Interim Report
of Task Force 6 on Environmental Sustainability

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Coordinators
Yolanda Kakabadse-Navarro
Jeff McNeely
Don J. Melnick

Comments are welcome and should be directed to:

Robin Sears at rrs26@columbia.edu

Note to the reader
This Interim Report is a preliminary output of the Millennium Project Task Force 6 on Environmental Sustainability. The recommendations presented herein are preliminary and circulated for public discussion. Comments are welcome and should be sent to the e-mail address indicated above. The Task Force will be revising the contents of this document in preparation of its Final Task Force report, due December 2004. The Final Task Force report will feed into the Millennium Project's Final Synthesis Report, due to the Secretary-General by June 30, 2005

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The Millennium Project is an independent advisory body to the United Nations Secretary-General Kofi Annan commissioned with recommending, by June 2005, the best strategies for meeting the Millennium Development Goals (MDGs). This includes reviewing current innovative practices, prioritizing policy reforms, identifying frameworks for policy implementation, and evaluating financing options. The Project's ultimate objective is to help ensure that all developing countries meet the MDGs.

As a United Nations-sponsored initiative, the Millennium Project proceeds under the overall guidance of the Secretary-General and United Nations Development Programme (UNDP) Administrator Mark Malloch Brown in his capacity as chair of the United Nations Development Group (UNDG). Professor Jeffrey Sachs directs the Project, which brings together the expertise of world-class scholars in both developed and developing countries, United Nations agencies, and public, non-governmental, and private-sector institutions. Ten Task Forces carry out the bulk of the Millennium Project's analytical work with support from a small secretariat based at UNDP headquarters in New York. The Task Forces and their Coordinators are listed below.

Task Force	Task Force Coordinator
1-Poverty and Economic Development	• Mari Pangestu • Jeffrey Sachs
2-Hunger	• Pedro Sanchez • M.S. Swaminathan
3-Education and Gender Equality	• Nancy Birdsall • Amina Ibrahim • Geeta Rao Gupta
4-Child Health and Maternal Health	• Mushtaque Chowdhury • Allan Rosenfield
5-HIV/AIDS, Malaria, TB, Other Major Diseases and Access to Essential Medicines	• Agnes Binagwaho • Jaap Broekmans • Paula Munderi • Josh Ruxin • Burton Singer
6-Environmental Sustainability	• Yolanda Kakabadse Navarro • Jeff McNeely • Don Melnick
7-Water and Sanitation	• Roberto Lenton • Albert Wright
8-Improving the Lives of Slum Dwellers	• Pietro Garau • Elliott Sclar
9-Open, Rule-Based Trading Systems	• Patrick Messerlin • Ernesto Zedillo
10-Science, Technology and Innovation	• Calestous Juma • Lee Yee Cheong

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Millennium Project

Task Force 6 on Environmental Sustainability

INTERIM REPORT

April 2004

Preface

This report is written to provide a scientifically and economically authoritative perspective on the essential role of MDG7, and how it can be achieved. Many of the relevant WSSD targets are also addressed. We have sought to be provocative and forward-looking, moving beyond incremental improvements to recommend bold steps that will enable our planet to prosper.

This Interim Report is the result of a year's worth of discussions and meetings involving the 27 members of Task Force 6 and associates to the task force, listed in Appendix III. The report is a summary of the work of the Task Force and draws both ideas and text from seven papers commissioned by this group on issues related to environmental sustainability and environmental management. These papers and their authors are listed in Appendix IV. The final versions of the papers were not complete at the time of releasing this Interim Report but will be posted on the Millennium Project web site under Task Force 6. That said, not all of the content of this Interim Report was developed with consensus in the group. In the next six months as we deepen the analysis and develop an operational plan of action we will use a more structured process to arrive at consensus.

We are grateful for the guidance of Guido Schmidt-Traub, John McArthur and their associates at the secretariat of the Millennium Project for providing guidance on structure and content of the report. We have also benefited from interactions and discussions with members and coordinators of the other Millennium Project Task Forces.

While we have discussed the work of the Millennium Project and our task force in particular with as many colleagues and associates as possible, this Interim Report still reflects the ideas of a very small group of people. The Report also lacks a geographical analysis of environmental degradation and poverty, but the point is that the environment is important everywhere because it provides the essential foundation to sustainable development for the global public. Concrete evidence of the cause and effect of environmental degradation and poverty is difficult to obtain, possibly because the two are so intimately intertwined. We invite readers to provide us with critical comments on and reactions to our analysis as it stands and, especially, the recommended action points. These can be directed to Robin Sears whose contact information is in Appendix I.

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1 INTRODUCTION

The sustainable management of ecosystems, their biologically diverse components, and the services they provide the human population is absolutely essential to alleviating many of the world's most pressing concerns and addressing most of the Millennium Development Goals (MDGs).

While the intrinsic value of species, ecosystems and ecosystem services may be difficult to calculate with precision, it is important to focus on their present and future economic and social benefits because such considerations strongly motivate decisions. No doubt intrinsic values of nature also play an important role in human well-being and in decision making processes. However, the Task Force firmly believes that the primary guide for current and future decisions should be the public and private human benefits derived from biodiversity (ecosystems, species, and genes) and its services discounted into the future.

A considerable body of scientific data points to environmental degradation – the erosion of genetic diversity, the loss of species, the degradation of ecosystems, and the decline of ecosystem services – as a direct cause of many of the most pressing issues we face today, including poverty, declining human health, hunger, undrinkable water, emerging diseases, rural-urban migration, and civil strife. In the face of this evidence, we often find ourselves dealing only with the "symptoms" of a larger environmentally induced "disease," and neglecting the underlying causes of the loss of biodiversity and its declining services to humans that collaterally affect all aspects of our lives. Agricultural productivity, clean drinking water, supply of fuelwood, fossil fuels, disease prevention, and fisheries, as well as protection from landslides and flooding, are all services upon which each of us relies. All of these services are at risk in the current treatment of the environment by activities of the world's businesses, governments, and citizens.

We recognize the fundamental importance of addressing hunger, water availability, disease, civil unrest and the other MDGs. However, a root cause of these unmet human needs is the increasing degradation of the biological systems upon which all life, including the human population, depends. **The Task Force on Environmental Sustainability, therefore, seeks to identify appropriate policy measures that will reverse environmental degradation and ensure more productive management of ecosystems as a basis for enabling the other MDGs to be met.** This will require that the sustainable management of ecosystems, their constituent species, and their essential services are directly incorporated into development planning in sectors such as agriculture, water, forestry, fisheries, energy, transportation, health, and industrial production.

While it is clear that environmental sustainability provides the essential foundation to all development, it is not always clear what is meant by the term. Environmental

sustainability means the ability of communities of plants, animals, micro-organisms, and their non-living surroundings to sustain themselves, and people, far into the future. It includes providing critical ecosystem goods and services to people and other species (Box 1). Sustaining these communities, called "ecosystems", requires people to act in ways that do not disrupt their functioning, and even improve the provision of goods and services.

Today the opposite is happening. Our planet is losing species at a rate that is two to three orders of magnitude faster than the background rate, many ecosystems are being degraded or completely destroyed, and the loss of ecosystem services is undermining sustainable development.

In September 2000, at the United Nations Millennium Summit, world leaders agreed to the Millennium Development Goals (MDGs), which focus the efforts of the world community on achieving significant, measurable improvements in human well-being by the year 2015. They establish targets for measuring results, helping to guide activities of developing countries, the rich countries whose policies profoundly affect the developing ones, the multilateral and bilateral institutions that help countries to implement the goals, and private sector enterprises of all scales who may wish to contribute. So far the actual primary targets of the development enterprise – the poor – are being represented mostly by surrogates. In addition to setting concrete targets, indicators were defined to help assess the progress of individual countries toward reaching those targets. These MDGs now stand at the center of the global agenda, though implementation for action and measures for achievement will involve multiple actors at the national level, and reach down to the local level. Together these actors will provide the global partnership for development called for in MDG8.

The Millennium Development Goals

1. Eradicate extreme poverty and hunger
2. Achieve universal primary education
3. Promote gender equality and empower women
4. Reduce child mortality
5. Improve maternal health
6. Combat HIV/AIDS, malaria and other diseases
7. Ensure environmental sustainability
8. Develop a global partnership for development

(Source: UNDP web site: www.undp.org/mdg/)

In 2002, the World Summit on Sustainable Development (WSSD) was held to take stock of the achievements, challenges and new issues arising since the 1992 Earth Summit. The resulting Johannesburg Declaration on Sustainable Development and subsequent Plan of Implementation reaffirmed that "managing the natural resources base in a sustainable and integrated manner is essential for sustainable development." It further stated that "to reverse the current trend in natural resource degradation as soon as possible, it is necessary to implement strategies which should include targets adopted at the national and, where appropriate, regional levels to protect ecosystems and to achieve integrated management of land, water and living resources, while strengthening regional, national and local capacities."[1] With regard to national sustainable development strategies, they

[1] Plan of Implementation of the World Summit on Sustainable Development, the final text of agreements negotiated by Governments at the World Summit on Sustainable Development, 26 August – 4 September 2002, Johannesburg, South Africa, United Nations, 2003, paragraph 24. (URL: www.un.org/esa/sustdev)

requested that "States should take immediate steps to make progress in the formulation and elaboration" and "begin their implementation by 2005."[2]

The task ahead is to enable countries to meet their commitments made at the Millennium Summit, the WSSD, the various multilateral environmental agreements, and several other international conferences. However, the world is currently lacking a clear operational understanding of how the goal of environmental sustainability can be achieved, how the benefits can be equitably distributed, and how the inevitable tradeoffs can be defined in the most appropriate way. To date no robust framework for implementation exists to address the problem at the global, regional and national scales, while concomitantly allowing for local specificity in the implementation of recommendations, as well as providing the means by which to measure progress.

The Millennium Project was established to fill this gap. Ten thematically-oriented task forces are working to identify the best strategies for reaching the MDGs and the operational priorities, organizational means of implementation, and financing structures necessary to achieve the MDGs. The Task Force on Environmental Sustainability – Task Force 6 - is charged with addressing MDG 7, Target 9 and identifying appropriate policy measures that will reverse environmental degradation and ensure more productive management of ecosystems as a key to meeting the other MDGs. The Mission and Goals of TF6 are included in Annex I.

MDG Goal 7: Ensure environmental sustainability

Target 9 Integrate the principles of sustainable development into country policies and programmes and reverse the loss of environmental resources

Indicator 25	Proportion of land area covered by forest
Indicator 26	Ratio of area protected to maintain biological diversity to surface area
Indicator 27	Energy use (metric ton oil equivalent) per $1 GDP (PPP)
Indicator 28	Carbon dioxide emissions (per capita) and consumption of ozone-depleting CFCs (ODP tons)
Indicator 29	Proportion of population using solid fuels

Conservation of biodiversity and the delivery of the associated ecosystem goods and services provide the foundation for human survival, providing food, soil nutrients, clean water, disease and climate buffering, building materials, energy, pharmaceuticals, and much else. Moreover, ecosystem services (Box 1) provide our species with renewable goods and services that will enable us to adapt to the changing conditions that are sure to characterize the coming decades.

[2] *Ibid*., paragraph 162 (b).

Because of the fundamental importance of environmental sustainability to addressing poverty, hunger, water availability, disease, and civil unrest, 'environmental sustainability' needs to be widely recognized as the foundation on which achievement of the other MDGs depends. Conversely, if the other MDGs are not achieved, it will be exceedingly difficult to ensure environmental sustainability. Therefore, the MDGs need to be implemented as a package.

In this report we use the term ecosystem services to refer to the whole complex of goods, services and processes delivered by biological systems. We also address the abiotic (non-living) resources including both non-renewable ones such as fossil groundwater, fossil fuels, minerals, and chemicals, among others, and renewable ones such as the freshwater circulating in the water cycle. We distinguish between freshwater seen as an abiotic resource (to drink, to water plants, to provide habitat for aquatic life) and freshwater as a service delivered by ecosystem processes (rainwater, soil water).

Box 1. Benefits of biological resources

Biological resources deliver two main kinds of benefits. The first are biological goods, including food, fibre, timber, fuel, ornaments, and many others. The second are "ecosystem services", classified by the Millennium Ecosystem Assessment (2003) as follows:

Ecosystem Services Classification

Provisioning	**Regulating**	**Cultural**
Goods produced or provided by ecosystems	Benefits obtained from regulation of ecosystem processes	Non-material benefits obtained from ecosystems
• food • fresh water • fuel wood • fiber • biochemicals • genetic resources	• climate regulation • disease regulation • water regulation • detoxification • pollination	• spiritual • recreational • aesthetic • inspirational • educational • communal • symbolic

Supporting

Services necessary for production of other ecosystem services

- Water Cycling
- Soil formation
- Nutrient cycling
- Primary production

Many of these ecosystem services are public goods, in that their use by one person does not exclude use by others or diminish the good. Because many ecosystem services are produced by nature at no cost to individuals, the marginal opportunity cost is zero, so theory suggests that the price should also be zero. But the cost of maintaining the ecosystems that produce these public goods is considerably greater than zero, and profits are made by activities that disrupt the delivery of ecosystem services and thereby reduce the provision of the public good. The challenge is to find ways of providing the public goods of ecosystem services at the optimal level.

All four kinds of ecosystem services contribute to a society's "natural capital". The natural capital together with the manufactured, human and social capital constitutes the full wealth of a nation. In the case of provisioning services, the characteristic of their delivery that is most directly relevant to human well-being is their flow (e.g. kilograms of maize per hectare); nevertheless, the ability to continue providing such flow depends on how much is produced through ecosystem processes and how much is exhausted by that flow (e.g. tons of cod produced per year vs. tons of cod harvested). The regulating and supporting services cannot be directly accounted for in the natural capital, but contribute to it through the regulation and support of the capacity of ecosystems to deliver a flow of provisioning services. The cultural services are also non-tangible but are related to the natural capital as they affect the human decision processes related to the flow of provisioning services and management of ecosystems (Costanza et al. 1997, Daily and Walker 2000, Etkins et al. 2003, Balmford et al. 2002, Millennium Ecosystem Assessment, 2003).

1.1 The environment we seek to sustain

The environment comprises the Earth's biotic and abiotic resources and the geochemical, hydrological, and biological processes and cycles that maintain life. The concept of ecosystem includes the components and processes that comprise the environment and provides a helpful framework for discussions related to the environment. As defined in the Millennium Ecosystem Assessment, an ecosystem is "a dynamic complex of plant, animal, and microorganism communities and the non-living environment interacting as a functional unit. Humans are an integral part of ecosystems. Ecosystems vary enormously in size; a temporary pond in a tree hollow and an ocean basin can both be ecosystems" (Millennium Ecosystem Assessment 2003g:3). Humans are fully dependent on the flow of benefits of biological resources (Box 2).

Box 2: Valuing the benefits of biological resources

Biological resources have three main kinds of values

- **Direct use values**. These include *consumptive-use values* that reflect the monetary worth of specific, market-based goods and services, such as an agricultural crop or a loaf of bread. The market prices do not necessarily represent true values to society because they include distortions introduced by government policies, such as subsidies, exchange rates, and taxes; and associated environmental damages and market failures are often ignored ("externalized"). Economists often use the concept of "social prices" to adjust the market prices to correct for environmental externalities, market failures and policy distortions. *Nonconsumptive-use values*, such as the value of tourism, are more difficult to assess directly, though methods such as assessing the travel cost to participate in tourism is a way of assessing the value.
- **Indirect-use values**. These include the value of the ecosystem services that were discussed in Box 1. Ways of estimating such values may include assessing replacement costs or opportunity costs that identify benefits foregone (though the loss of a species cannot be given a value, because a species is irreplaceable).
- **Non-use values.** These are also called *existence values*, given by people to a species or ecosystem that they may never use directly or indirectly, or even see. *Option values*, the premiums that people assign to environmental resources beyond their expected use values, are also included in this category, in valuing the capacity to maintain options for the future.

1.1.1 Abiotic components

Freshwater

Water is a natural environmental resource that is essential to life. It provides transport, supports fisheries, dilutes pollution wastes, and yields hydroelectricity. Water is withdrawn from rivers, lakes, reservoirs, and wells for domestic water supply, industrial water supply and irrigation.

According to the World Water Commission, the global withdrawals in the mid-1990s amounted to some 3900 km^3/yr, with two-thirds consumed and the remaining one-third returned to water sources. Irrigated agriculture accounts for about 70% of the water withdrawals consumed worldwide. Water required for food production consumes 50-100 times more water than is consumed for household needs (Falkenmark 2003, WRI 1998). The UN considers 50 liters per day per person to be the minimum required for supporting sustainable forms of development, and 20 liters per day per person as the minimum requirement for mere existence. It is generally accepted that at least 30% of a river's flow should remain to maintain its basic ecosystem functions and aquatic biodiversity. The huge scale of consumptive use has depleted many rivers and lakes in the developing world, with the Aral Sea basin as perhaps the most dramatic example. Where the return flow carries pollutants added during use, such river depletion gives rise to serious health problems for humans and animals. The drying of the Aral Sea, with associated air pollution caused by wind transport of dried sediments, cause health problems as far away as Europe.

While information on water use tends to focus on withdrawals (quantity), assessing environmental sustainability must also include what happens after withdrawal and use. At the global scale, water cycling between the sea, atmosphere and continents constitutes the 'bloodstream' of the biosphere. Water circulation is also closely linked to the climate regulation system because of the fundamental role in energy transformations that water plays in the atmosphere. At the local scale, freshwater used to meet societal water supply needs is regulated both by soil characteristics that influence groundwater recharge and dry season river flow, and by plant production which consumes huge amounts of water as "productive losses" to the atmosphere through transpiration. The water cycle amplifies such quality and quantity-related effects on local water upwards in scale, in both time and space, causing regional-scale ecological degradation such as acidification and eutrophication.

