of water per person. Development specialists regard such meager amounts of water supplies as inadequate to meet the minimum requirements for agricultural production and drinking water of a community. In terms of human health, widespread increases in hunger, malnutrition and disease will generally appear in communities in which such inadequate amounts of freshwater are the only option available to the general population.

(ii) ***Coastal Ecosystems***

Some of the richest natural ecosystems are found in the coastal areas of many parts of the world, where they harbor a vast array of species habitats, such as tidal wetlands, mangrove forests, coral reefs, barrier islands, sandy beaches, inland bays, estuaries and river deltas. In coastal areas, fish and shellfish are found in abundance, along with different species of birds that find places to nest and feed, and where many varieties of saltwater plants and underwater reeds grow in profusion. Not only do coastal ecosystems attract animals, plants and humans to cohabit together, they provide a meeting place where the continental landmass and oceanic seawater converge to produce a natural environment, bristling with life-forms in an ever changing landscape of light, wind and waves. Coastal ecosystems store and reuse nutrients and minerals, filter and remove waterborne pollutants, and regulate and maintain the global hydrological cycle.

At present, more than 40% of the world's inhabitants (2.5 billion people) live within a short distance of coastal areas. Because of this proximity, human communities over the years have had a profound impact on the coastal ecosystem. For instance, in the past century most of the mangroves in coastal areas have been irretrievably destroyed by human activity, with some loss estimates of as high as 85% of what was believed to have existed at one time worldwide. Mangroves serve as an important spawning ground for many tropical fish species, whose loss would have a major impact on the health and well being of the coastal communities of the region. Other important coastal ecosystem are the peat swamps found in Southeast Asia, where nearly half of Indonesia's and more than 90% of Vietnam's natural coastal ecosystem are now believed to be in serious decline. At present, the seagrass population in the Florida, Texas and Mississippi is believed to be significantly reduced, with estimates of loss as high as 90% in the Galveston Bay area.

Another natural ecosystem under siege today is marine coral reefs, which are among the most important habitat of many oceanic species. It is estimated that more than 25,000 species inhabit the shallow waters of coral reefs. This is four times greater than the current number of animal species found in a tropical forest. Coral reefs are also the habitat and nursery of many oceanic fish species, with estimates of up to 20% of the world's total marine fish population. Coral reefs assist in the development of mangroves and coastal wetlands, and they protect the main coastland from severe windstorms and beach erosion. It is estimated that coral reefs annually account for some $375 billion of direct and indirect goods and services on a global scale. Today, because of over-fishing, sediment damage, harvesting of coral beds and tourist activity, coral reefs are under serious threat of extinction. It is believed that currently 10 % of coral reefs are under severe stress, with another 20 % decline predicted in the next two decades and a projected two-thirds loss by the end of the century if nothing is done to reverse the present worldwide trend.

Over-fishing of marine resources has been recognized as a worldwide phenomenon since the early 1990s, after a half-century of increased annual harvesting of oceanic fish and shellfish species in almost all regions of the world led to a significant decline of major commercial fish stocks. Climate change has also contributed to the changes in fish species population as a result of changing seawater temperatures. For instance, during the El Nino events of 1997-1998, increased surface ocean temperatures caused severe bleaching of coral reefs in many regions of the world. A rise in sea level in coastal areas is expected to accompany the increase in average global temperature. Current projections by the Intergovernmental Panel on Climate Change (IPCC) estimate a sea level rise ranging between 15 and 95 centimeters by 2100, which would have an enormous adverse impact on many natural ecosystems and human communities in coastal regions.

The worldwide decline in marine resources in recent years has serious implications for communities in coastal areas, where people live and support themselves by harvesting fish and shellfish. Between 1950 and 1994, one third of the critically important commercial fish species were reported to have declined. Fish is the main food staple and protein source in many countries in developing regions. Thus, any major collapse of oceanic fishing stocks would have catastrophic consequences for these societies, where the health status and well being of the population would be sharply reduced. The recent introduction of fish aquaculture and international pressures to restrict fishing in designated oceanic areas may begin to stem the current tide of over-harvesting of commercial fish stocks. Otherwise the future social and economic prospects of many coastal communities around the world, especially in developing regions, do not look very bright.