Current availability of water per capita varies considerably including:

- regions which have already "hit the ceiling" in the sense that they cannot mobilize any more water because the remaining water has to be left as environmental flow (so-called closed basins);
- regions with very low water use but rapidly increasing levels of population pressure on the limited water ("water crowding"), and therefore vulnerable to both pollution and water disputes; and
- the water surplus regions using a limited fraction of available water and with large per capita amounts available.

Under current trends, two-thirds of the world population may be subject to moderate to high water stress in terms of use-to-availability ratio by 2025 (UNFPA 2003).

Soils[3]

Soils deliver many regulating ecosystem services such as buffering and moderation of the hydrological cycle, retention and delivery of nutrients to plants, waste disposal, buffering and filtering pollutants, soil fertility maintenance, and regulation of major element cycles. They also deliver important supporting services such as nutrient cycling, providing physical support of plants and habitat for a wide proportion of world's biological diversity. These provisioning and supporting services are critical to the provision of freshwater and food, wood and wood-fuels, and non-wood forest products (Daily 1997, UNEP 2002). All of these services are delivered locally, although they depend on processes that occur at multiple spatial and temporal scales.

Exhaustion of soils from overuse or inadequate replenishment is a major problem in much of the world. Over the last few decades, the soil's ability to maintain fertility, generated over long periods, has been strongly undermined by inappropriate land use. An estimated 2 billion hectares, fully 17% of Earth's vegetated land surface, have undergone human induced soil degradation since 1945 (Oldeman et al. 1990). Changes in land use and pressures to maximize food production are the major drivers of such change. Soil degradation occurs as a result of erosion by water or wind, water logging and salinization, compaction and crusting, acidification, loss of soil organic matter, soil microorganisms nutrient depletion, loss of soil biodiversity and accumulation of pollutants in the soil (WRI 2000).

Fertility is the potential of the soil system to support plant growth and primary productivity. A key component of soil fertility is soil water that provides one of the two most important raw materials for photosynthesis (the other being carbon dioxide from the air) and carries nutrients to the growing plant. Maintenance of soil fertility depends on nutrient cycling, complex processes carried out by a great diversity of micro- and macro-organisms, that allows nutrients to be extracted from their mineral sources (atmosphere, hydrosphere or lithosphere) or recycled from dead organisms. These processes require freshwater and the presence of particular physical structures (from biotic and abiotic components) to enable the mechanisms that act as buffers to limit losses and undesirable transfers of nutrients to other ecosystems (Daily 1995).

Over the past few decades, the soil's ability to maintain fertility, generated over long periods, has been strongly undermined by inappropriate land use. An estimated 2 billion hectares, fully 17% of Earth's vegetated land surface, have undergone human induced soil degradation since 1945 (Oldeman et al. 1990). Changes in land use and pressures to maximize food production are the major drivers of such change. In Africa and several other regions of the world, poorly maintained soil fertility is the fundamental biophysical cause of stagnant per capita food production.

[3] Based on contributions to the Millennium Ecosystem Assessment, currently under review.

Soil fertility maintenance is not so much about the amount of nitrogen (N) or phosphorous (P) in soils but rather how they are available to crops. The decline in organic matter content of soils has contributed to the reduction in nutrient availability through acidification and compaction of soils and the formation of P-iron or aluminum compounds making N and P unavailable. In tropical soils application of phosphorous through mulch or chemical fertilizer together with organic matter contributes to thirty times more P available. Similarly, the incorporation of nitrogen-fixing legumes can contribute from 80 to 400 kg/ha/year of nitrogen more cost-efficiently than through chemical fertilizer (Sanchez 2002).

Air

Anthropogenic activities since the pre-industrial era have changed the chemical composition of the atmosphere and the physical properties of the land's surface which in turn affect air quality and climate. Human activities since the beginning of the industrial era have increased the atmospheric concentrations of greenhouse gases - such as carbon dioxide (CO_2), methane (CH_4), nitrous oxide (N_2O), and tropospheric ozone (O_3) - and of aerosols. This increase is primarily due to the combustion of fossil fuels, agriculture, and land-use changes. The long-range aerial transport of pollutants means that the countries generating the pollution are able to pass the costs on to other countries.

Oceans

By far the largest habitat for life on earth, oceans make up almost 80% of our planet's surface. Oceans are the source of much of our fish catch and play a significant role in many ecosystem services, of which perhaps the most important is in controlling the climate. In coastal areas, the sea interacts directly with the land, eroding and depositing sediments and occasionally causing major floods. About 40% of the global human population lives within sixty kilometers of the coastline and with an increasing rate of rural to urban migration this figure will likely increase dramatically in the coming thirty years.

The oceans face major threats in the form of marine pollution, overexploitation of fisheries, by-catch of non-target and protected species, and coastal habitat loss. These problems are the result of increasing pressure by humans on both terrestrial and marine natural resources, and the use of the oceans to deposit wastes. Population growth and increasing urbanization, industrialization and tourism in coastal areas are root causes of this increased pressure (UNEP 2002). Many parts of the coastal zone, especially enclosed bays and estuaries, are suffering from the problem of invasive alien species carried by ballast water. It is now widely recognized that the best approach to marine problems is through a cross-sectoral and holistic approach that manages marine and coastal environments along with their watersheds, an approach that has been formalized as the discipline of integrated coastal management (ICM).

1.1.2 Biotic components

Biodiversity refers to the variability in our planet's living organisms. It is usually considered in terms of three components: the millions of species; the genes they contain; and the complex ecosystems they help form. Each species has evolved into its current form in relation to numerous other species, processes, and environments. While each fills a niche occupied by no other species, that niche has been developed through interacting with a network of other species and processes. Thus the diversity of life structures life itself. Biodiversity is best considered as a public good, available to all and not subject to conventional economic analysis.

The physical manifestations of biodiversity are biological resources, which provide multiple benefits in the form of goods and services (Box 1). These ecosystem services have use values, non-use values, and option values (Box 2), and their distribution is a fundamental issue in sustainable development. Ecosystem services have characteristics of both public and private goods, so conserving them and using them sustainably will require both public and private investment. The 1992 Convention on Biological Diversity, with 188 State Parties, is the major international instrument for agreeing on measures to conserve biodiversity, use biological resources sustainably, and ensure the equitable distribution of benefits arising from the use of genetic resources.

Species

Since the first modern attempts to catalogue life on Earth begun by Linnaeus and his contemporaries in the mid-eighteenth century, ~1.7 million species have been identified and described. Estimates of undiscovered species on Earth range from 10 million to 100 million. Threatened plant and animal species are found across the taxonomic spectrum. The *2000 IUCN Red List of Threatened Species* reports a depressing story: 24% of mammals and 12% of birds are threatened. Preliminary studies on other major taxa indicate that 20-30% of reptiles, amphibians and fishes are also threatened, and a similar proportion of plants. Unfortunately very little is yet known of the level of threat facing invertebrate taxa (which contain very large numbers of species), but early indications are that the great majority of species in freshwater habitats are under extreme threat. The consensus of biologists is that the current rate of species extinction is 100 to 1000 times the historic background rate[4].

Genes

A systematic effort to measure diversity at the genetic level for all species has, understandably, not been undertaken. Genome-mapping projects have focused primarily on microorganisms, particularly those that are human pathogens, with a few notable exceptions such as the human genome project. Nature.com maintains a freely accessible database of genomics research published in *Nature* for 33 species, six of which are multicellular organisms (http://www.nature.com/genomics/papers/).

Generally, genetic diversity is expected to decline as populations are reduced in size. Reduced genetic diversity, or increased inbreeding, is believed to lead ultimately to a loss

[4] Source: Background to the 2003 IUCN Red List of Threatened Species (URL: www.iucn.org/themes/ssc).

of adaptation (evolutionary) potential, demonstrated through effects such as increased susceptibility to disease or reduced capacity to adapt to changing conditions (Keller and Waller 2002, Wolfe 2000). These effects, in turn, greatly increase the likelihood of extinction of any particular species.

Ecosystems and their services

Conditions for most ecosystems around the world are deteriorating. The World Resources Institute has published a series of pilot analyses of global ecosystems (PAGE) in 2000, finding that conditions across five large scale ecosystem types studied are uniformly declining (Box 3). While the ocean ecosystem comprises a major percentage of the Earth's surface, it was not included in the PAGE reports, or here, because the majority of the fisheries (upwards to 95%) and degradation are in coastal zones which include the intertidal and subtidal areas on and above the continental shelf.

The benefits people obtain from ecosystem goods and services underpin the basis for their livelihood, health and security, but delivery of these ecosystem services is also under threat. For example, per capita consumption of fish – an important source of protein for the poor – has increased steadily with the result that one-half of all wild fish stocks are fully exploited, 25% are overexploited or significantly depleted, and only 25% are under or moderately exploited (FAO 2003, Wood et al. 2000). Overexploitation of marine resources can cause many biological and possibly genetic effects. "Fishing down the food chain" has also occurred, which is a shift from large high-trophic level fish to community dominated by smaller fish (Pauly et al. 1998). This trend is reflected in FAO global fisheries catch statistics; the mean trophic level of fish species caught declined between 1950 and 1994 (Pauly et al. 1998). In addition, coral reefs provide fish and seafood for one billion people in Asia alone, but 80% of those reefs are at risk from coastal development and fishing-related pressures (Bryant et al. 1998; Roberts et al. 2002). Aquaculture is filling the supply gap to some extent – it now accounts for one-third of all fish consumed by volume – but modern aquaculture practices can have negative ecological impacts such as the introduction of potentially invasive non-native species, water pollution, the spread of disease, and over-consumption of species used as food for cultivated species.

Recent estimates suggest that over 1.5 billion m^3 of timber are produced worldwide in a year while a staggering 1.8 billion m^3 are used for fuel (wood or charcoal) (Matthews et al. 2000). Timber and fuelwood are major products which support the livelihoods of rural people, and shortage of fuelwood is a serious problem for the rural poor. While more fuelwood plantations are being planted, the benefits from them are largely for external markets and do not provide local people with ecosystem services such as wildlife habitat or genetic diversity that are provided by natural forest (Millennium Ecosystem Assessment 2003f, Millennium Ecosystem Assessment 2003c, FAOSTAT 2003). A moderate reduction in wood-fuel's share of energy consumption in developing countries is expected as some energy policies are promoting use of other energy options by households. An increased use of wood-fuels for industrial energy in developed countries is also expected as a result of environmental concerns, and suggests that, in a much longer term, the demand for biomass energy may increase not only in developed countries but also in developing countries, with increased industrial use offsetting an

eventual decline in residential woodfuel demand (FAO 2002). The environmental impacts of this change in energy production have received inadequate attention, but will certainly affect land use and air quality.

Box 3 Conditions and Trends of five major ecosystem types

Ecosystem	Condition	Trend
• Coastal [1]	• 20% of land area • 19% of land within 100 km of coastline is altered for agriculture or urban use	• 5-80% of original mangrove lost
• Forests[2]	• 25% of land area • only 40% undisturbed by human activity • 80% of endemic bird areas are in forests	• 20% decrease since pre-agricultural times • since 1980, at least 10% decline in developing countries
• Freshwater[3]	• <1% of land area but services estimated at USD trillions • large dams impound 14% of world's runoff	• 50% of world's wetlands lost during the 20th century
• Grasslands[4]	• 40% of land area • almost 50% of Centres of Plant Diversity include grassland habitat • 12% of threatened birds are specific to grasslands • nearly 49% lightly to moderately degraded	• significant loss due to conversion for agriculture
• Agroecosystems[5]	• 28% of earth's surface • 31% of this is cropland (primarily cereal production) with 69% under pasture	• pasture area increasing at 0.3% annually • areas under irrigation increasing ~1.6% annually

[1] Burke et al. (2000), [2] Matthews et al. (2000), [3] Revenga et al. 2000, [4] White et al. , 2000, [5] Wood, 2000.

1.2 Environmental Sustainability and the Other MDGs

The Millennium Project aims to put forward a set of policies and investments that will help the more than one billion people living in extreme poverty to break out of the "poverty trap". These efforts will require a great deal of inter-sectoral cooperation and negotiation and cross-sectoral, or integrated, implementation. Many of the actions proposed by each Task Force to address specific MDG targets will involve synergies, trade-offs and dependencies with other MDG targets.

The various MDG goals and targets have many possible relationships between them. Advances in one sector may be dependent upon progress made in another, or lack of progress in one sector may present a barrier for achieving progress in another (e.g., where lack of clean drinking water makes it difficult to achieve health goals). Achieving

different sectoral goals may also appear to be in conflict (e.g., where the installation of transportation infrastructure necessarily fragments natural habitats and threatens biodiversity and ecosystem services). Finally, synergistic relationships among goals may occur in situations where a single intervention or package of interventions will achieve advances in multiple goals across sectors much more cost-effectively than if they were applied in a single sector. An example of this may be the provision of food to primary schools by local farmers providing a secure market for farmers and nutrition for children.

Thus, a spectrum of interaction of interventions can be proposed to meet many of the targets. A model demonstrating the complexity of these interactions is shown in Figure 1. showing some of the potential negative consequences the actions taken to address the food security and poverty goals on the environmental sustainability goal. This schematic primarily highlights the freshwater component of the environment, an abiotic resource of the environment that is fundamental to life's processes.

The ecological and economic underpinnings of most ecosystem services are poorly understood because of the complexity of the interactions or because science has not yet advanced that far. Better science will enhance the conservation and appropriate management of ecosystem services.

This section explores some of the relationships between MDG7 and MDGs 1-6, demonstrating that MDG7 provides an essential element to, even the foundation for achieving, of most of the other MDGs.

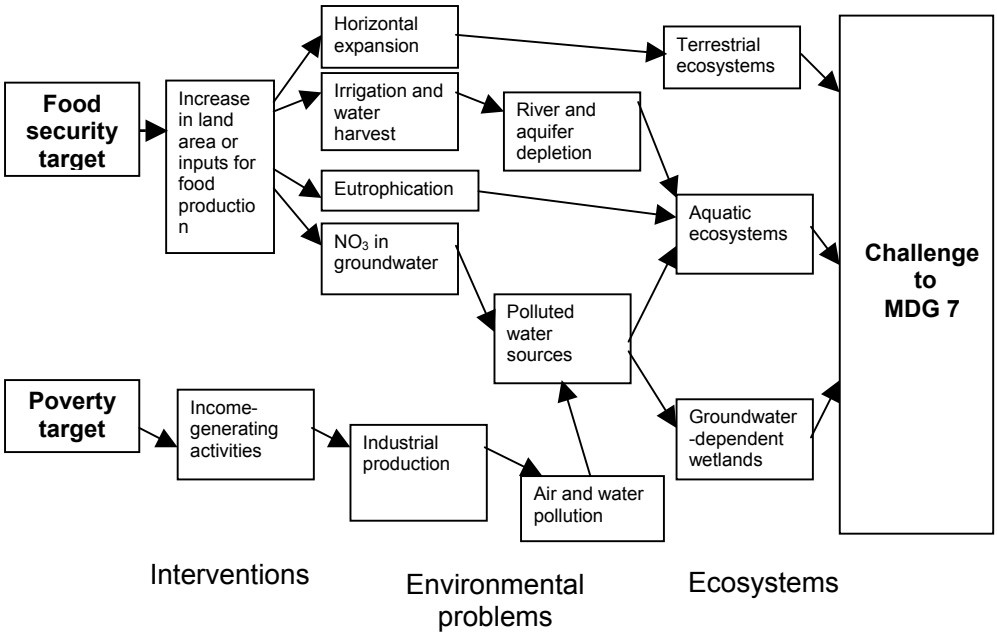

Figure 1. Schematic of the chain of events that may occur as a result of actions taken to alleviate hunger and poverty and that might have negative consequences for the goal of environmental sustainability, including access to clean drinking water (Target 10) and sustainable use and management of environmental resources (Target 9). (Source: M. Falkenmark, personal communication, 9 October 2003).

MDGoal 1: Eradicate extreme poverty and hunger

Target 1 *Halve, by 2015, the proportion of people whose income is less than one dollar a day*

The poor are both the victims and the agents of environmental damage. About half of the world's poor live in rural areas that are environmentally fragile, and they rely on natural resources over which they have little legal control. Land-hungry farmers resort to cultivating unsuitable areas, such as steeply sloped erosion prone hillsides; semi-arid land where soil degradation is rapid; and tropical forests where crop yields on cleared fields frequently drop sharply after just a few years. Poor families often lack the resources to avoid degrading their environment. The very poor, struggling at the edge of subsistence, are preoccupied with day-to-day survival. Their fragile and limited resources, their often poorly defined property rights, and their limited access to credit and insurance markets prevents the poor from investing as much as they should in environmental protection. The impacts of poverty, especially in conjunction with population growth, on environmental sustainability include the depletion of natural resources such as fuelwood, food and medicinal plants, and wildlife and coastal and inland fisheries; land clearance and subsequent degradation and loss of ecosystem services and biodiversity provided by native habitat. The result is a degraded environment that is unable to optimize yields and therefore products necessary to improve livelihoods.

Regional variation in institutional, financial, and technical capability is reflected in varying capacity to manage the environmental affect of poverty. At opposite extremes in the developing world are China and sub-Saharan Africa. Although China has a much higher population density than sub-Saharan Africa, it has the political will and the institutional, financial and technical capability to implement both poverty alleviation and environmental restoration. An example is China's afforestation program and efforts to halt cultivation on steep slopes. In Africa, on the other hand, the capacity of many countries to manage the environmental impact of poverty is severely limited.

Although the provision of energy services is not a stated target of any MDG, it will be necessary for reaching Target 1. The Johannesburg Plan of Implementation calls for joint actions and improved efforts to improve access to reliable and affordable energy services for sustainable development sufficient to facilitate the achievement of the MDGs. Measures of energy consumption provide a good proxy for many of the causes of poverty and underdevelopment such as poor education, insufficient health care, and hardship imposed on women and children. The average total energy consumption per capita in industrialized countries, in 1990, was 5.28 tons of oil equivalent (TOE) per year while that of LCDs was 0.63 TOE (World Energy Council cited in Goldemberg 1996). Meanwhile, per capita energy consumption and human well-being are strongly correlated. Thus, providing access to efficient energy sources is an important avenue for development and social change.

Many of the most egregious environmental problems are caused, in part, by energy extraction, production or use: air pollution, acid rain, and climate change are caused by burning of fossil fuels or biomass (wood, bagasse, and other agricultural residues or feces) for cooking, heating, and transportation. Oil spills during transport also cause terrible marine and coastal degradation. Electricity production from fossil fuels (coal, natural gas, oil) and biomass is the main source of several chemicals and particulates that degrade the environment: sulfur oxides, nitrogen oxides, carbon dioxide, methane, carbon monoxide, and particulates. Wood combustion produces the highest levels per unit of carbon monoxide and methane of all. Hydroelectric power generation does not produce these pollutants, but causes other environmental damage through the construction of large dykes, formation of lakes and general interference with river flows. Reactor operations for nuclear energy produce negligible pollution, but toxic nuclear waste is a major concern (Goldemberg 1996).

Nevertheless, energy is one of the "necessary evils" of development. Therefore, careful consideration of the relative impacts on the environment and on human health should be given to all proposals to increase energy services.

Target 2 *Halve, by 2015, the proportion of people who suffer from hunger*

The link between food security and environmental sustainability is very clear. Low-income rural people rely heavily on the direct consumption of wild foods, medicines, and fuels, both to provide extra food and income during “hungry” periods and to meet micronutrient and protein needs. Bushmeat is the main source of animal protein in West Africa, while coastal and lake fisheries provide the main protein source for people in SE Asia and elsewhere. Thirty million low-income people earn their livelihoods primarily from fishing, a number that has doubled in the last 30 years. Consequently, the depletion of coastal fisheries, in addition to widespread degradation resulting from the introduction of sediments, nutrients and other pollutants into coastal areas from human terrestrial activities has serious impacts on food security (Burke et al. 2000, Roberts et al. 2002).

The maintenance of terrestrial and marine ecosystem function and diversity is a prerequisite to the sustainable production of the world’s food. Where people cannot rely on chemical fertilizers or abundant irrigation water for agricultural production, the condition of the local ecosystem matters significantly. The loss of both wild and agricultural biodiversity, and the degradation of the ecosystems and landscapes within which they are situated, is a severe and growing threat to the achievement of the agriculture-related aspects of the MDGs. Currently the problems confronting agriculture in 82 low-income food-deficit countries, all related to the loss of biodiversity and ecosystem functions, include the following as outlined in an IUCN Biodiversity Brief (IUCN et al. 2003):

(a) *Limited arable land:* Most fertile land is already under cultivation.
(b) *Shrinking size of family farms:* In most poor developing countries, family farms have been divided into smaller and smaller parcels for each, new larger generation of heirs.

(c) *Land degradation:* Each year, land degradation claims 5-7 million hectares of farmland.
(d) *The shrinking genetic base for cultivars:* 75% of the genetic diversity of crops has been lost over the past 100 years.

While biodiversity is fundamental to productive and sustainable agriculture and fisheries, both agricultural practices and fisheries harvest practices are often a cause of biodiversity degradation or loss at the level of ecosystem, species and genes. Problems associated with high-input agroecosystems include salinization of irrigated areas, nutrient and pesticide leaching, and pesticide resistance; and soil erosion and loss of soil fertility are associated with small-scale, extensive systems (Wood et al. 2000). Socio-economic problems also have resulted from the destruction of the local resource base and local technologies and practices. In short, the potential contribution of both wild and domesticated biodiversity to implementing the agriculture and fisheries-related aspects of the MDGs – particularly the poverty and hunger targets – is immense, as are the threats to their achievement posed by continued loss of biodiversity and the goods and services it provides.

MDGoal 3: Promote gender equality and empower women

Target 4 Eliminate gender disparity in primary and secondary education, preferably by 2005, and to all levels of education no later than 2015

Women across the world perhaps play the most important roles as the cooks, the gardeners, the seamstresses, the educators of their children; and the traditional healers and, as such, they have a critical role in the conservation of biodiversity. Daily tasks such as food gathering, gardening, washing, making clothes, and preservation make women extremely knowledgeable about their environments (Millennium Ecosystem Assessment, 2003a) . The dependence on and maintenance of ecosystem services by women, especially rural women, makes it imperative to provide them with greater autonomy in the way ecosystems are used and managed. Despite their knowledge about the environment, women have suffered restricted access to productive resources, lack of mobility because of household responsibilities and social customs, and limited access to information, education, credit and other inputs. The latter reasons hold true for the rural poor in general, as well.

Like men, women are concerned about the quality and sustainability of life for present and future generations. However, discriminatory attitudes, unjust social and economic structures and lack of resources bring them into a vicious circle where they often have little influence on sustainable development and in fact suffer most from the absence of it since they are the primary people to collect water and fuelwood. In many countries, national laws and local customs deny women the right to secure title or inherit land driving them to clear public woodlands for fuelwood and short-term income.

Limiting women's access to education, good jobs, credit and control over resources can have a profound indirect impact on biodiversity conservation, ecosystem health and

ecosystem services. When women lack the knowledge, means or authority to manage the natural resources on which they directly depend, degradation of these resources is more likely to occur. In addition, in such circumstances birth rates tend to be higher, children less healthy and population growth more rapid, leading to greater pressure placed on surrounding natural habitats in order to meet basic needs of food, water, and fuel.

MDGoal 4: Reduce child mortality
Target 5 Reduce by two-thirds, between 1990 and 2015, the under-five mortality rate

MDGoal 5: Improve maternal health
Target 6 Reduce by three-quarters, between 1990 and 2015, the maternal mortality ratio

MDGoal 6: Combat HIV/AIDS, malaria and other diseases
Target 7 Have halted by 2015 and begun to reverse the spread of HIV/AIDS
Target 8 Have halted by 2015 and begun to reverse the incidence of malaria and other major diseases

Achieving the health-related MDGs depends largely on increasing access to medicine and health workers, increasing nutritional level, providing sanitary living and working conditions, and increasing education and training. However, the underlying environmental conditions, in many cases, greatly affect health conditions. This is definitely true for high mortality due to water-borne and insect-borne infectious diseases. Access to clean drinking water depends upon water quality in rivers and aquifers which, in turn, depends on good watershed management and pollution control.

An issue not addressed by the MDGs is that of emerging infectious diseases, and environmental change and land use is cited as one of the six major factors leading to their emergence (Cohen 2000). These, and other, changes result in increase in host susceptibility, increase in disease transmission, and emergence of new disease. Humanity is facing an unprecedented threat in the form of emerging diseases, which have had a negative impact on both the demography and the economy of many developing countries (Cohen 2000). Emerging infectious diseases that affect marine organisms, wildlife, livestock, and humans have had their origin in illegal wildlife trade, international movement of livestock and agricultural products, human travel, human encroachment on wild areas, and climatic events (Daszak et al. 2000, Harvell et al. 1999). The global emergence of HIV-AIDS had its origin in human-wildlife contact (Gao et al. 1999, Weiss and Wrangham 1999). Ebola virus also arose from bushmeat consumption or other contact with infected wild apes. Similarly, the destruction of wildlife and encroachment in its habitat has been linked to SARS, reportedly due to trade and consumption of infected wildlife captured in southern China. Climatic events such as El Niño Southern Oscillations (ENSO) can cause changes in the ranges of disease hosts, resulting in the emergence or expansion of disease ranges. This, coupled with forest removal, may be the cause of outbreaks of malaria in areas of South America where previously it had been eradicated.

Clearly, emerging diseases require immediate actions by all countries to ensure that these remain contained and under control. This implies at least specific anti-poaching

operations, strict animal health monitoring programs, health surveillance of travelers, control of illegal wildlife trade – both national and international, and enhanced ecological and biomedical research to be prepared for the certain future of additional emerging diseases and outbreaks and expanding ranges of those already known.

On the other hand, health-related problems also pose potential and actual effects on the environment. For example, overuse of wild natural resources such as medicinal plants and wildlife may result when poor households lose income to purchase suitable medicines. A substantial number of ways of responding to this situation have been identified in Africa (Africa Biodiversity Collaborative Group 2002). These include managing natural resources in such a way as to provide medicinal plants to treat health problems and illnesses, substituting home-grown and wild-collected food products for those families suffering loss of laborers, and marketing of natural resources to provide cash income (e.g. herbal remedies, wild foods, ecotourism).

In addition, the existing infrastructure of the community-based natural resource management programs can be used in many ways to educate staff and community leaders on the links between the natural environment and health issues as well as on how to manage natural resources in order to cope with health problems. The natural resources sector can develop institutional coping strategies and best practices for health problems in conservation institutions, including government agencies, non-governmental organizations, and academic institutions. It can link research with other sectors for mutually beneficial multi-disciplinary research; promote sustainable land and resource use through the development of management plans for those natural resources that are affected by health epidemics; develop alternatives where resources are being used unsustainably; and document and apply traditional knowledge on medicinal plants, wild-collected food stuffs, and traditional resource management practice so information and uses are not lost.

Human health is closely related to access to freshwater (MDG 7, Target 10) in cases where, in the absence of safe-guards, water-borne biotic and abiotic pollutants pose health risks to users. Water-borne diseases constitute a major obstacle to the achievement of a healthy population in most developing countries where 90-95% of all sewage and 70% of industrial wastes are dumped untreated into surface water (UNFPA 2001). At present 2.2 million people die each year from water contaminated by human feces (WHO 2000).

MDGoal 7: Ensure environmental sustainability

Target 10 Halve by 2015 the proportion of people without sustainable access to safe drinking water

Target 10 addresses access to safe drinking water and environmental sustainability is directly tied in with that. We recognize that freshwater (both quantity and quality) as an available resource to both humans and in the ecosystems is a critical issue, so important that both this task force and Task Force 7 on Water and Sanitation are treating it.

Freshwater is one of the fundamental components of the Earth's environment and its maintenance is an incontrovertible requirement for environmental sustainability.

Water's many different functions in the planet's life support system involves it in most of the MDGs playing a multitude of parallel functions: as a basic component of both crop production (food security goal) and carbon sequestration (environmental sustainability goal), both involving huge vapor flows; as a vital ingredient of human survival and the alleviation of health-related problems (water supply and sanitation goal); as a landscape agent active, through its erosive capacity and function as mobile solvent, in translating land use activities into ecological change; and as a habitat for aquatic biota (environmental sustainability goal). At the same time, water is a finite resource to be wisely shared between water-dependent MDG activities, activities which are all essential as entry points to several of the social goals.

The fundamental importance of water as a dividing line between poverty and prosperity is demonstrated by the world map of global income distribution: most of the top/high priority countries for the Millennium Development Goals identified in the Human Development Report (2003) are largely located in the tropics and subtropics and the majority of them in the arid zone where water scarcity and drought proneness add particular challenges to MDG achievement (see Figure 1). Most of the priority countries have to cope with the particular challenge of water deficiency problems.

Local freshwater provision to meet societal water supply is regulated by soil infiltrability and plant water uptake, influencing groundwater recharge and dry season streamflow. Since most rain evaporates, the local water courses go empty most of the year and low groundwater recharge is reflected in low water tables. This means difficulties in terms of access even to drinking water: long walks and high lifts consuming much human energy to get access to the daily water needed by a family. Target 10 aims at reducing this hardship and release human energy for productive purposes to increase welfare.

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MDGoal 8: Develop a Global Partnership for Development

Target 12 Develop further an open, rule-based, predictable, non-discriminatory trading and financial system

The links between environment and trade are many and very complex. At the broadest level, international trade is an important driver of economic development and its rapid growth and liberalization. However, its effect on the movement of goods dramatically accelerates the extraction and use of natural resources (metals, minerals, fisheries,

forests) and land- or ocean-based production. Trade is central to human health, prosperity and social welfare, creating choices and opening human minds to new ideas and cultures. Food trade will grow in importance as a means to compensate for deficiencies in food self-sufficiency due to water scarcity. Trade binds people together in a dynamic and complex network of mutually beneficial commercial relationships. The extent to which trade affects people living in poverty is related to several things: the maintenance of a sustainable scale of resource use and the fair distribution of resources. The rules and regulations governing the operations of trade and engagement of nations have multiple influences on human life.

The problems with trade and the environment arise from the lack of consensus between the rules and regulations governing trade, which are embodied in international trade institutions such as the WTO, and environmental law which is based in a set of multilateral agreements, regional agreements, and national regulations (IISD and UNEP 2000). This situation makes it very difficult to assure that trade and the environment are mutually beneficial. There are conflicting international policies of trade, too, which further complicate the issue (Amilien 1996). Current trade policies tend to promote natural resource depletion worldwide simply because there are few effective controls on setting sustainable levels of resource extraction or human capacity to assure that excessive volumes are not crossing borders. Therefore, other strategies need to be explored in combination with regulation in order to reduce environmental impacts to a sustainable level.

Target 14 Address the Special Needs of landlocked countries and small island developing States (through the Programme of Action for the Sustainable Development of Small Island Developing States and the outcome of the 22nd special session of the General Assembly)

Small island developing States (SIDS) vary enormously according to distinct bio-physical, socio-cultural and economic characteristics. Their efforts for sustainable development are, however, constrained by common disadvantages such as limited natural resources, fragility of ecosystems, vulnerability to natural hazards, and peculiar population dynamics. Many SIDS host very productive and fragile ecosystems such as mangroves, tidal forests, sea grass systems, coral reefs, and lagoons. These are important resources for the whole island ecosystem and economies. These ecosystems are particularly vulnerable to rising sea levels due to climatic changes, excessive resource extraction, and pollution. Invasive species present a major threat to island wildlife. The biotic devastation of native species in the form of species extinctions and drastic population reductions are dramatic and as a result, small islands have proportionately the highest numbers of endangered species in the world. Natural disasters exacerbate economic vulnerability because they create additional costs and divert resources from directly productive activities, let alone when they disrupt the whole economy. Counteracting vulnerability requires a capacity to adapt and to increase resilience that

depends on certain features of the economic system. Thus, economic and environmental vulnerability are inter-twined.

The small size of SIDS particularly intensifies interactions between land and sea and between the natural and human environments. Many SIDS rely on tourism and their natural resource assets provide the basis for this. Multiple use of natural resources and antagonistic and competitive needs must be addressed through a multi-use, ecosystem-oriented mode of management. The limited number of human resources and skills increases the suitability of cross-sectoral approaches. The key role of resource owners and users and their related knowledge of ecosystem processes and functions calls for strengthening and supporting participatory planning and community-based management of island resources. Because of these exceptional vulnerabilities of SIDS in almost all sectors (social, economic, ecological, biophysical), it is of utmost importance to apply integrated development approaches to addressing existing or potential problems related to poverty and environmental sustainability.

The MDGs and Transportation

Another area for development that will be necessary for achieving many aspects of all the MDGs is improved transportation infrastructure. We recognize that rural road construction in food-insecure areas is needed both to provide residents more rapid access to commercial markets and to allow for access to aid, health care, education and other social goods and services to the residents. The construction of roads, however, has been a precursor of major environmental degradation in some regions, particularly forested areas such as the Amazon (Laurance et al. 2001, Pfaff 1999) and Congo basins. Their establishment can be detrimental to the ecological functions on the landscape by accelerating deforestation and destruction of biodiversity through poaching and habitat destruction. Another result of ramping up transportation is an increase in air pollution and consumption and burning of fossil fuels putting more pollution and carbon dioxide into the atmosphere. Road vehicle operation accounts for about half the world's oil consumption (Goldemberg 1996). Combustion engines emit noxious gas and particulate matter that poses serious risks to the health of humans, animals and other organisms.

Successful management of the problems caused by infrastructure development depends no less on political will than it does on having the required institutional, financial and technical capacity to do so. Roads require maintenance. Often the political will to avoid the negative impact of infrastructure development is absent because priority is given to socio-economic development or relief of pressure on existing highly populated and degraded areas, as in the resettlement programs of Brazil and Indonesia. It should be noted that the countries that have inadequate road networks also tend to have very low per capita emissions of greenhouse gases. For example, an expansion of vehicle transport in sub-Saharan Africa will not make a substantial contribution to long-term climate change. Nevertheless, road construction, maintenance and automobile design should be carried out with a view towards minimizing adverse impacts on the environment.

National governments, regional economic communities, local and regional associations, and large international donor organizations have important roles to play in the future planning, financing, and managing of integrated and coordinated systems. Small- and medium-sized private entrepreneurs and local governments and communities must also be involved. An increased environmental law enforcement capacity will be necessary to oversee the development activities in these new areas of improved infrastructure. Improved vehicle efficiency and alternative fuels, the improvement and promotion of public transportation systems, and the promotion of alternative modes of transportation (e.g., bicycle) are approaches to mitigate the environmental impact of transportation.

2 Causes and drivers of environmental change

A fundamental dilemma of human life-support activities is that they often generate more or less unavoidable environmental problems due to the physical and chemical landscape manipulations they tend to involve. In the worst cases, human actions can render ecosystems unable to deliver ecosystem services such as freshwater, productive soils, or game animals with dire consequences for human livelihoods, vulnerability and security (Folke and et al. 2002). At the foundation of the environmental sustainability goal is the question of how we can balance the dynamic between reliance and impact on the natural environment.