(iii) ***Forest Ecosystems***

All throughout history, human beings have had a special relationship with trees, vegetation and animals found in forests and woodlands, from which humans derive many of their most important resources, including building materials, fuel wood, food products and medicines. Forests and woodlands are natural ecosystems containing many practical goods and services, but they also serve as a place for recreation and spiritual retreat for individuals who wish to leave their synthetic urban environment for brief periods of time. Forest tree cover regulates freshwater recharge on land surfaces by providing a medium for gently absorbing rainwater. Through its extensive root system, forests also provides a means to counter soil erosion on the forest floor. Moreover, forest ecosystems in tropical areas contain some of the most abundant sources of biodiversity in the world, with probably half of all unidentified biological species present within its local and regional boundaries.

At present, primary (old growth, virgin) and secondary (replanted, anthropogenic) forests cover about one-fourth of the earth's landmass outside the Arctic and Antarctic regions. Although the exent of forests and woodlands before the advent of agricultural communities is not known, it is believed that between 20 % and 50 % of forested areas have been slashed, burned or harvested in the past 10,000 years. The United

Nations Food and Agriculture Organization (FAO) has estimated that on a worldwide scale, forests have declined by about 2.2 % over the past decade, with significant losses in the tropical zone and modest increases in forest productivity in some developed regions. Other estimates by the World Resources Institute (WRI) show greater rates of global forest decline, with as much as a 10% decrease in tropical forested areas since 1980, at a probable loss rate of 130,000 km^3 per year. In WRI's calculations, tree plantation areas were not included in the definition of forested lands, as was the case in the FAO's forest assessment study. Both studies show, however, that anthropogenic impacts on forest ecosystems continue to affect human communities in developed and developing regions, where an estimated 1.7 billion people depend upon forest resources, such as timber, fuel wood, food materials and traditional medicines. For an estimated 150 million indigenous people who live in tropical forested regions, the loss of forest ecosystems not only affects their immediate natural environment, it destroys their entire way of life, both materially and spiritually, which sustained them over thousands of years of human history.

The major causes of forest loss in developing regions appear to be: (a) increased conversion to agricultural production, including rapid growth of subsistence farming in sub-Saharan Africa, (b) encroachment from cattle ranching operations, and (c) collection and use of fuel wood in marginal forested and woodland areas. Other important aspects of deforestation practices, such as tree harvesting, road building and land clearing activities lead to the loss of animal and plant habitats, whereby alien invasive species replace native fauna and flora, and seriously disturb the migratory patterns of bird species and animal wildlife. Although in many developed regions, commercial operators harvesting timber have adopted more sustainable clearance practices, this has not been the case in most tropical regions, where the net annual number of trees harvested greatly exceeds the forest's regrowth and maturation rates. Thus, once trees and underbrush are cleared in a developing country, the land is generally put to other commercial and non-commercial uses, such as plantation cultivation, cattle ranching and/or subsistence farming.

While forest wildfires are part of the regeneration process of natural ecosystems, human-caused fires in forested lands vastly exceed those that occur naturally. Worldwide, human communities cause 90 % of fires in forested areas and grasslands through extensive slash and burn techniques for agricultural resettlement and other human activities. Recent studies show that a large fraction of the population in Southeast Asia suffers from chronic respiratory health problems due to daily exposures to smoke, haze and particulate matter caused by large-scale biomass burning of forested areas in the region. In a preliminary report released by the United Nations Environment Programme in August 2002, a team of scientists reported the existence of an "Asian brown cloud" that hovers over a large region of South Asia, covering the entire Indian subcontinent -- from Sri Lanka, India, Bangladesh, Nepal to Pakistan and Afghanistan -- and extending into further parts of Southeast Asia. As reported in this study, the particulate matter haze that was produced by a combination of forest fires, biomass burning and fossil fuel combustion was observed to be about 3 kilometers in height, and was linked by research scientists to hundreds of thousands of premature deaths among adults and children in the region. In addition to the direct impact on human health, the report predicts that if the current atmospheric conditions continue to prevail, a major decline in precipitation will occur over many parts of the Indian subcontinent in the next few decades, with serious consequences for agricultural production and available water resources in the region.