Understanding the factors that drive human-nature interactions and cause degradation of the environment is necessary for developing appropriate interventions that will mitigate the negative impact of our actions. Two broad classes of drivers of environmental change are recognized, direct and indirect (Millennium Ecosystem Assessment 2003g). Drivers directly affecting the environment include habitat degradation, overexploitation, invasive species, climate change, pollution and natural disasters. Indirect drivers of environmental change, forces that act on the direct drivers, include the biophysical, demographic, economic, socio-political, and technological. While it is instructive to describe individual drivers, one must not lose sight of the complexity of human interactions with environmental systems, and the feedback mechanisms between and among individual drivers that confound attempts to disaggregate these factors.

2.1 Indirect Drivers

2.1.1 Demographic change

Population growth, along with the geographic distribution of populations and the resulting patterns of resource consumption and waste production, are key indirect drivers of environmental change. Population numbers drive demand for all ecosystem goods and services – particularly those that are the building blocks for food, shelter and energy. The UN Population Division forecasts a population increase (median projection) of 2.6 billion people between 2003 and 2050 for a total world population of 8.9 billion. This project expects that by 2030, 86% of the global population will live in developing countries and 60% will live in urban centers. The rural-urban population shift will be highest in the Asia/Pacific region and in Africa (Table 1).

The implications of this population rise on depletion of natural habitat are enormous. Population growth decreases per-capita availability of finite renewable resources such as freshwater as well as non-renewable resources including fossil fuels.[5] Significant population increases, and the land cover transformations they cause, reduce the size of natural habitats, which can further reduce the per-capita availability of ecosystem services. For example, for every one thousand people in Ethiopia, it is estimated that one hundred and eighty hectares of land are being used for crops, and the population will rise in the next twenty years from sixty-three million to one hundred million (International Food Policy Research Institute, 2002).

Region	Rural / urban populations 2003 (%)	Predicted r/u split 2030 (%)	Distribution shift	Rate of increase in urban areas
Latin America – Caribbean	25 / 75	16 / 84	urban → urban	1.12
Asia / Pacific	63 / 37	46 / 54	rural → equal	1.45
Africa	62 / 38	47 / 53	rural → equal	1.40
Europe	37 / 73	20 / 80	urban → more urban	1.10
N America	23 / 77	16 / 84	urban → more urban	1.10
Oceania	26 / 74	33 / 77	urban → more urban	1.04
Global	52 / 48	39 / 61	equal → urban	1.27

Table 1. Percentages of rural - urban population in the present and predictions for 2030 for the six major regions of the world. (Source: UN DESA Population Division. 2004. *Urban and Rural Areas 2003*. New York: UN)

It is, however, not just increase in population numbers that creates environmental problems. Rapid urban growth with no or poor planning, as a result of rural-urban migration, has a dramatic effect on loss and fragmentation of native habitat and the subsequent extinction of species, replacement of native with non-native species, and increased local and downstream pollution (McKinney 2002). A study conducted of land cover change as a result of urban growth in Turkey revealed that the urban area of one city, Adana, increased by a factor of 2.07 in 16 years (Alphan 2003). Conversion of the agricultural and semi-natural land surrounding the city resulted in losses of the natural drainage and vegetation coverage and consequential flash-flooding. In a similar study of Fuqing County, China, urban expansion in five years claimed 1226ha of forest (much of it to orchards) and 3712ha of arable land and, thus, greatly reduced production area and natural habitat.

On the other hand, urbanization may take pressure off of rural landscapes and result in a more efficient use of energy and food production systems. More study will have to be conducted to examine the actual and potential benefits that could result from a rural to urban population shift.

[5] It is important to note here that environmental degradation and the depletion of non-renewable resources are driven not only by population numbers, but especially by per capita consumption levels and patterns, as discussed under 'Economic drivers'.

2.1.2 Markets and Trade

Increasing from a relatively modest US$ 192 billion in 1965, global trade has boomed to an estimated US$ 6.5 trillion in 2003 (UNCTAD 2002). This increase in international trade has a strong impact on the environment. Rising incomes tend to raise the level of consumption which results in a larger and heavier footprint, at the global level, on the environment (Wackernagel and Rees 1996), but higher income also increases people's ability and willingness to mitigate adverse environmental change. On the other hand, at the local level, the rural poor have a greater footprint on the environment. The link between income level and environmental impact, however, is highly context-specific and often depends on the type of ecosystem service or environmental resources examined and the choices made by individuals or businesses.

The world's economy is guided by consumer behavior and the markets that respond to it. Markets fueling this international trade have failed to include the full environmental costs and benefits of production and consumption. Behavior resulting in environmental degradation is encouraged due to the "tragedy of the commons" which is exacerbated by the lack of well-defined and transferable property rights, and to externalities that prevent people from incurring the full cost or capturing the full benefits of their actions. In the face of no reward for leaving biological resources intact, and considerable returns for using those same resources, environmental degradation will be greatly exacerbated. Public goods, such as air quality, will consistently be under-produced without appropriate policies and government intervention.

Certain policies and investments in infrastructure are known to promote the accelerated conversion of ecosystems. Road building into forested areas is a prime example of an aggressive promotion of land conversion and extensive resource use; government-supported colonization and resettlement programs have similar effects. Other sector-specific policies, like subsidies for agricultural production and for energy consumption, or provisions of excessively cheap access to timber and fisheries work in the same direction. Even policies that in some situations make good macroeconomic sense, like currency devaluation, export incentives or rural investment programs, can have strong negative side-effects on ecosystem services (Angelsen and Kaimowitz 1999; Wood et al. 2000). Environmental sustainability principles must be integrated into these policies in all sectors of the government.

Subsidies

Inadequate economic incentive structures and subsidies are major problems. Government expenditures on environmentally damaging subsidies in four sectors – water, agriculture, energy, and transportation – totaled some $700 billion per year worldwide during the 1990s, accounting for 2 – 2.4% of the world GNP and ten times the amount of global level ODA in recent years. Global subsidies for fishing alone are estimated at $10-15 billion per year, about one-quarter of the $56 billion trade of fish. This subsidization has promoted a vast overcapitalization of the industry which in turn has led to more rapid overharvesting of fish and a declining global fish harvest.
(Pearce and Barbier 2000, UNDP 2003, World Resources Report 2000)

Market failures are often worsened by inappropriate policy and institutional frameworks. Markets fail because of:

- Lack of clear and secure property rights or access to resources leading to over-exploitation or under-investment in conservation.
- Externalizing of environmental costs
- Insecurity resulting from armed conflicts, economic crises, epidemic diseases, or environmental disaster, leading to short-term decision-making at the expense of long-term interests.
- Missing or weak markets for sustainable products and services, which undermines incentives to adopt environmentally beneficial production methods.
- Unequal distribution of income and wealth leading to inequitable weight given to the preferences of rich consumers and unbalanced patterns of production.

The overall orientation of economic policy can help or harm the environment through its effects on the level and structure of economic activity generally. For example, direct or indirect government subsidies often provide negative incentives to practice environmentally sustainable management of resources. Other factors include the balance between the public and private sectors in the economy, the degree of openness to international trade and foreign investment, monetary policy (e.g. interest or exchange rates), and the policies of trade/aid partners. Such policies are rarely drawn up with the environment in mind.

The combined rate of growth of GDP, income inequality, and trade and capital flows and their destination, are crucial variables in the evaluation of the direction and extent of economic impacts on land use patterns, resource extraction, water diversion, pollution, biodiversity loss, and overall ecosystem degradation. **Developing countries that teeter on the edge of profound poverty urgently need economic development. The challenge before us is how to develop policies that allow for rapid economic development without the consequent extreme environmental degradation that often accompanies such growth.**

2.1.3 Technology

Advancing technology affects the environment, both negatively and positively. In the first case, changes in technology directly influence demand for ecosystem services and can adversely affect the ability of former users to access those services while ecosystems are altered by area contraction, fragmentation, species loss, and pollution. In the second case, scientific understanding and technology can help humans mitigate stress on ecosystems and environmental services by creating ecosystem-friendly alternatives and efficiencies. However, relying on technological fixes for environmental problems caused by technological “advances” is often a trap of circularity. A good example of technology negatively affecting the environment is in fisheries, where our increased ability to harvest fish exceeds the demographic changes required to maintain the populations, causing overexploitation. Factory trawlers, a technology that is capable of long-distance fishing where processing occurs on board, is an example of technology that allows of overexploitation.

The differential access to technological and scientific innovations between developed and developing countries is profoundly unbalanced, with developed countries having substantially more access. Conversely, developing countries contain a much greater proportion of biological resources than developed countries as well as much more rapid environmental change. Access to information about their own ecosystems is paramount in developing countries if they are to efficiently draw on the benefits from their ecosystems without degrading those systems beyond their ability to function properly and provide the benefits upon which we all depend. In addition, tools need to be promoted that allow developing countries to assess the condition of local ecosystems and the short- and long-term impacts that changes in population, economy, and policy are having on that health. Perversely, while science and technology are rapidly advancing in many sectors, much about the environment and our interactions with it remains unknown. Lack of knowledge and lack of access to user friendly versions of knowledge are a key impediment to sustainable use of ecosystem services.

2.1.4 Knowledge Gaps

We have only identified 10% of existing species and within those described species, a significant proportion has been named more than once and there are complicated issues of taxonomic synonymy. One estimate suggests that while approximately 13,000 new species are named each year, the current rates of resolving synonymies reduce this number to around 10,000 distinct species for a synonymy rate of 20% in named species (May, 1999). The species that have been named are not available in a single reference work or index. As a result of all these difficulties, taxonomy has become a significant focus in both governmental and non-governmental arenas. The Global Taxonomy Initiative[6] is operating under a CBD mandate while Species 2000 is the work of a "Federation" of database organizations working closely with users, taxonomists and sponsoring agencies[7].

Filling the gap between what we know about biodiversity and what we don't is a huge task that is complicated by many factors. Emerging technologies in genomics are making it 'easier' to identify species through advanced techniques such as polymerase chain reaction (PCR) and exponential advances in information management allow more rapid access to reference sources (McNeely 2002). Nonetheless, significant challenges ahead include coming to agreement on species definitions, increasing national capacities in taxonomy, and supporting wide accessibility of all knowledge related to biodiversity. As well, knowledge about ecosystem restoration is only emerging, yet restoration is much more expensive, sometimes orders of magnitude more, than conservation of the same ecosystems.

While many are working to enhance our understanding of the full scope of biological diversity, significant efforts are being made to identify geographic areas with the greatest concentrations of diversity: megadiversity countries (Conservation International),

[6] Global Taxonomic Initiative URL: http://www.biodiv.org/programmes/cross-cutting/taxonomy/
[7] Species 2000 program URL http://www.species2000.org/

conservation hotspots (Conservation International), Important Bird Areas (BirdLife International), Global 200 Ecoregions (WWF, National Geographic) Centres of Plant Diversity (IUCN and WWF), and marine biodiversity (Roberts et al. 2002). Interestingly, these various prioritization systems have significant overlap; namely 68% between the hotspots and the IBAs, 82% between hotspots and Centres of Plant Diversity, and 92% between hotspots and the Global 200 regions (Myers et al. 2000). However, these models do not include any assessment of functional (versus taxonomic) diversity or the range of relationships among individual components within an ecosystem. In addition, no comprehensive global assessment has yet been made of ecosystem service values on a geographic basis, including the oceans. In addition to understanding the relative importance and value of ecosystem services in different geographic regions of the world, the value of those services at the local scale also merits investigation.

In a recent UNEP survey of knowledge about 28 different aspects of the environment UNEP 2003) respondents suggested that both 'climate' and 'atmosphere' were reasonably well covered by existing assessments. Topics deemed to be 'not at all well' covered by existing assessments included ecosystem services, environment and conflict, environment and poverty and environment and trade. **It seems safe to conclude that the links between environment and human well being are not as well understood as they should be for informed decision-making.**

2.1.5 Institutional frameworks

The absence or malfunctioning of political institutions can act as an important driver of environmental degradation. Considerable forest clearing has occurred in developing countries during periods when central and local governments have become weak or corrupt and police authority and civil order have eroded (Laurance 2000).

The limited participation of key stakeholders in the planning and management of sustainable development is a major political oversight, particularly for women and the rural poor. Limiting access to education, good jobs, credit and control over resources can have a profound indirect impact on biodiversity conservation, ecosystem health and ecosystem services. When these groups lack the knowledge, means or authority to manage the natural resources on which they directly depend, environmental degradation is more likely to occur along with higher birth rates and more rapid population growth.

Members of the general public often do not understand the direct links between human health, economic well-being, and the condition of natural systems in which they live. This can be compounded by a lack of awareness about the effects of certain technologies, industrial practices or policy changes on the environment and human well being. However, the harsh realities of the impoverished life often drive people to follow these practices and accept the environmental and health trade-offs whether or not they are aware of the impacts on the environment. Nevertheless, a well-informed public can make better decisions in their daily lives and in the electoral process, thereby providing incentives for political leaders to address environmental degradation and protect biodiversity and the ecosystems into which it is organized.

2.2 Direct drivers

Direct drivers of environmental degradation cover a broad range of human and natural impacts on the environment and are readily apparent. Key direct drivers of environmental change include habitat degradation, overexploitation, invasive species, pollution and climate change. Natural events such as floods, volcanic eruptions or earthquakes can also often lead to the destruction and disruption of human lives and natural habitat but these are not covered here.

2.2.1 Habitat degradation

Land cover change through urbanization, road construction and subsequent colonization by people, energy and mining activities, deforestation, agricultural expansion, illicit crops, and fire incidents are among the most dramatic changes. Problems associated with land cover change include loss of natural habitat, change in soil drainage, loss of ecosystem services, and depletion of natural resources among others. In addition, important marine habitats that provide ecosystem services are being degraded or compromised by destructive fishing activity such as trawling and dredging (Burke et al. 2000).

Soil degradation occurs as a result of erosion by water or wind, water logging and salinization, compaction and crusting, acidification, loss of soil organic matter, soil microorganisms nutrient depletion, loss of soil biodiversity and accumulation of pollutants in the soil (WRI 2000). Sustaining soil productivity requires that soil-degrading pressures be balanced with soil-conserving practices, such as the use of improved fallows or introduction of legume species (Sanchez 2002, WRI 2000).

2.2.2 Overexploitation

The overharvest of crops, wildlife, fisheries, or other biotic resources results in dramatic declines in populations of those species, often to the point of causing them to drop below minimum viable reproductive levels (or causing commercial collapse, such as cod in the North Atlantic). This loss of biodiversity is first felt by people who depend on natural biotic resources for medicine, food, and household goods; often these are the poorest people. The loss of fisheries as a major food source would be extremely problematic. Wild capture fisheries provide significant sources of protein for many populations around the world (16.5% total animal protein worldwide), especially the poor (Burke et al. 2000). Overexploitation of these resources both disrupt ecosystems and threaten this food supply. Sustainable harvest of fish is essential for reducing overexploitation and maintaining food supplies for present and future generations. Medicines and drugs from the wild are important for everyone. An estimated 40% of modern drugs come from the wild, worth around $40 billion a year in over-the-counter sales (Tuxill 1999). In Europe, 2000 different medicinal and aromatic plants are used on a commercial basis, the vast majority of them coming from the tropics. Moreover, future drugs from tropical forests alone may be worth $900 billion a year. It would be hard to put a figure on the costs to humankind of losing the benefits of nature's "drug store".

A particular sustainability problem that needs to be addressed is the large-scale overpumping of aquifers in mainly agricultural regions, including parts of India, NW China, W Asia, W USA and the Arabian peninsula (Millennium Ecosystem Assessment 2003h). It has been estimated that some 20% of current global crop production may be based on such overuse. In order to return to a sustainable situation, considerable amounts of water will in the future have to be reserved for recharging these aquifers. Such restoration is particularly crucial in coastal areas to stop the disastrous effects of saltwater intrusion.

Meeting the future demand for freshwater is daunting as access to scarcer water sources will become increasingly more costly, ecosystem services associated with freshwater provision decline, and water demand increases as a result of population growth, economic growth and life-style changes. Since water is a finite resource, feeding humanity will be an issue of conscious trade-offs between water for food and water for natural ecosystems.

Modification of river flow by damming for energy services, channelizing and diverting flow for irrigation and flood control, wetland drainage, and groundwater withdrawal all cause major environmental problems. Currently some 10% of the overall water resources are being withdrawn from rivers and aquifers, two-thirds of which are literally consumed during use – most of it in irrigated agriculture – while one-third returns to the flow, generally loaded with pollutants. Growing food is the main biologically-driven consumptive use of water, making this loss unavoidable. Agricultural use of water, can become more efficient with technological advances, an issue that is being explored by Task Force 2 on Hunger.

2.2.3 Invasive alien species

Invasive alien species (IAS) – defined as non-native species that become established in a new environment, then proliferate and spread in ways that damage human interests – are now recognized as one of the greatest biological threats to our planet's environmental and economic well-being. Most nations are already grappling with complex and costly invasive species problems. Zebra mussels from the Caspian and Black Sea region affect fisheries, mollusk diversity and electric power generation in Canada and the USA; water hyacinth from the Amazon chokes African and Asian waterways; rats carried originally by the first Polynesians exterminate native birds on Pacific islands; and deadly new disease organisms such as the viruses causing SARS, HIV/AIDS, and West Nile fever, attack human, animal and plant populations in both temperate and tropical countries. For all animal extinctions where the cause is known, invasive alien species are the leading culprit, contributing to the demise of 39% of extinct species (IUCN 2000). The *2000 IUCN Red List of Threatened Species* reported that IAS harmed 30% of threatened birds and 15% of threatened plants. Addressing the problem of invasive alien species is urgent because the threat is growing daily, and the economic and environmental impacts are severe.

One reason why invasive alien species are attracting more attention is that they are having substantial negative impacts on numerous economic sectors beyond the obvious impacts on agriculture (weeds), forestry (pests), and health (diseases or disease vectors).

The probability that any one introduced species will become invasive may be low, but the damage costs and costs of control of the species that do become invasive can be extremely high (e.g., the recent invasion of eastern Canada by the European brown spruce longhorn beetle, which threatens the Canadian timber industry).

Invasive alien insect pests, such as the white cassava mealybug and larger grain borer in Africa, pose direct threats to food security. Alien weeds constrain efforts to restore degraded land, regenerate forests and improve use of water for irrigation and fisheries. Water hyacinth and other alien water weeds affecting water use currently cost developing countries in Africa and Asia over US$ 100 million annually. Invasive alien species pose a threat to over US$ 13 billion of current and planned World Bank funding to projects in the irrigation, drainage, water supply, sanitation and power sectors. And a study of three developing nations (South Africa, India, and Brazil) found annual losses to introduced pests of US$ 138 billion per year (Pimental et al. 2001).

2.2.4 Pollution

Water and air pollution problems originate in the fact that waste production follows most human activities. Waste from industrial and household activities – heavy metals, particulate matter, toxic chemicals, persistent organic pollutants (POPs), organic nutrients, carbon dioxide, and so on – may be "disposed" of in water, on land or into the air, but they eventually cycle back into the food we eat, air we breathe, and water we drink, mainly through natural hydrological and atmospheric processes. In early phases of human development, the problem was less important due to low population, and generally degradable waste products. As human activities intensified, waste products increased in complexity and toxicity.

It is estimated that more than one billion people (one sixth of the world's population) remain without access to safe drinking water (Craun 2001) because of pollution of rivers by organic and inorganic chemicals and pollution and salinization of aquifers. Over 2.4 billion people lack adequate sanitation, and 3.4 million people, mostly children, die every year of water-related diseases (WHO 2002).

The addition of massive amounts of chemical fertilizers to agricultural fields in recent decades has resulted in increasing annual nitrogen inputs to ecosystems by 150% and phosphorus fluxes by 4.6% (Millennium Ecosystem Assessment 2003d). The result of this high chemical load is eutrophication of water tables and freshwater and coastal environments, characterized by dramatic changes in biotic and abiotic conditions. Eutrophication occasionally leads to toxicity, loss of biodiversity, and general lowering of water quality (Carpenter et al. 1998).

Energy in convenient and affordable forms, such as coal, oil and gas, is an indispensable ingredient of economic progress from the household level to industrial scale manufacture and whole transportation systems. However, pollution resulting from the burning of fossil fuels for production of electricity or in combustion engines is the primary cause of many of the most dangerous environmental problems at every level from the local to the global.

Ninety percent of electrical energy production in Mexico, for example, is derived from fossil fuels. The main pollutants emitted in the combustion of fossil fuels are particulates, ozone precursors (e.g., hydrocarbons and oxides of nitrogen), precursors of acid deposition (e.g., sulfur dioxide), and carbon dioxide (Goldemberg 1996).

Environmental problems related to the ways energy is produced and consumed include urban air pollution caused by industry and transportation, indoor air pollution caused by cooking and heating, acid rain caused by burning of fossil fuels, coastal and marine habitat degradation caused by oil spills, ozone depletion caused by industrial processes, greenhouse warming and global climate change caused by burning of fossil fuels, toxic chemicals and hazardous wastes caused by industry and nuclear energy, and deforestation and biomass depletion for fuelwood. These environmental and related health problems are largely treated as externalities to the energy market, which leaves them with little chance to be addressed.

Pollution of air and water pose major threats to both human health and the well-being of animals and plants. Heavy metals such as arsenic, lead and mercury in agricultural waste, geologic sources (or naturally occurring in groundwater), and industrial and municipal refuse have been repeatedly implicated in adverse health outcomes that follow exposure through drinking water. They enter the food chain through ingestion and dermal contact in animals and accumulation in crop plants. POPs are highly fat soluble; they degrade very slowly in the environment and can bioaccumulate to high levels as they move up the food chain. For example, dioxin bioaccumulates through terrestrial food webs and can become concentrated in milk and other dairy products (Box 4). Some POPs can act as endocrine disrupters in mammals, mimicking the body's hormones. Elevated levels of nitrogen in the discharge from sewage and agricultural fertilizer run-off cause dramatic algal blooms wreaking havoc on marine and freshwater ecosystems. Methyl mercury can bioaccumulate through the food chain in aquatic systems to reach toxic levels in predatory fish, as was the case in Minamata Bay, Japan, where severe birth defects (e.g., cerebral palsy) resulted from fetotoxicity in pregnant women who consumed contaminated fish (Koos and Longo 1976). This study alerted the world to the dangers of mercury in the environment. Currently, five Canadian provinces and over 35 U.S. states have issued health advisories to reduce the consumption of certain freshwater fish that are known to contain excessive levels of mercury.

While pollution does not discriminate, in general the poor suffer more than the rich because of differential access to health services, clean-air technology and real estate. Women are twice as likely as men to have an acute respiratory infection due to their exposure to high emissions such as particulates from cooking and cleaning. The World Health Organization estimates that 2.5 million women and young children die prematurely due to breathing fumes from indoor biomass stoves (IEA 2002b). High incidences of respiratory infections are found in the impoverished areas of cities which tend to be in close proximity to highways or industrial plants.

Box 4. Contaminated milk in India

In 1994, 1172 samples of buffalo and cattle milk were collected from 52 milk producing districts of India to analyze toxic residues. On an average, the milk was found to contain 4.5 ppm of DDT used in agriculture and anti-malaria activities. This is 90 times the stipulated limit. (Source: Sompal 2001)

2.2.5 Climate change

Greenhouse gases and aerosols influence global climate through changes in radiation patterns of the earth- i.e. changes in the energy balance of earth-atmosphere systems – and changes in cloud formation. Scientific opinion concludes that concentrations of key greenhouse gases and other atmospheric constituents will continue to change in the future as a result of human activities. As a result, an increase of the global averages of surface temperature by 1.4 to 5.8°C over the period 1990 to 2100 is expected. This warming is very likely to be without precedent during at least the past 10,000 years.

Global averages of annual precipitation are projected to increase during the 21st century, though at regional scales these can vary in either direction by 5 to 20%. Glaciers are projected to continue their widespread retreat during the 21st century. The mean sea level is projected to rise by 0.09 to 0.88 m between the years 1990 and 2100, with significant regional variations. Also, many parts of the world have suffered major heat waves, floods, droughts and other extreme weather events. While individual events, such as El Niño-related phenomena, cannot be directly linked to human-induced climate change, the frequency and magnitude of these types of events are predicted to increase in a warmer world (IPCC 2001, Millennium Ecosystem Assessment 2003e)

Findings of the IPCC Third Assessment Report (2001) suggest that changes in biological systems are associated with, though not causally linked to, climate change. Observed and predicted changes in terrestrial ecosystems (including freshwater) include changes in species distributions, population sizes, community composition and plant productivity have been found. As well, changes in the timing of biological events (phenology), morphology, physiology and behavior of many taxa; frequency of outbreaks of pests and diseases; and streamflow, floods, drought, water temperature and quality have been observed. In coastal and marine ecosystems, both sensitive to changes in water temperature and global climatic events, various effects may be attributed to climate change: bleaching of coral reefs, more disease and toxicity (Harvell et al. 1999), changes to fish populations, large fluctuations in abundance of marine birds and mammals in the Pacific and western Arctic oceans, and a rise in sea level. Sea level rise is a particular concern for fisheries, since about 70% of global fish resources depend on nearshore or estuarine habitats at some phase in their life cycle (IPCC 2001).

The effect of climate change on biodiversity and ecosystem services also has implications for conservation efforts that are based on delineation of protected area boundaries. An area established to encompass the home range of a charismatic or keystone animal could become inconsequential for that animal with ecosystem changes associated with climate change.

An example illustrating the interactions and trade-offs among environmental services is provided in Box 5 presenting a case study of the situation in the semi-arid savannahs of Zimbabwe.

Box 5. Case study: Ecosystem services and the people of the semi-arid savannahs of Zimbabwe[8]

People living in a number of communal land farming areas in the semi-arid zones of Zimbabwe clearly demonstrate dependence on the natural environment to provide their basic needs. In addition to dryland cropping and irrigated gardening where sufficient water is available, people rear livestock and harvest a wide diversity of woodland products, both for subsistence use and for sale. The main ecosystem services supporting people's livelihoods are surface- and ground-freshwater, grazing resources, and a wide range of woodland products including woodfuels, construction materials, and non-wood forest products such as medicines and food for both people and livestock. Overall, the physical, financial, human and natural capital assets of households are severely constrained. Poverty is widespread and often severe

The net value of the provisioning ecosystem services (arable agriculture and livestock production plus woodland products) consumed by an average household in Romwe and Mutangi is US$ 352 household^{-1} yr^{-1}, or 55% of their total net income. In contrast, cash income averages only US$ 290 household^{-1} yr^{-1}, of which the sale of woodland products contributes just 3%. Income from remittances from relatives living outside the area and off-farm employment makes up 73% of total annual cash income, while sales of agricultural produce (20%) and livestock (4%) make up the rest. Thus the average household in these two communities derived two-thirds of its livelihood directly or indirectly from the surrounding natural system or recently transformed arable lands. The value of the communal land environments also involves cultural ecosystem services. These include places inhabited by spirits, guardians and totems; sites of local religious significance; peaceful locations; and places in which indicators of impending rain or drought can be found. The land itself binds people together, linking them with their ancestors (Mararike 1999).

Institutional arrangements for managing these common-pool resources are often weak and conflicting, and the transaction costs of negotiating and sustaining management agreements are high. Given the low monetary value of the products obtained from these areas, the prospects for internalising the costs of transformation and degradation are limited. Attempts to do so may simply increase conflict and illegal activities (Campbell et al. 2002).

The inhabitants of these tropical semi-arid savannas show a strong dependence of their livelihoods on the provisioning services they deliver. The inhabitants are very vulnerable to strong shifts in the delivery of these ecosystem services associated with strong climatic variability, and may contribute perhaps to people sinking further into poverty and making the task of poverty reduction much more difficult. Also, the recognition of regulating and supporting services is far beyond the day to day struggle for living. Yet, their assured delivery could contribute to lower vulnerability of local populations. Reducing poverty in these areas will require an integrated, longer-term, and multi-tiered set of interventions: locally, in terms of creating more opportunities for people to take charge of their own development; at district level, through creating an enabling and supportive environment in which markets can function and from where people can seek services and advice;

[8] Source: Balvanera and Prabhu 2004.

and nationally, by ensuring macro-economic stability and creating the conditions for investment and economic growth so that people are not confined to a subsistence livelihood.

3 PRESCRIPTION FOR THE FUTURE

Why haven't countries made more progress toward the goal of environmental sustainability? The details differ from country to country, but several general factors are worth noting. Negative environmental trade-offs often exist in the pursuit of economic growth and in the pursuit of other Millennium Development Goals. Steps that may appear to be highly beneficial to a national economy in the short term – such as increasing fisheries harvests, building roads, building hydroelectric plants and so forth – often have negative environmental impacts that cannot be mitigated. In turn, these negative environmental impacts will, in the long term (> 20 years), have direct negative consequences on the very activities they were designed for and on quality of life. They may also have immediate direct negative consequences "downstream" from the site. Another troubling factor is that the people benefiting from actions that degrade the environment are often not the same who pay the costs of environmental degradation. For example, today's generation may benefit from the overharvesting of forests and fisheries, but future generations will pay the price because the productivity of these resources will be damaged. Similarly, a factory owner may benefit from the cheap electricity produced by a new hydropower plant, but the downstream community that previously depended on fisheries as a source of food may pay the price. Also, consumers in developing countries may benefit from exotic wood extraction in tropical forests, but local communities in the Amazon will be suffer from local climatic changes or soil erosion. As a result, the political and economic pressures to take actions that have negative environmental side effects often 'trump' the institutions charged with protecting environmental sustainability. A corollary to this is that the benefits derived from positive action on ensuring environmental sustainability are often not perceived by those who bear the costs, thus little incentive exists for making the necessary investments.

Further, ecological services are classic "public goods", provided by nature in ways that benefit everyone, and the benefits that one person receives from using an ecosystem service does not exclude similar use by others. Economists point out that whenever use by one person does not cost other people, the marginal opportunity cost is zero and therefore the price should be zero. But of course the cost of production of benefits from ecosystem services is considerably greater than zero, and the previous section has shown that many development activities can reduce the capacity of ecosystems to provide the required public good. One fundamental characteristic of public goods is that they invariably are provided at a level that is considerably less than optimal in terms of delivering benefits to people. The public goods aspects of ecosystem services require considerably greater attention, but may offer ways for exploring innovative funding mechanisms to provide public funding to deliver the benefits from these public goods.

Countries may aspire to achieve environmental sustainability. Furthermore, today's decision-makers may acknowledge that over the long run countries need to move toward environmental sustainability. However, adequate incentives to take immediate steps are simply not in place. Environmental ministries tend to be one of the weakest substantial branches of government. And the people who pay the costs of environmental degradation are often the weakest sectors of society: the poor, women, and rural farming or fishing communities.

In light of this practical reality, how can a set of actions be selected that stand a chance of achieving real progress? The set of actions to promote more rapid progress toward this goal must have the following characteristics:

First, the set of **actions must be robust in terms of both time and space be targeted to the appropriate scale**. Environmental sustainability requires a long-term perspective, yet at the same time, important short-term problems of resource degradation and public health threats must be addressed immediately. Although a policy might be designed to reverse the loss of an environmental resource, it is not contributing to environmental sustainability if twenty years hence the resource is again degraded. For example, if we seek to identify actions that can promote environmentally sustainable management of agriculture or fisheries, we need to take into account potential impacts of climate change, the likelihood of periodic droughts affecting crop production, or cyclical changes in ocean currents affecting fisheries production. Spatial scale is equally important. A local community might not be capable of independently solving its own problems of environmental sustainability because some of the driving forces of environmental change, such as transportation policies or taxes, are set at a national scale. Similarly, an individual country could be prevented from solving its problems of environmental sustainability because of global driving forces such as climate change, trade policies, long range transport of pollutants, global market forces such as agricultural subsidies, and invasive species.

Second, the set of **actions must be directed across sectors** and should focus as much on changes needed in other sectors as on changes needed in the "environment" sector. Sustainability requires addressing both the direct and indirect causes of environmental degradation. The contrast here with the other MDGs could not be more striking. While the lack of progress toward the education goal can be addressed most logically by taking stronger steps to promote education, the lack of progress toward environmental sustainability will be addressed most efficiently by both stronger environmental actions and actions in other sectors (agriculture, forestry, fisheries, trade) that currently deplete biological resources. **An essential consequence of a cross-sectoral approach to solving the environmental problems of the world is the direct incorporation of environmental sustainability in the design of actions to achieve all of the other MDGs.** The achievement of the poverty goal, or the hunger goal, must be environmentally sustainable, or the goal, will not be achieved over the long term. What is needed is not green 'add-ons' to otherwise unsustainable projects, or even band-aid projects, but instead more systemic changes that result in policies and projects that are, at their core, environmentally sustainable.

At the very basic level, certain conditions must be met for any of the interventions to be made. Listed in Box 6, these key guiding principles will be considered when we identify mechanisms for implementation.

Box 6. Principles for interventions to ensure environmental sustainability (based on OECD Sustainable Development Guidelines (OECD 2001)).

- People centered.
- Consensus on long-term vision.
- Comprehensive and integrated.
- Targeted with clear budgetary priorities.
- Based on comprehensive and reliable analysis.
- Incorporate monitoring, learning and continuous improvement.
- Country-led and nationally-owned.
- High-level government commitment and influential lead institutions.
- Building on existing processes and strategies.
- Effective participation.
- Link national and local levels.
- Develop and build on existing capacity.

With these characteristics in mind, we suggest the following set of operational actions that could significantly advance national progress toward the environmental sustainability goal. We put forward this plan on the assumption that when relevant, user-friendly knowledge can be made available and people and institutional capacity can be built to use it, they can then participate more effectively in decision-making to improve laws, policies, instruments and institutions. This flow from knowledge to capacity to governance will guide the Action Plan presentation.