(iv) *Grassland Ecosystems*

Grasslands are part of the earth's variegated network of ecosystems -- they generally lie in the intermediate zone between regions that receive sufficient annual rainfall to sustain dense forests and woodlands, and regions that are arid and dry, such as deserts and semi-deserts, where rainfall or precipitation in any form is a rare event. There are many types of grasslands; some are found in humid areas and some thrive in semi-arid drylands; others exist as alpine meadows and river-bank marshes. Humid grasslands, with their wet, tall grasses, are found in South America. A well known example is the pampas region of Argentina. Dry

grasslands, with dry, short grass are extensively seen in North America, Eastern Europe and northern regions of Asia. For example, they are found in Midwestern prairies and Rocky Mountain region of the United States and Canada, and in the vast steppes regions of Ukraine, Russia and the northern and central Asian plains. However, west of the Mississippi River in the United States, grasses can grow to heights of up to 3.5 meters (about 10 - 11 feet) because of the warm, humid conditions of the river basin during the summer months. In southern parts of Asia, grasslands are present in the Hindu Kush and the Himalayan regions as shrublands and alpine meadows. In the central Tibetan Plateau grasslands take the form of dry alpine steppes, while in the Nile River delta region and the Tigris-Euphrates River basin, grasslands exist as flooded savannas and alluvial salt marshes.

In addition to the Argentine pampas, other major grasslands in the southern hemisphere are the campos regions of Uruguay and Brazil, the veldt region of southern Africa and the savanna outback regions of Australia, which is the native domain of the Eucalyptus and Pimelea trees and of many types of marsupial animals, such as the red wallaby, hairy-nosed wombat, and several species of reptiles and insects. As natural ecosystems, grasslands are a thriving habitat to numerous species of wintering and migratory birds, while they provide sustenance to both wild and domesticated herbivores that feed on the extensive native grass and plant species of the region. Finally, grassland ecosystems are home to hundreds of mammalian animals; the cheetah, lion, rhinoceros, and wildebeest of the African highlands; the coyote, prairie dog and caribou in North America; the jaguar, armadillo and llama in South America; and the snow leopard and elephant in Asia, to name some of the most prominent mammals in these regions.

Historically, grasslands have played an important part in providing large quantities of staple food products and other goods and services to human communities. Almost all cereal crops, including rice, millet, rye, oats, corn, wheat, sorghum and barley, which are widely cultivated in modern agriculture, trace their genetic heritage to plant species that were systematically grown and developed over thousands of years in grassland human communities. Other important food and material outputs of grasslands include meat, dairy, wool and leather products, derived from cattle and sheep raised on farms, pastures, ranches and animal feedlots. Because of their rich variety of wildlife animals, grasslands around the world have attracted considerable recreational uses in the form of hunting and eco-tourism. Although these uses are major sources of revenue for the economy, they have serious implications for wildlife conservation in these regions. Several grassland animals have now been placed on the list of endangered and threatened species. These include the Asian elephant, the African rhinoceros (from illegal poaching), and the Manchurian tiger. More than half the animals on Canada's endangered species list are mammals and birds that reside in the prairie, including e.g., the small fox, the burrowing owl and the peregrine falcon.

At present, the total grassland ecosystems on the globe cover an area between 41 and 56 million km^3, which is about 30 - 40 % of earth's landmass (the higher estimates include shrublands and the Arctic tundra region in the definition of grasslands). In many quarters of the world, grasslands constitute one-third to two-thirds of the land area of a country or region, making them an integral part of several important regional watersheds, such as the Orange, Limpopo and Zambezi River basins in central and southern Africa, the upper Mississippi-Missouri River basin in the United States, and the Murray-Darling River basin in southeastern Australia. While most grasslands regions in Asia, Africa and Australia have retained much of their original geographic characteristics, that has not been the case in North America, where a large fraction (estimated to be around 70%) of former prairie lands has been converted into farming operations with medium- and large-scale agricultural production units. With extensive planting of wheat, corn and other forage crops and with dairy farms and animal feedlots dotting the landscape, the United States and Canada have become the major grain, milk and meat producing region of the world.

The most significant environmental impact on grassland ecosystems in both developed and developing regions, has been the establishment of urban and suburban population centers; rural farms with their

numerous fencing barriers, and roadways and transportation networks that crisscross the wide expanses of the grasslands. Such fragmentation of grasslands has had serious impacts on species habitats and on the migratory patterns of native animals. It has also led to the increased potential for wildfires in grassland areas, many of which are deliberately started by humans as a low-cost means for managing grasslands for agricultural production and raising livestock. Frequent reliance on fire as a grassland management technique has led, in recent years, to the destruction of many native plant species, causing soil erosion and loss of water resources.