Table 2. Summary of the Plan of Action

PROBLEM	ACTION	ACTORS
Knowledge for Decisions		
Inadequate knowledge about the environment	1. Encourage all existing environmental monitoring and assessment as well as develop and implement in areas where there are gaps	national governments, international scientific and conservation community
Inadequate management of environmental knowledge	2. Agree on a global strategy for access to relevant, user-friendly information about the environment 3. Establish a Global Life Observation system of forecasting and monitoring	research institutions, scientists and information technologists, national governments
Lack of indicators to measure progress towards environmental sustainability	4. Develop and agree on a set of indicators and provide regular reports that will enable management and policy to adapt as necessary	intergovernmental bodies
Capacity for Environmental Management		
Lack of skills, expertise and tools for environmental management	5. Undertake a needs assessment for capacity building and technology transfer which can be shared with potential partners for implementation 6. Encourage integration of environmental issues within existing educational curricula and ensure continuing education opportunities for professionals in the field 7. Establish a national fund in each country to train and retain environmental experts in the public and private sectors in that country	intergovernmental bodies, NGOs, education ministries and teachers, national governments
Institutional culture, planning and organization does not support environmental sustainability	8. Encourage mainstreaming of environmental values in all aspects of institutional planning 9. Support Leadership training for individuals within the environmental field who show inherent ability 10. Promote training in participatory processes within institutions 11. Support the establishment and maintenance of networks in the environmental field	finance agencies, intergovernmental agencies, national governments

PROBLEM	ACTION	ACTORS
Inadequate public understanding of environmental issues and their role in human well-being	12. Target communications and public awareness strategies at the national level to educate the public about relevant local, national and global environmental issues and the role of public and private actors in them 13. Encourage all primary schools to develop and use locally-relevant curricula on issues related to environmental sustainability	media companies, public broadcasting corporations, environmental NGOs and scientists, education ministries
Market-Based Strategies		
Subsidies lead to environmentally-damaging activities	14. Identify and eliminate or decouple from production all environmentally-damaging subsidies in the fishing, timber and agriculture sectors 15. Establish a fund to support a 'transition phase' for training and relocation of displaced producers	national governments, international trade organizations, corporations
Current tax regimes do not address responsibility for environmental degradation	16. Shift a portion of the country's tax burden away from "goods" such as income and investment toward environmental "bads" such as pollution and excessive resource consumption	national governments
Today's markets fail to account for the full spectrum of the public goods costs and benefits associated with ecosystem.	17. Develop an international system to monetize ecosystem goods and services so that they may be traded on the open market	intergovernmental agencies, finance agencies
Markets that promote environmental services are not supported	18. Encourage the international community and consumers in wealthy countries to support existing markets for certified natural resources and sustainable production processes	global businesses, investors, consumers, certification agencies, market experts
Improving Environmental Management and Governance at the International level		
Development activities cause environmental degradation	19. Require an environmental sustainability impact assessment for all development project proposals regardless of sector	lending agencies

PROBLEM	ACTION	ACTORS
A lack of financial incentive within the PRSP process to address environmental issues	20. Establish a formal mechanism between environmental funding agencies and the World Bank, and other donors funding Poverty Reduction Strategies (PRS), to channel additional environmental funding into national PRS processes, ensuring that measures to achieve environmental sustainability are integrated into the PRSs.	lending agencies, national governments
Climate change threatens many aspects of human wellbeing and ecosystem function	21. Ensure that global mean surface temperature increase does not exceed 2^{o}C and that the rate of change does not exceed 0.2^{o}C per decade 22. Develop and implement supporting policies and energy-efficient and clean technologies, coupled with effective technology transfer 23. Promote adaptation to climate change	intergovernmental agencies, national governments
Improving Environmental Management at the landscape level		
An inadequate and non-representative amount of intact terrestrial and marine habitat is currently protected	24. Establish by 2010, terrestrially[9] and 2012 in the marine area, a global network of comprehensive, representative and effectively managed national and regional protected area systems 25. Support a multilateral effort, including global funds, to assist those countries in need of resources with the financing to set aside these natural areas and to develop the capacity to manage, monitor, and protect them	national governments, multilateral agencies, NGOs, scientific organizations
Current management practices are based on static principles and are not flexible enough to react to changing situations.	26. Support incorporation of adaptive management techniques at all levels of environmental management	national government, resource management experts, land managers

[9] Terrestrial includes inland water ecosystems

PROBLEM	ACTION	ACTORS
Management at the level of ecosystems does not take into account interactions among ecosystems and surrounding habitats.	27. Mainstream ecoagriculture techniques into current production areas, especially in areas of poverty and make efforts to conduct farmer-to-farmer exchange of knowledge and technology 28. Use the IWRM approach in all environmental management and planning and infrastructure development	farmers, agricultural technicians, resource management experts, national government

3.1 Knowledge for Decisions

3.1.1 Filling the Knowledge Gaps

PROBLEM: Inadequate knowledge about the environment

Information is the foundation of sustainable development and is a basic and essential ingredient for successful planning and decision-making. If decisions are made without sound data and information, they will be little better than best guesses and are likely to be wrong. Economic and social data are widely available and well understood. The situation for environmental data and information is somewhat different. High quality, comprehensive and timely information on the environment remains a scarce resource, and finding the 'right' information can pose problems: data are difficult and expensive to obtain. It is also difficult to find indicators that capture and reflect the complexity of the environment and human vulnerability to environmental change. Environmental data acquisition remains a basic need in most countries, particularly developing countries that lack the technical and financial capacity to maintain a large-scale environmental monitoring effort.

Significant work to synthesize existing information, identify gaps and develop indicators that will help monitor biodiversity and, more important, present scenarios based on our current knowledge, is needed. Indicators that provide an accurate view of the status of biodiversity should be agreed and monitored. Enhanced capacity to measure, monitor, and forecast on a local, national and regional scale must be supported through the training of local scientists and technicians and the networking of researchers and research institutions. Each country needs have a fully up-to-date scientific infrastructure to conduct the requisite monitoring and forecasting required to specifically address the environmental consequences of local and national development plans and actions. Adaptive management is unlikely without such infrastructure.

> *Action 1. Encourage all existing environmental monitoring and assessment as well as development and implementation in areas where gaps remain. Specifically, support for the work of GBIF, GEO and the work of environmental NGOs will be invaluable to promoting a better understanding of our environment.*

3.1.2 Environmental information management

PROBLEM: Inadequate management of environmental Knowledge

Great technological improvements have been made in environmental research and monitoring and numerous programs exist at the national and international levels using these tools (too many to list here). The knowledge generated from all these sources should be managed in a co-ordinated and collaborative fashion in order to extract the maximum value possible. Under a model such as that already employed through the Global Observation Systems, the environment community should band together to develop a Global Life Observation consortium.

Significant advances in information management technology have also vastly improved access to a myriad of data sources. However, providing that information in a relevant, user-friendly form has not been so easy. In addition, ensuring data quality, principles of data custodianship and attribution and intellectual property rights remains a complex and political challenge for the environmental community.

> *Action 3: Prepare and agree on a global strategy for access to relevant, user-friendly information about the environment.*
>
> *Action 2. Develop a Global Life Observatory. This will be a global network of national life observatories that will build on existing information and provide the first comprehensive assessment of the state of our environmental resources, life on Earth, its species, ecosystems and their geographic distributions. The initiative will help to develop and implement the technology to monitor changes and provide forecasts using scientifically-credible predictive models under different land use policies and scenarios.*

3.1.3 Using environmental indicators to assess progress

PROBLEM: Lack of indicators to measure progress towards environmental sustainability

Significant work to synthesize what exists, identify gaps and develop indicators that will help monitor biodiversity is needed. It is important to recognize that we can not hope to complete a global biodiversity inventory within the time frame of the 2010 biodiversity target established at WSSD. Indicators that provide an accurate view of the status of biodiversity should be agreed and monitored as soon as possible if we are to have an initial reading by 2010. While the specific indicators may vary from country to country, they should share certain characteristics relating to their specificity, measurability, achievability and incorporation of timelines. Many indicators are already in use and being further developed. Reports such as the GEO 3 (UNEP, 2000) incorporate such indicators and provide a global overview of the situation. More details on existing

indicators and processes at the national level are available from the Convention on Biological Diversity (UNEP/CBD/SBSTTA/9/10).

> *Action 4: Agree and implement a suite of environmental indicators at the global, regional, and national levels. Report on those indicators at regular intervals, revising management and policy actions accordingly.*

3.2 Ensuring Capacity for Environmental Sustainability

When relevant and user-friendly information exists, decision makers still need the capacity – awareness, skills and tools – to make the right policy decisions. Furthermore, decision makers cannot make environmentally sustainable policy in the absence of a supportive set of stakeholders who have learned to value the basic role of a healthy environment in ensuring their well-being. We recommend several actions to empower stakeholders to work towards environmental sustainability: capacity building and technology transfer; institution strengthening; and public awareness and education activities.

3.2.1 Capacity building and Technology Transfer

PROBLEM: Lack of skills, expertise and tools for environmental management

Countries with high biodiversity and low financial resources lack training opportunities, technical expertise, and influence in setting and addressing global conservation agendas, relative to countries of low biodiversity and large financial resources, which are abundant in training opportunities, technical expertise, and influence. One indicator or reflection of this imbalance is the disproportionate representation of North American and European scientists in the Global Biodiversity Assessment of the United Nations Environment Program[10] with the US, France and England all having greater than 20 researchers involved, Australia with 11-20, Brazil, Canada, Mexico, Russia, South Africa, India, and a few European countries having 6-10 and all but five countries in Africa and the South America having one or fewer researchers involved. While the 8,000 experts that comprise the IUCN Species Survival Commission come from 173 countries around the globe including a majority from the 'South,' this network does not typically provide training, tools, or resources.

At the 2004 CBD Conference of the parties, participants were clear that capacity building and technology transfer were key to ensuring sustainability, but that these activities must be demand-driven, include South-North and South-South exchanges as well as the more common North-South exchanges. Furthermore, they should be adequately resourced over the long term. The lesson from these discussions is that two key areas should be addressed: understanding the capacity building needs of each country; and integrating

[10] UNEP 1995. Gobal Biodiversity Assessment. United Nations Environment Programme. Cambridge, UK: Cambridge University Press; WRI 1997.

environmental concerns within training and education opportunities for students and professionals.

Five years ago, the FAO conducted an analysis of the world's agricultural universities, and concluded that the majority had little contact with or influence on the rural societies they were meant to serve.[11] In addition, minimal attention is paid from these universities to the impact of agricultural activities on the function and services of the ecosystems that underlie all agricultural production. The education sector in countries should be able to provide conservation science and resource management education and training programs that integrate the natural and social sciences for a broad range of students. Professional training programs in environmental sciences and leadership training should also be provided to people working in private and public agencies dealing with the environment.

> *Action 5. Undertake a country-level needs assessment for capacity building and technology transfer that can be shared with potential partners for implementation.*
>
> *Action 6: Encourage integration of environmental issues, including practical internships and hands-on field experiences, within existing educational curricula and ensure continuing education opportunities for professionals in the field.*
>
> *Action 7: Establish national funds to train and retain environmental experts working on sustainable development in general in the public and private sectors in that country.*

3.2.2 Strengthening Institutions

PROBLEM: Institutional culture, planning and organization do not support environmental sustainability.

The institutional challenges we face are not merely about how to increase the quality of human resources, unearth new discoveries and technologies, and create policies, but also include the vision and culture within which the work occurs. It is critical that institutions possess vision and leadership for environmental sustainability. However, if environmental sustainability is to be achieved, fundamental reforms of institutions will have to occur.

Formal institutions such as government, finance and education tend to have a narrow focus and vision that were designed to meet the needs of a different world, one that placed emphasis more on economic structure and individual property than on the global commons such as air, water, and biodiversity (Myers 2002). This is in contrast with the institutions and cultural values of indigenous and other local or traditional communities that have tended to possess such wisdom. Globalization and modernization have

[11] Johnson, Hilde F. 2003. Sustainability, Education and the Management of Change in the Tropics. Earth Seminar, Lysebu Hotel, 3 September 2003. Speech by Norway's Minister of International Development.

diminished the existence and power these local institutions, and indeed, local respect for the environment. The challenges that lie ahead include strengthening existing institutions that do work on the basis of environmental sustainability, and incorporating the knowledge and wisdom generated there into government institutions, such as the formal education system. In this way, imparting knowledge of technology can be accompanied by the nurturance and stewardship of ethics and wisdom. Only through the combination of technical knowledge and an ethical understanding of our common reliance on sustainability will we marshal the human resources needed to address the globe's environmental and social problems, unearth new discoveries, and create policies that ensure environmental sustainability.

To achieve sustainability, the world needs organizations that demonstrate:

i) **Environmental value and vision**. Mainstreaming and building common environmental values among stakeholders will contribute to the accountability and sustainability of every level of decision making process.
ii) **Leadership**. Environmental leadership is a medium for the dissemination process and continual improvement of environmental sustainability action.
iii) **Empowerment of human resources**. Building competence and human resource for environmental sustainability is urgent especially with the increasing disparity of knowledge and technical capacities among the 'haves' and 'have-nots', between women and men, between indigenous and non-indigenous people.
iv) **Networking and collaboration**. Collaborative action, including partnerships, among stakeholders is critical for environmental sustainability to become a global effort.

In this context, we draw on DFID's (2003) definition of institutional strengthening as the following:

> "a process which facilitates and assists changes in organizations (both formal and informal), typically through reform and development of systems, structure, program, strategic planning, and shared values, taking into account the wider external environment (political, institutional, legal, economic and social) in order to improve the effectiveness and efficiency with which the organization fulfils its mission to achieve environmental sustainability".

> *Action 8: Encourage mainstreaming of environmental value in all aspects of institutional planning.*

> *Action 9: Support leadership training for individuals within the environmental field who show inherent ability.*

> *Action 10: Promote training in participatory processes within institutions.*

Action 11: Support the establishment and maintenance of networks in the environmental field, particularly for South-South cooperation

3.2.3 Public Awareness and Education

PROBLEM: Inadequate public understanding of environmental issues and their role in human well-being.

Public awareness of environmental issues and their complex interactions and relationship to human activity are key to ensuring support and political will to undertake the activities necessary for environmental sustainability. This awareness can be achieved both through the mass media as well as within public education curricula

Media campaign on environmental issues

The case for biodiversity must be established within other sectors concerned with development. Biodiversity conservation and sustainable use must be integrated into all actions intended to alleviate poverty and achieve sustainable livelihoods. Achieving this integration will depend to a large extent on general understanding of the role of biodiversity in human welfare. Civil society is not well informed about the damages incurred in the environment from their actions or actions of others, about the health and livelihood risks of a degraded environment, or about accountability. Elected officials must answer to a public well informed on the links between human well-being, the fate of the planet, and activities that effect the environment. A public awareness campaign should be carried out on all levels from the local through schools or community organizations to the national and international through media broadcasts and literature. Education of civil society not only allows them to make better decisions in their own practices and livelihoods, but also to be empowered to create change where it is needed.

Action 12. Undertake targeted communications and public awareness campaigns at the national level to educate the public about relevant local, national and global environmental issues, the value of ecosystem services to their everyday lives, and the role of public and private actors in them.

Primary and secondary school environmental education campaign

Environmental sustainability can only be achieved when education begins at the primary level to integrate the concept of sustainability with local culture and ethics, and when primary education links children to their specific place. As it is, too often nationally-derived curricula teach children to ignore their surroundings rather than learn from them. Children are tomorrow's stewards of nature and require hands-on, experiential learning,

featuring interactions and responses to nature that involve artistic and aesthetic as well as scientific approaches as a way of knowing about the world.

> *Action 13. Assist primary schools in developing and using locally-relevant curricula on issues related to environmental sustainability and involving parks, protected areas, nature centers, botanical gardens, and the like to support environmental education.*

3.3 Market-related solutions

Market mechanisms do not always ensure the public good of environmental protection. In some cases, markets do not exist for particular environmental attributes such as the global environmental commons or local ecosystem services. In other cases where markets do exist for these goods and services, either perverse incentives exist, through institutional or market failure, that result in unsustainable use of them, or externalities are not internalized. In this latter situation the costs of environmental protection (for example, loss of land use rights by local people when a strict protected area is established) are not paid by those who receive the benefits from that protection (downriver neighbors, the global citizen). Market and institutional failures provide the main incentives driving both commercial agents and rural farmers to engage in unsustainable deforestation activities (Duraiappah 1998). Thus, the correction of market failures related to the environment is a systemic solution that is fundamental to solving many environmental problems.

Despite the complexities of market-based solutions, we recommend that countries pursue four market-related policy changes.

3.3.1 Remove perverse subsidies in forestry, fisheries and agriculture

PROBLEM: Subsidies lead to environmentally-damaging activities.

Subsidies not only drive overcapitalization of natural resources, but also drive poverty in poor countries where these subsidies are not available to small producers, or when subsidies in the OECD countries lead to overproduction that harms developing country farmers.. Since rural poverty represents about 62% of total world poverty, and much of the income in rural sectors is derived from agricultural activities, development interventions must address the inequity of market prices for agricultural products, even when this may lead to higher food prices. It may be paradoxical to argue that cheap food hurts the rural poor, but for the rural poor farmers, receiving a fair price for their products is essential to their very survival, unless they also receive subsidies at the same levels as those with whom they compete in the market place. According to the Institute for Agriculture and Trade Policy, US maize sells in Mexico for 25% less than it costs to grow and harvest, due to agricultural subsidies paid to American farmers. As a result, Mexican farmers receive prices that are so low that they lose money with each hectare

they plant. According to the World Trade Organization, European farmers get 35% of their income in the form of government subsidies, while US farmers receive 20%.

In some cases, harmful subsidies have been removed in recent decades. For example, pesticide subsidies in Indonesia totaled nearly $150 million per year in the mid-1980s resulting in considerable overuse of pesticides, downstream pollution, and health problems among farmers. When subsides were ended, pesticide use dropped, rice production increased, and the government saved considerable money (World Bank 1997).

Subsidies in three sectors – fisheries, timber and agriculture - benefit an extremely small group of people (mainly in rich countries) at extremely high costs to society (particularly in poor countries). Because of the 'vested interest' in these industries to maintain subsidies, political pressure, and in some cases corruption, have made it nearly impossible to eliminate them. Rapid action must be taken to end these subsidies before they undermine the essential natural resources whose overexploitation they support. A possible solution to help break the stalemate would be the presence of resources to fund a 'transition' phase for individuals who will suffer economic hardship by the loss of jobs. This fund could be used to train affected people for other jobs and support relocation if they need to move to other locations to look for work.

> *Action 14. Identify and eliminate or decouple from production all environmentally-damaging subsidies in the fishing, timber and agriculture sectors by 2015.*
>
> *Action 15: Establish a fund to support a 'transition phase' for training and relocation for displaced producers.*

3.3.2 Environmental tax reform

PROBLEM: Current tax regimes do not address responsibility for environmental degradation

A variety of steps have been taken by countries to begin to correct some market failures and thereby internalize the seemingly external costs and benefits of environmental degradation or management, respectively. For example, some countries have established pollution taxes on certain emissions (e.g., carbon dioxide, SO_2, NO_X, excessive use of fertilizers) which results in a combination of increased revenue or reduction in emissions. Caution must be taken to not lose sight of the environmental goal of environmental taxes by emphasizing revenue generation (Pearce and Barbier 2000). One approach is for a country to shift a portion of its tax burden from income tax to pollution tax so that revenue levels will be maintained while at the same time correcting the market failure to capture environmental externalities. This type of tax shifting has been implemented by several European countries but is not yet widespread. Germany may be the leader in this with simultaneous reduction in income taxes and increase in energy tax, particularly on motor fuels and electricity. Thus far it has shifted 2% of its tax burden from income to

environmentally destructive activities and has seen a 5% decrease in motor fuel sales and jump in car-pooling services (Fischlowitz-Roberts 2002)..