Another important factor in grassland degradation is related to overgrazing by livestock, especially in dryland regions, where severe soil erosion cause loss of productivity of native grasses and other cover vegetation. Generally speaking, the major cause of overgrazing is the low mobility of the livestock population in many regions of the world. In traditional communities, overgrazing was avoided by frequent movement of pastoral and nomadic groups to new pasture lands, which allowed former grazing areas to recover their fertility. Today, increased use of enclosed pastures and sedentary animal husbandry practices in many regions has led to significant degradation of grasslands. A graphic illustration of this problem is seen in the degraded grassland steppes of China, Russia and Mongolia, where in recent years non-mobile livestock grazing practices have been widely introduced by the centrally planned governments of the region. At present, overgrazed grassland areas are expanding in many regions of Asia and Africa, where some 20 - 25% of drylands are classified as seriously degraded. Without reversal of the current trends toward establishing large-scale commercial livestock grazing projects in enclosed pastures and feedlots, the long-term health and well-being of human communities in grassland regions cannot be assured.

(v) ***Rural and Urban Ecosystems***

Most people today reside in closely contiguous rural and urban/suburban areas, with a very few individuals or groups living in settlements that are scattered away in sandy deserts, dry mountain ranges or the cold, arctic zone. Those who live in largely rural areas are mostly engaged in agricultural or forestry activities of one sort or another, generally to supply goods and services for those living in highly populated cities and towns. Such interconnected rural-urban human communities are, in fact, a broad network of natural and anthropogenic ecosystems, which are knit together in a synergistic relationship. Such a rural-urban ecosystem is based on two principal factors: (a) the interaction of biological organisms with earth's geochemical nutrient cycles, and (b) the solar energy captured by photosynthetic organisms.

As a biological species, humans have evolved as dependent members of a larger living and non-living world. Perched at the top of the food chain, humans are completely dependent on other animal and plant species, including microbial organisms at the lower end of the food chain, to meet their nutritional needs in order to survive and reproduce themselves. Simply put, humans receive material substance and energy from the following three main sources: (a) life-preserving oxygen by breathing air, (b) internal aqueous medium of cells by drinking water, and (c) organic carbon and solar energy by eating foods derived from other biological species in the natural ecosystem (incorporated as carbohydrates, protein and fat, along with trace amounts of minerals). In turn, human beings (like all animals) provide plant species with carbon dioxide, while at the same time providing the internal and external environments of their bodies as a host to symbiotic microbes and opportunistic organisms. Thus, human beings, as an animal species, are interactive partners in a larger food web of myriad biological organisms placed within earth's global hydrological and nutrient cycles, all deriving their major source of energy from nuclear fission occurring in the inner core of the sun.

(a) ***Rural and Agricultural Communities:*** Fifty years ago, 70% of the world's population lived in rural areas. This figure declined steadily to less than 50% at the beginning of the new millennium. In many developed regions of the world, only 20 - 25% of the population lives in rural areas. In the United States, 66

million people (23%) live in rural areas, of the total population of 287 million in mid-2002. The greatest decline in rural population has occurred in Asia and Africa. In these regions during the 1950s, around 84% lived in rural areas, which has now declined to around 62%. Part of the reason for the large shift in rural populations in developing regions (except in Latin America, where the rural/urban ratios have been comparable to industrialized countries) is the large-scale rural to urban migrations that have occurred in the past two or three decades in Asia and Africa. This demographic transition has occurred because of growing populations and dwindling resources in rural areas, combined with greater employment opportunities in the larger cities and towns in rapidly developing countries over the past thirty years.

One of the success stories in social and economic development in the second half of the 20th century is that worldwide food production kept pace with global population growth rates. On a per capita basis, the amount of food available today is greater than it was in the early 1960s, while the prices of food products have been lowered quite dramatically. For instance, total world grain production rose from 0.91 billion tons in 1960 to 1.83 billion tons in 2000 (a two-fold increase), modestly improving the per capita supply of grains from 270 to 302 kilograms per person during the same time period. With some fluctuations from year to year, annual grain production of wheat, corn and rice all rose in the past several decades. Similarly, total meat production worldwide grew from 64 million tons in 1960 to 232 million tons in 2000 (a 3.6-fold increase), with per capita consumption rising from 21 to 38.2 kilograms per person, a nearly two-fold increase. Overall, beef, pork and poultry production accounted for more than 90% of the world's meat supply, although per capita beef production has fallen by 17% since its high in the mid-1970s, indicating a shift in consumer preferences toward lower fat meat products.

Another global indicator of agricultural productivity is examining the irrigated land in the past few decades, especially in Asia, where two-thirds of the world's irrigation systems are located. In 1961, 139 million hectares of agricultural land was under irrigation globally; this rose to 274 million hectares in 1999, nearly doubling during a 38-year period. However, because of the excessive use of ground water to irrigate agricultural lands in recent years, many important aquifers in various regions in the world have much lower capacities today. At present, the extensive Ogallala aquifer in western United States, which supplies water to 20% of irrigated lands in the country, is being depleted at an excessive rate of 12 billion cubic meters per year. Since the late 1970s, over 1 million hectares of previously irrigated land have lost access to this underground water source. Similar excessive use of underground water has also occurred in the Punjab region of northwestern India and Pakistan, where shallow tube-wells have been extensively drilled to draw underground water to irrigate farmland in the two countries. In the northern Chinese plain, which is the major grain-growing region of the country, the demand for water has greatly exceeded supplies in recent years because of the enormous diminution of the large aquifers in the region. If present trends continue, the consequences for the Chinese economy would be very serious, since the upper plains region of the country currently supplies 70% of grain to the population.

While the past half-century has met most of the important challenges to agricultural production from a growing world population, it is not entirely clear whether to expect similar successes over the next twenty to fifty years. To begin with, the agricultural farming community will need to raise grain and meat production to meet the demands of an ever increasing affluent population in both developed and developing countries, where in the next two decades a projected 1.7 billion people will be added to the present global population of over 6 billion. Increasingly, fertile, arable land is becoming harder to find, while more and more marginal lands, with poor intrinsic fertility and uneven terrain, are being encroached upon. Today, more farms use intensive agricultural and cultivation techniques, with greater inputs of chemical fertilizers and pesticides, which have long-term environmental and health impacts on a region. Because of excessive land use and overgrazing practices and the use of modern livestock raising methods, many agricultural lands have become seriously degraded from constant soil erosion, nutrient depletion, salinization and chemical pollution. In the future, water resources for agriculture use will only decrease. There does not

seem to be much room for further improvement unless strict water conservation measures are put into widespread practice. Thus, at the beginning of the new millennium, although the state of rural life and global agriculture seems relatively benign and well settled on the surface, darkening clouds in the form of lower land fertility, increased soil erosion and greater water scarcity have appeared on the horizon, which do not bode well for the future.

(b) ***Cities, Towns and Urban Communities***

> "For thousands of years, cities have existed apart from nature. Why should we begin now to think of cities in terms usually reserved for the natural environment? The fact is, in the world that we've created for ourselves, cities occupy pivotal positions, for better or worse, in the patterns of global ecology. This becomes clear when we put aside our standard images of cities and consider their ecological functions. Cities of the industrial era have consciously excluded natural processes, substituting mechanical devices made possible by intensive use of fossil fuels. Rather than using the solar energy continuously falling on their streets and buildings, they dissipate it as excess heat. At the same time, they import immense quantities of concentrated energy in various forms, most of it derived from petroleum coaxed from the ground in distant landscapes. They rush the water falling upon their roofs and streets as rain out through concrete pipes and channels into the nearest bay or river and, at the same time, bring water in from distant landscapes through similar concrete channels. From outer landscapes, too, they import nutrients in the form of food, use it once, then send it out through pipes as sewage waste."
> -- John T. Lyle, *Urban Ecosystems*

Today, nearly a majority of the world's population lives in cities, towns and other urban centers, where for the most part they enjoy a standard of living and obtain goods and services unlike any imagined or hoped for in human history. Although one-third of their population in Asia and Africa lives in urban communities at present, more than three-quarters of the population of Latin America, Europe and North America live in large, densely populated cities and towns. However, with increasing urbanization and rural migration to urban centers in developing regions, current demographic projections indicate that in the next 50 years, well over 80% of the world's population will be living in towns and cities. Although part of the population will continue to live in or near rural villages and farms, the majority will live completely isolated from the surrounding agricultural and forested lands, essentially ignorant of or indifferent to their daily dependence on the labors of agricultural, livestock and forestry workers, or unaware of the critical need of human communities to conserve the finite resources of natural ecosystems.