Governments will see such a plan to be in their interest when it enables them to reduce income tax burdens on the public. The systems must be designed so that the new tax burden on pollution does not become regressive. For example, if carbon taxes are established, some credit will need to be given to low income automobile drivers who would then face an inequitably high increase in the cost of transportation.

Taxing mechanisms introduce additional costs to individuals who do not want to bear those costs and potentially to state agencies charged with monitoring and reporting on progress in the abatement of environmental damage. Another challenge is that many of the most destructive practices are carried out covertly and, as such, would escape the eye of the market or monitoring institutions. A stronger regulatory body would help with that obstacle.

> *Action 16. At the national level, shift a portion of a country's tax burden away from "goods" such as income and investment toward environmental "bads" such as pollution and excessive resource consumption.*

3.3.3 Internalize the true costs of ecosystem goods and services

PROBLEM: Today's markets fail to account for the full spectrum of costs and benefits associated with ecosystem goods and services.

Considerable attention is now being given to valuation of ecosystem services, and providing markets for them, but progress is slow. Economic tools need to be created and existing ones strengthened to give credible and accurate values to ecosystem services and make evident their importance to human well-being (Costanza et al. 1997, Daily and Walker 2000, Heal 2000). This can guide decision-making processes by contrasting the relative impact of a suite of alternative actions on a given resource.

Carbon markets are now well developed, in the European Union at least, as part of the global response to climate change in cap and trade systems where overall emissions are capped at a certain level and then firms can trade emission credits to achieve savings and pollution reductions. Other markets for ecosystem services are beginning to emerge, including for watershed protection, pollination, pollution control, and ecotourism.

Monetizing public goods, or the benefits derived from them, is a complex issue and a great deal of economic analysis on the topic needs to be examined. Enabling monetizing to function properly at the national or regional level will require the support of the international trade community in the form of capital, trade rules, and standards for the target commodities. A major obstacle is the lack of international standards on these emerging commodities. Just as oil has a quality standard, so should a ton of carbon.

Eventually, a country can then add new tradable commodities to their net worth and bring them to the international market.

Many people argue that trading systems are inequitable in that they, in effect, give property rights for pollution to firms enabling them to profit from something that should not have been allowed in the first place. The correction of market failures is also often an "institutionally-intensive" action. The establishment of an effective pollution trading system, for example, requires the presence of a significant monitoring and enforcing system and a well developed and well-functioning financial market.

> *Action 17. Develop an international system to monetize and standardized ecosystem goods and services so that they may be traded on the open market.*

3.3.4 Support and strengthen existing and emerging markets

PROBLEM: Markets that value environmental services are not supported.

Market economics and market-oriented product development can in some cases augment the value of ecosystem services and improve income from natural resources to rural people as a potentially important conservation tool (LaFleur and Channell 1995). One strategy is the implementation of mechanisms for providing direct payments to land owners for sustained delivery of freshwater, bioregulation, climate regulation and protection against the hazards (Balmford and et al. 2002, Ferraro and Kiss 2002, Heal 2000). In some cases, farmers are already being paid for their role in conserving traditional breeds or cultivated varieties, or even wild biodiversity (McNeely and Scherr 2003). In other cases, markets for products or goods produced in environmentally sustainable ways exist as in the case of certified timber, organic foods, certified fish, shade-grown coffee, and some non-timber forest products. In addition to this market solution, an international system must be developed to *value* ecosystem goods and services so that better policy decisions could be made regarding economic costs and benefits of environmental protection in relation to other sectors such as health.

This solution will require the existence of third-party certification bodies such as the Forest Stewardship Council for timber or the Organic Crop Improvement Association for organic agricultural products. This solution will also require the education and cooperation of cadres of 'green consumers' that produce the demand for environmentally-friendly and certified products; 'green investors' who support eco-friendly publicly-traded companies or pressure those that are not; and corporations with an environmental conscience willing to make the necessary changes in production methods. For example, Chiquita Brands International invested heavily in certification and has reduced its chemical use by 80% in order to supply the enormous European demand for certified bananas (McNeely and Scherr 2003).

Market-oriented economic and product development do not always furnish positive solutions and sometimes come with major drawbacks. These approaches can be subject to

product-specific longevity limitations due to economic cycles for the product and may have strong impact on social customs, values, and local division of labor in rural communities, leading to increasing levels of poverty. These impacts need to be evaluated in terms of both their social cost and their implications for conservation.

The outcome of global support for eco-friendly markets and the products and processes that supply them will be a natural environment with fewer damaging chemicals and soil degrading production activities, safer work conditions for producers such as field hands on banana plantations and factory workers.

> *Action 18. Support existing markets for certified natural resources and sustainable production processes, and prepare to pay for global ecosystem goods and services (e.g., clean air, clean water, carbon sequestration) that are stewarded or managed by local communities and national governments.*

3.4 Improving Environmental Management and Governance at the International level

Numerous general environmental policies and regulations that exist already at international, regional, national and local levels deal with subjects such as natural resource management, pollution control, agricultural production, water use, and mineral extraction. Many of these are ineffective simply because of a lack of government support or human capacity to monitor and enforce them. A broad recommendation, and one that appears in almost all international environmental conventions, instruments and agreements, is that adequate funding must be provided by governments to agencies responsible for monitoring and enforcement. In addition to this general request, we highlight three specific policy interventions that could have a direct effect on environmental management. These three recommendations are relevant to international environmental regimes and should be carried out in a combination of international- and national-level actions.

3.4.1 Integrate environmental sustainability in all development strategies

PROBLEM: Development activities result in environmental degradation

Alleviating poverty, instituting fair trade, assuring adequate health, minimizing the threat of natural disasters, providing social and economic equity, and maintaining ecosystem services are parts of our common aspiration for a safe and sustainable future. Each of these goals is associated with its own set of international instruments, institutions and stakeholders. Nevertheless, they are not easily achieved together because they are treated from independent sectors of society, regardless of clear tradeoffs among them. For example, projects promoted by transport ministries (e.g. road-building), commerce ministries (e.g., regulations on chemical pollutants), agriculture ministries (e.g. land-use

policies), can have major negative impacts on environmental sustainability. The single-sector development approach has often solved one problem while creating others that in the long-term erode environmental sustainability and human well-being. Cross-sectoral cooperation and coordination are critical to ensure that expenditures made in support of MDG targets are at least environmentally neutral and at best environmentally positive.

A process should be established that requires governments to propose projects that bridge sectoral development goals, i.e., that integrate social, economic and environmental principles in addressing issues of poverty, trade, health, equity and conflict, and other related goals. Our main concern, of course, is to curb the environmental impact of development projects, but in the spirit of sustainable development, social, economic, and environmental goals should all be addressed. This process would apply to all international funding mechanisms including the PRSP process, as well as independent proposals to all other donor agencies. All project proposals and PRSPs submitted to funding agencies should include both actions that directly address environmental problems, and actions that reduce the negative environmental impacts of achieving other goals.

> *Action 19. Require an environmental sustainability impact assessment for all development project proposals regardless of sector. Furthermore, no development plans in any sector should receive financial or logistical support unless measures to mitigate adverse environmental impacts have been fully integrated.*

3.4.2 Link PRSP process to environmental funding

PROBLEM: A lack of financial incentives within the PRSP process to address environmental issues.

One of the primary planning instruments for developing countries is the Poverty Reduction Strategy Paper (PRSP). To date approximately 50 countries have prepared a PRSP, but few of these integrate any environmental factors, and those few focus almost exclusively on water and sanitation (Bojö and Reddy 2003b). This trend highlights a major shortcoming in the PRSP process because the available data indicate that developing countries are still giving inadequate attention to managing forests, agricultural land, and other environmental resources. Land area covered by forests decreased in most tropical countries, particularly where logging activity is high (Indonesia, Myanmar, Thailand, Malaysia, Brazil, Mexico, Panama, Peru) from 1990 to 2000, and CO_2 emissions have increased, sometimes dramatically, in those places (UNDP 2003). By giving greater attention to MDG 7, Target 9 in their PRSPs, developing countries may be able to make significant progress toward safe drinking water, improved sanitation, and more reliable resource and environmental management (Bojö and Reddy 2003a).

One way to provide incentives to integrate environmental factors into the PRSPs would be to link the process to a traditional environmental funding source, offering an additional

inlet of financial resources. The primary agency that funds projects related to global and regional environmental issues is the Global Environment Facility (GEF). The GEF, however, remains largely isolated from the mainstream development agenda because it is not effectively linked to other types of development instruments such as PRSPs, and international organizations such as WTO, WHO, UNAIDS.

A mechanism should be established to align the traditional sources of environmental funding with the PRSP implementation process. This may require the development of a type of sister facility to the GEF that specifically targets national-level environmental plans, or the identification of existing funds. The mechanism to align these financiers could be done by a fast track approval for funding of national environmental programs identified in the PRSP, provided that they satisfy strict technical and operational standards. This would require a coordination of the identified funding processes with those used to provide funding for the PRSP, by donors, such as the World Bank.

The benefits of such an alignment could be twofold. First, countries would be encouraged to place greater emphasis on environmental policies as well as the environmental impact of other sector policies in their PRSP processes. Second, the administrative burden of preparing and processing funding proposals on recipient countries could be greatly reduced by aligning both funding mechanisms. This new strategy would go a long way towards the incorporation of principles of environmental sustainability into broad-stream economic, social and political agendas.

An accord would have to be reached between the environmental funding agency and the World Bank with an agreed framework for the review process and funding mechanisms. Task teams of technical experts within the respective institutions will have to be established to evaluate proposals related to complementary support arising from complying with principles of environmental sustainability. In its pilot phase, a coordinating group consisting of representatives of the institutions concerned, national representatives, academia and other 'neutral' stakeholders should evaluate the process and begin the cycle of adaptively managing this new bridging mechanism.

> *Action 20. Establish a formal mechanism between environmental funding agencies and the World Bank, and other donors funding Poverty Reduction Strategies (PRS), to channel additional environmental funding into national PRS processes, ensuring that measures to achieve environmental sustainability are integrated into the PRSs.*

3.4.3 Protect the Earth's climate system

PROBLEM: Climate change threatens many aspects of human wellbeing and ecosystem function.

Human-induced climate change is caused by the emissions of greenhouse gases and partially offset in some regions by sulfate aerosols. Of the many important anthropogenic

greenhouse gases (e.g., methane, nitrous oxide and ozone), the single most important is carbon dioxide, primarily because of the large emissions resulting from energy production and use (i.e., the combustion of oil, gas and coal) and burning associated with land-use change (i.e., tropical deforestation). In 1990, CO_2 emissions accounted for 55% of greenhouse gases contributing to global warming.

Most scientists now agree that the Earth's climate is changing due to human activities, and that while industrialized countries have caused the problem, developing countries and poor people are the most vulnerable. It is also clear that the actions of today's generation will profoundly affect the Earth inherited by our children and future generations. Evidence suggests that low-lying Small Island States and deltaic regions of developing countries in South Asia, the South Pacific, and the Indian Ocean could eventually disappear under water, displacing tens of millions of people in the process; peoples' exposure to malaria and dengue fever, already rampant in the tropics and sub-tropics, could become even more severe, spreading northward into the temperate zone; crop production could significantly decrease in Africa, Latin America and in other developing countries; and fresh water could become even more scarce in many areas of the world already facing shortages (IPCC 2001). Climate change will also exacerbate the loss of biodiversity, increase the risk of extinction for many species, especially those that are already at risk due to factors such as low population numbers, restricted or patchy habitats and limited climatic ranges (e.g. Thomas et al., 2004), and disrupt ecosystem services essential for sustainable development. For the 800 million people who go to bed hungry every night, and the 2 billion others exposed to insect-borne diseases and water scarcity, climate change threatens to bring more suffering in its wake. In this way, climate change may undermine long-term development and the ability of many poor people to escape poverty, and will clearly threaten our ability to achieve many of the MDGs.

To avoid, or limit, human-induced changes to the Earth's climate requires significantly reducing the anthropogenic emissions of greenhouse gases, in particular carbon dioxide. Although it is well recognized that scientific uncertainties exist and that an exact quantification linking greenhouse gas emissions to regionally-specific impacts is not yet possible, enough is known to set a target for a "maximum allowable" change and rate of change in global mean surface temperature.

This recommendation is based on our view that the atmospheric carbon dioxide target of 450ppm is the right long-term target but that it may be modified as we gain more information on the causes and consequences of climate change over the next decade. The indicator proposed for this target is carbon dioxide emissions per capita.

Cost-effective and equitable solutions to the carbon emissions problem are available, but political will and moral leadership are needed, with politicians and the private sector recognizing the need to take the long-term view. An internationally coordinated public-private research program is needed, as are innovative technology transfer mechanisms and mechanisms to diffuse new technologies into the marketplace.

The proposed emissions reductions involve the development and implementation of supporting policies (e.g., energy pricing strategies and taxes, removing subsidies that increase green house gas emissions, domestic and international tradable emissions permits, voluntary programs, regulatory programs including energy-efficiency standards, incentives for use of new technologies during market build-up; and education and training such as product advisories and labels) to overcome barriers to the diffusion of new efficient technologies into the market-place. Rapidly accumulating advances in many of the technologies needed to address climate change and other environmental issues are lowering costs and making them either competitive or justified (e.g., photo-voltaic technology in small isolated communities). In addition to intensified R&D, a mechanism is needed to disseminate the new technologies and encourage their use, for example through short-term subsidies (i.e. incentives to offset initial transaction costs).

Reducing greenhouse gas emissions offers a unique opportunity to modernize energy systems, address local and regional air pollution problems (and thus protect human health), and protect biodiversity and ecological systems, which are the very foundation of sustainable development. In short, the global community needs to move very rapidly towards a de-carbonized system of energy production and consumption.

> *Action 21. Limit the maximum allowable increase in global mean surface temperature to 2^{o}C with the rate of change not exceeding 0.2^{o}C per decade. This will require that the atmospheric concentration of carbon dioxide be limited to about 450 ppm and emissions in 2015 limited to 9.5 GtC per year*
>
> *Action 22. Develop and implement supporting policies and an accelerated development of energy-efficient and clean technologies requiring intensified R&D by governments and the private sector, coupled with effective technology transfer.*
>
> *Action 23: Support adaptive technologies to help deal with the impacts of climate change.*

3.5 Improving Environmental Management at the Landscape Level

Fundamental to life on earth is the maintenance of biodiversity in all its forms: genes, species and ecosystems. The diversity of life on earth provides the natural infrastructure upon which the health and well-being of the human population depend. This diversity enhances the ability of ecosystems to withstand changes such as drought or hurricanes, and is thus required to ensure the sustained delivery of ecosystem services. Sixty percent of the world's population directly depends on local natural resources such as free-flowing fresh water, fuel wood, wild-collected food, plant medicines, and fertile soils for agricultural production for their daily existence. The other forty percent can obtain these products through trade from distant ecosystems. In all cases, diverse systems are needed to ensure the long term provision of such resources, as well as for the delivery of other

services such as a those related to clean, healthy, and climatically adequate systems. The importance of diversity is moreover increasingly important as catastrophic events such as droughts or hurricanes are very likely to become more frequent

Sustainable development is short-hand for a much more transparent and explicit concept: environmentally sustainable economic and social development. As such, achieving sustainable development requires sustaining the potential and the capacity for prosperous social and economic and social development while reliably maintaining essential ecosystem services. Nevertheless, development has been based heavily on management schemes that promote the reduction of the diversity of life, therefore compromising the long term ability to sustain human well-being. Our record to date of achieving environmentally sound economic development is cause for deep concern.

In developing countries key environmental challenges tend to be closely linked to sustained economic development and improved human livelihoods, threatening the sustainable use of environmental resources and conservation of biological diversity. In addressing these challenges adequate attention must be given also to the fundamental hydro-climatic differences between the tropics, where most of the world's poor live, and the temperate zone hosting many industrialized countries (Falkenmark and Chapman 1989). The following interventions are geared towards minimizing the loss of biodiversity and ecosystem services and enhancing the flow of benefits from ecosystem services to rural people.

3.5.1 Increase the amount of fully protected intact land and sea ecosystem coverage

PROBLEM: An inadequate and non-representative amount of intact terrestrial and marine habitat is currently protected

In a detailed exercise conducted by the U.S. National Center for Ecological Analysis and Synthesis (NCEAS), it was estimated that adequate global ecosystem function required the full protection of 15% of terrestrial and 30% of marine territory (Balmford et al. 2002). These areas would act as sources of biodiversity and ecosystem functions for many other landscapes that are not fully protected and therefore subject to multiple uses. These other areas are essential, but it is highly unlikely that these “productive landscapes” (see below) can by themselves support the full array of biodiversity and ecosystem functions necessary to provide the ecosystem goods and services upon which the health and well-being of the human population depend.

At present, nearly 12% of the land surface and less than 0.5% of intact marine cover have been legally established as protected areas, though not all are yet effectively protected. Though we do not have any large scale experiments to demonstrate the necessity of intact “sources” for the proper functioning of productive landscape sinks, there is local evidence of the importance of intact natural areas for ecosystem services on anthropogenic landscapes (e.g., Kremen 2003). So, clearly some action must be taken to increase intact ecosystem coverage.