The urban landscape and municipal services in many developed countries today appear to be much improved over the situation that prevailed in most large cities and towns even as recently as 150 years ago. For instance, in the mid-19th century, many large urban centers in Europe (such as London, Paris or Rome) were characterized by a small enclave of the affluent living in ostentatious luxury, surrounded by the pitiful misery and widespread squalor of the urban poor. Such is not the case today, where in even the most densely populated cities and towns in Western Europe and North America, the past disparities in housing, living conditions and daily amenities of rich and poor inhabitants have been significantly reduced. In many urban communities, proper municipal planning and the welfare concerns for the poor and marginalized populations have replaced the sheer neglect and disregard of the nineteenth century.

Some cities in Latin America, such as Curitiba, the capital city of Parana province in Brazil, which is home to more than 2.5 million, have taken a leadership role in the planning and design of a livable, sustainable

urban community for their region. In this city, more than three-quarters of city dwellers use an above-ground mass bus system, which has served as a transportation model for other urban communities. Attractive urban parks have replaced blighted industrial and commercial sites along the city's riverbanks. With improved municipal services, such as garbage collection, child-care facilities, educational centers and the construction of outdoor shopping malls, the city have dramatically improved living and working conditions of Curitiba's residents.

Unfortunately, such achievements in urban planning and municipal services appear to be the exception rather the rule in most developing countries today. In most cities and towns in Asia, Africa and Latin America, urban living conditions today resemble those that prevailed in most industrialized, developed countries during the past few centuries. With few amenities and services available to the low-income poor who live in shanty-towns and squatter areas of large, congested cities, the daily lives of urban dwellers are a constant struggle to survive, to find means to house and feed their families, and to provide them with other necessary goods and services. The United Nations Children's Fund (UNICEF) in a recent report portrayed the life of an average child growing up in these degraded urban conditions as follows:

> Inadequate sanitation, drainage and water provision, uncollected waste, overcrowding and daily exposure to infectious and parasitic diseases are standard components of urban poverty. Low-income settlements are more often in polluted areas or on land at risk from landslides, floods or other hazards. Attempts to practice good hygiene and to ensure safety under such difficult conditions are nigh impossible. The environmental stresses of urban poverty are often accompanied by increased social stress, which has an impact on health; alcohol and drug use, domestic and community violence, sexual exploitation, discrimination and exclusion, all occur at higher levels in urban areas.
> -- UNICEF, *Cities for Children: Children's Rights, Poverty and Urban Management*

The higher income inhabitants of developed countries also share in some of the inconveniences and daily annoyances of urban life. More and more cities and towns of the developed countries have become clogged with cars, trucks and other motorized vehicles competing for limited space on crowded streets, making traveling during rush hours on the main arteries and busy highways of an metropolitan area an unpleasant undertaking. The urban poor who live in these densely populated cities do not have the same access to public and private goods and services as do the more affluent inhabitants, especially with regard to educational institutions, health care facilities, crime prevention or recreational amenities. Often, the poor have become literally invisible to many suburban commuters (especially in United States and Canada), whose only connection with urban life generally consists of working in closed, climate-controlled buildings, with an occasional foray into the city's center for recreational purposes.

However, the most egregious shortcoming of most urban planning programs of municipal governments today is their failure to recognize the close-knit and intimate relationship that links urban and rural ecosystems. For most urban dwellers, food comes conveniently packaged in local grocery stores, water is brought in through extensive underground pipes, electricity is mysteriously turned on by a switch, gasoline is readily available at neighborhood outlets, wastes are placed in collection bins or flushed down drainage pipes, and to get around one depresses the accelerator of a vehicle, powered by a 200-horsepower internal combustion engine. Living in such an artificial, synthetic environment, the average urban or suburban inhabitant easily loses all sense of perspective and possesses little or no understanding of the intricate web of life that sustains his or her daily existence. As more people move from rural areas into crowded urban population centers, fewer city dwellers will know, or even remember, how food, water, fiber, fuel, timber and other goods and services are obtained in the first place. This lack of consciousness of the primary role that natural and rural ecosystems play in the lives of most of the world's urban population should be addressed through the introduction of educational programs and the development of environmental

curricula in urban and suburban schools. Similarly, special efforts should be made to bring this recently acquired knowledge to the attention of policymakers, especially in developing countries, where environmental considerations are generally not taken into account in the present pursuit of rapid economic development. Only with such direct involvement on the part of urban and regional planners, along with the assistance of environmental specialists and other decision-makers, both in the public and private sectors, will a more sustainable network of human communities be achieved in the future.

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