Much of the land and ocean areas necessary to reach the 15%-30% goal are under government ownership. The others can be obtained with the proper funding and legal authorities in place. The critical steps to be taken must include (1) identifying within each country and region the important intact areas that can be allocated for protection, (2) establishing a fund to provide resources for national governments to act on their assessments, and (3) building national capacity to monitor, manage, and protect intact terrestrial and marine environments.

Recently the CBD COP 7 endorsed a decision to "*Adopt* the programme of work on protected areas annexed to the present decision with the objective of the establishment and maintenance by 2010 for terrestrial and by 2012 for marine areas of comprehensive, effectively managed, and ecologically representative national and regional systems of protected areas." This decision was in concert with and an important follow-up to the conclusions of the Vth IUCN World Parks Congress held in September 2003 in Durban, South Africa which was attended by about 3,000 of the world's leading experts on protected areas. The Congress sent a detailed message to the CBD COP7, specifying actions and targets to be included in the Programme of Work adopted by COP7.

> *Action 24. Establish by 2010, terrestrially[12] and 2012 in the marine area, a global network of comprehensive, representative and effectively managed national and regional protected area systems.*
>
> *Action 25: Support a multilateral effort, including global funds, to assist those countries in need of resources with the financing to establish these natural areas and to develop the capacity to manage, monitor, and protect them.*

3.5.2 Employ adaptive management practices for all ecosystems

PROBLEM: Current management practices are based on static principles and are not flexible enough to react to changing situations.

Environmental sustainability occurs within a dynamic state balancing an array of factors, which vary according to the context of the use. Sustainability of uses cannot be expressed with certainty, but rather as a probability that may have to change if the conditions in which management is taking place change. Achievement of sustainability is also dependent on institutional capacities to adapt to changing conditions based on monitoring and feedback. Given the uncertainties, sudden changes and different contexts in which the use of our environment occurs, adaptive management must be an essential part of any management program. Adaptive management requires implementation of a regular monitoring program and evaluation of indicators by which to evaluate the impact of actions and adjust as needed. Within the framework of the Convention on Biological Diversity, adaptive management has been more completely described.

[12] Terrestrial includes inland water ecosystems

Action 26: Support incorporation of adaptive management techniques at all levels of environmental management.

3.5.3 Promote management at the landscape scale

PROBLEM: Management at the level of ecosystems does not take into account interactions among ecosystems and surrounding habitats.

Effective and efficient management of the environment requires consideration of the full scope of landscapes involved in the managed system. Two particular approaches provide lessons.

Ecoagriculture

The ultimate challenge of sustainability-oriented environmental management is finding a proper balance between humans and the impacts caused to ecosystems in striving towards achieving MDGs. Problems occur when production activities are decoupled from environmental services which feed them. For example, nutrient and water cycling in a forest help to maintain the productivity of that forest. When the components of these cycles are altered, such as removing the existing vegetation, the plot of land no longer has the capability to renovate the original ecosystem services. To regain the original productivity of the soil one would have to let the forest return over many years or add vast quantity of inputs (fertilizer, seed, water). In the absence of these inputs, as is the case in many rural areas, the options for production are limited and the land is often marginalized, even within one year, to the point that the people must move on to the next patch of forest. In the classic situation of shifting agriculture, the farmers will stop production activities and allow the vegetation to regenerate (in fallows) for some years before repeating the cycle (Conklin 1961).

In situations where farmers have enough land to leave these fallows for adequate time periods, this production strategy works. But when population pressure is too high for this, the land as a resource degrades and people are left hungry and desperate. In these situations, assistance or inputs will have to be provided.

Many groups of rural producers have developed complex, dynamic production systems in which they use many of the geophysical features, ecosystem components, and ecological processes in systems of agrodiversity (Brookfield and Padoch 1994). In particular, they use and manage a suite of aquatic, forest and savannah resources, constructively utilize the variability in soil drainage and fertility to grow different crops, and create a gradient of micro-environmental conditions to grow a wide array of crops both woody and non-woody. They establish and maintain patches of agroforest, agrosilvopastoral mosaics, silvicultural units, agricultural fields, pastures and fish nurseries. This is the production landscape where a patchy mosaic of land units is maintained, adapting to different microenvironments with farmers managing for the production of construction materials, fuelwood, timber, fruits, vegetables, grains, and fish on both cash and subsistence levels.

In the production landscape farmers are concerned not only about productivity of the desired crop, but also about the ecological dynamics and interactions that occur in the mosaic of land units. They are concerned with the maintenance of ecosystem processes like replenishment of soils, regeneration of vegetation, and provision of habitat for seed dispersers and pollinators.

The rural producer who maintains such systems of high agrodiversity provides a model of integrated production and conservation that is an alternative to the disaggregated landscape where production is decoupled from the ecological processes and services that should exist at that site.

> *Action 27. Mainstream ecoagriculture techniques into current production areas, especially in areas of poverty, and promote farmer-to-farmer exchange of knowledge and technology.*

Mainstream the Integrated Water Resources Management approach

By its movement through the landscape from rainfall over the catchment through natural habitat and agricultural fields and on into rivers, freshwater tends to physically link several MDGs. Water links can generate intergoal conflicts such as when increasing food production involves consumptive water use by which huge amounts of water are evaporated to the atmosphere and subsequently not available for local downstream reuse.

The water, food and raw materials needed to secure human livelihood originate from resources in the natural environment. It is essential to realize that these resources cannot be harvested without the physical modification of components of the landscape (e.g. clearing, tilling) and water pathways (e.g. wells, pipes, storage), and chemical interferences (e.g. exhaust gases, solid refuse, wastewater, agricultural chemicals) with water and the atmosphere. Due to natural processes at work in the landscape – most of them water-related, these interferences tend to also affect water flow, pathways and quality and therefore disturb water-dependent local ecosystems. Some of these unintended side effects will be avoidable, but others will be difficult to avoid. When human populations grow these modifications intensify, thereby escalating the ecological disturbances.

Trade-offs will have to be struck within the Integrated Water Resources Management (IWRM) process between water-affecting and water-dependent activities and ecosystems. The link between IWRM and ecological services lies in the management of catchment areas as assets that deliver both water and other ecological goods and services in a single bundle. For this reason, criteria have to be developed for the identification and protection of key functions essential to the production of goods and services from terrestrial and aquatic ecosystems. The key issue, then, is how to secure the capacity to absorb continuous change without losing the capacity of local ecosystems to sustainably and predictably supply ecological goods and services. Thus, the overriding task of the IWRM catchment-based approach is to secure and protect a local ecosystem, the goods and

services it supplies to the human population, and its ability to adapt to changes as they occur.

The amount of freshwater provided by different land based ecosystems varies considerably with the relation between precipitation and evaporative demand. The Millennium Ecosystem Assessment notes that forests and mountain ecosystems generate the largest amounts of water, 54 and 27%, respectively (Millennium Ecosystem Assessment 2003b: sections 8.1 & 8.3) and supply renewable water to some 2 billion people, or one-third of the world population. The proportion of the runoff generated that eventually flows downstream, and to human populations, amounts to 72-100% of total runoff, indicating an astounding efficiency in the geography of human habitation (Millennium Ecosystem Assessment 2003b: sections 8.1 & 8.3).

The IWRM approach must be taught in natural resource management programs in universities and technical schools and introduced through training, human and institutional capacity building among current environmental professionals and policy makers in order for this watershed-scale approach to be integrated into national development plans. The approach is predicated on the principles of adaptive management.

> *Action 28. Use the IWRM approach in all environmental management and planning and infrastructure development by 2006. Include the approach as part of the core curriculum of educational and professional training programs on natural resource management.*

4 RESOURCES FOR IMPLEMENTATION

The Plan of Action needs resources, both human and financial, to move forward with implementation.

4.1 Financing the Actions

The World Commission on Environment and Development, or Brundlant Commission, concluded that sustainable development requires, among other factors, rapid economic growth. The Commission also noted, however, that economic growth alone is not sufficient. In recent years there have been many critics and a growing number of citizens openly opposed to economic growth at the cost of social equity and environmental sustainability. As a result, many scholars and development specialists have joined to outline and design new development options that ensure equitable opportunities for all while, at the same time, minimizing the consumption of energy and mining of natural resources. Is such economic growth environmentally sound and socially equitable?

For environmentally sustainable development to have any chance at all in the future, a radical change is required in consciousness, attitudes and spending patterns by a minority of people (the wealthy) for the benefit of the majority of the world's population (the poor and undernourished). Recognition of the importance of social equity as well as of the

maintenance of ecosystem services and the conservation of biological and cultural diversity are therefore critical to the planet's survival. Consequently, financing sustainable development requires investments based on similar paradigms. This is not a small challenge.

There is an urgent need to innovate in the way governments allocate money for economic development and environmental management. Before any changes happen, first government leaders must recognize the fundamental links between the environment and human well-being. In most developing countries, government spending for environmental management and protection has dramatically declined while economic growth rates are increasingly dependent upon extraction of non-renewable resources and unsustainable exploitation of renewable resources. Prospects for reversing this trend are slim as prices for the commodities derived from non-sustainable resource exploitation remain relatively low and a globalized economy increases competition to the detriment of resource-dependent countries.

All things considered, we propose six ways to address environmental and social issues and allocate money in ways that could help slow or reverse present trends in deficient financing for environmentally sustainable development. These are preliminary recommendations and will require country-specific analysis for inclusion in the final report.

1. Re-think the environmental national accounts. Fifteen years ago, much was done by UN agencies and governments to start national accounting systems that take into consideration the value and depreciation of the natural resources of the countries. Ideas like the "satellite accounts" were developed in some countries. However, none of the developing countries have made environmental accounting a working reality. Our recommendation is to move forward from the theoretical advances made so far, into the realm of true green accounting practices and their importance in resource allocation, resource conservation and environmentally sound growth and development.

2. Exploitation pays for protection. Make the exploitation of non-renewable resources pay for environmental protection and management by aggressively promoting trans-sector allocation of resources. This is not a new idea, and proven approaches exist that could be mainstreamed. There are many cases worldwide where revenues from the petroleum industry and generation of energy and water usage are directly allocated to environmental management. In Brazil, for example, a portion of an ecological value added tax on goods, services, energy and communications goes to municipalities based on various indicators of environmental performance (May et al. 2002). In the States of Parana and Minas Gerais an increase in the size and number of protected areas is attributed to the success of this tax. In Colombia, energy generation produces kilowatts of electricity as well as financial resources to manage the environment at the regional and local levels. In Ecuador, a percentage of all electricity revenues are directly allocated to watershed management. These reallocations are not necessarily designed to reduce the resource-exploiting activity, rather to simply target funding allocation to help pay for protection of environmental resources elsewhere. The advantage of implementing such an

approach is that no matter which administration is in power at any given time, resources for the environment flow constantly and reliably where the effects are most needed and required: at the community and local levels. In addition, this approach provides opportunities for companies - the private sector - that are exploiting natural resources under concessionary terms to contribute positively and directly to sustainable development and environmental management: a role that needs to be greatly strengthened.

3. Solicit additional budgetary resources and earmark the environment. Many would say that among the world's wealthy countries the environment suffers from budgetary neglect. In the poorest countries the environment often receives nary a glance from the finance ministry. Additional finance will be required to carry out economic and other development activities to raise the living standards of the poor. However, while funds should be allocated equitably across sectors, enough funds must be directed toward the defense of the environment and ecosystems upon which all life, the well-being of the human population, and the survival of humankind itself depend. We advocate promoting public awareness and political decision-making towards defining national security interests as those involving the environment, the urban and rural habitat of people, and the opportunity of future generations to enjoy a healthy and productive place on the planet. Thus, policy priorities and resource allocations shall be defined accordingly.

In this context, local governments and regional entities should play an ever-increasingly active role in decision-making. Environmental management will improve only when people at the community and local level have a greater say in defining priorities and resource allocations.

4. Build upon existing funding mechanisms. International organizations, development banks, and the UN agencies should build upon existing mechanisms for environmental financing such as the GEF, and strengthen North-South transfers, especially for those resource-poor countries unable to generate income from natural resource exploitation. In this respect, increased funds and greater awareness that such investments pay off for humanity as a whole are urgently needed.

5. Mobilize infrastructure development funds. As it is already regulated in some countries, a percentage of infrastructure development costs should be allocated to environmental protection and management and managed as local or regional environmental funds. NGO, private and public partnerships have proven effective in many cases where funds are collected from developers, and then allocated at the local level, and managed by NGOs or local communities. In order to increase efficiency and effectiveness of these efforts, however, greater coordination and cooperation among the different actors is required. NGOs, especially, need to focus on priority issues, join strengths, capitalize on complementarities, and develop effective partnerships with both the public and private sectors.

6. Green investment. Many more ventures should take advantage of opportunities in green investments. Such an approach would increase institutional sustainability and

directly link social and economic development with environmental protection and management. There are many examples of successful green markets. Ecotourism and other "green" service industries are enjoying economic success in many places and the development effect is growing worldwide (Shanley et al. 2002). The Clean Development Mechanism (CDM) of the Kyoto Protocol that establishes mechanisms for trade-offs between environmental benefits and capital costs are being implemented and showing some promise for success (Smith and Scherr 2002). The CDM also may be a powerful tool for financing transfer of technology through transferring private capital to technologies that are geared toward environmental sustainability.

7. Gain the full value of national resources. Countries that are rich in natural resources need to devise ways to attain the maximum value of those resources by engaging in value-added activities, controlling foreign access to those resources, and managing them with 10,000-year time horizon.

4.2 Engaging Responsible Actors

As evidenced by the uncountable number of multilateral environmental agreements, conservation initiatives, development projects and the like there have been many good ideas, technological innovations, and outreach processes circulating in the world. But success in any of these is in the ability to engage the responsible actors in creating change. More accountability needs to be put into place. In this section, we briefly discuss who these actors are that we identified in chapter three and generally what their responsibilities may be in implementing the recommended actions. In the coming year while we refine the action plan, identifying the mechanisms and costs for implementing it, we will undoubtedly redefine the responsibilities of these actors and perhaps change the makeup.

International bodies

International bodies such as convention secretariats, international agencies, and lending and donor agencies can play an important role in effecting change at all levels of society. Agencies are effective in establishing and maintaining partnerships and alliances between and among a variety of sources, including companies and foundations, as well as bilateral and multilateral donors, in furtherance of the Millennium Development Goals. They are also effective in providing guidance to the local and national actors who will implement change on the ground. Many of these agencies, while they may have their own agendas, are sometimes less partisan than government agencies and therefore can provide more sound guidance and information to government agencies, local communities and civic groups.

International convention bodies have defined a host of principles and standards relevant to environmental sustainability that are adopted by many national governments. These bodies can play a stronger role in promoting the implementation and enforcement of these principles and standards. Some examples of these are the Guidelines for Sustainable

Forest Management of the ITTO, the 'Forest Principles' of the IFF, and the Cartagena Protocol on Biosafety.

Governments – National and Local

One of the primary instruments for allocating funding to development activities in the coming years will be through the Poverty Reduction Strategy Papers (PRSPs) and consequent PRS Policies. The development of the PRSP is carried out by national governments, presumably in collaboration with local authorities. Thus far, in the country PRSPs issues related to the environment are scantily covered and barely detected in the proposed national budget (Bojö and Reddy 2003b). The reasons for this are many, but two are the most glaring. The first is that it is the Ministry of Finance that is primarily involved in the development of the PRSP and budget, and there is little communication between it and the Ministry of Environment and those related to social services. Furthermore, the Finance minister is likely to be thinking primarily about boosting the economy in the quickest way possible and may not recognize the fundamental importance of the maintenance of ecosystem services and biodiversity to sustainable development. The second reason for the lack of attention to the environment in the PRSPs is that the data or evidence on the state of the environment may not be available to those developing the report.

Thus, the responsibility of national governments is to obtain data or evidence on the state of the environment, make the conceptual link between long-term human well-being and the principles of environmental sustainability, and both propose actions to address the issues of environmental degradation and consider the principles of environmental sustainability when proposing development actions in other sectors. Government agencies also play an important role in outreach and education of civil society and should promote the principles of environmental sustainability through relevant programs.

Government agencies should also be charged with addressing the many levels of corruption that prevent funds earmarked for the environment from reaching the right people and institutions and allows environmentally-unsound business practices to go unchecked.

Most countries expecting to benefit from the recommendations of the Millennium Project are at different stages of implementing decentralization policies for good governance. Therefore, local governments are expected to become fully responsible for the development of their communities. The ultimate stage for this decentralization process is for local governments to prepare and implement development programs for territories under their responsibility. The role of the national government is supposed to be limited to that of oversight of local development and handle issues of national interest that go beyond a given community. Most donors are highly interested in supporting good governance, democratization and decentralization.

Civil society, including Indigenous and other local communities

The people most adversely affected by environmental degradation and resource depletion are those who live off the land: the rural poor. Global and regional environmental issues such as air and water pollution affect a great number of people and ecosystems without discrimination, but it is the poor who have the least amount of resources to deal with the deleterious effects or prevent exposure to pollutants. And among the poor, it is the women and children who are often the worst off for their lack of access to land, resources, and decision-making power stemming from social and political inequality. While proper industrial practices and government action should address many of the issues of environmental degradation, many of the actions and changes required to address the challenges of sustainable resource management at the local level must be carried out at the community and household levels. Local communities should be the starting and ending point of all actions because they have little to no options of leaving and/or changing occupation even if the local environment is degraded to a point of no longer sustaining their livelihood. Many international meetings or societies on the intersection of science and environmental policy have recently fully recognized or reaffirmed the role that local communities play in controlling access to natural resources. There are also many cases where local control is the only way to protect the environment and the natural resources necessary for the local subsistence or commercial economies.

Civic groups such as community-based associations, religious groups, local and international NGOs, and others play a very important role in making change on the ground. Much as civic groups can also place great pressure on business for fair labor practices, they can also pressure industry and government to be accountable for their practices in ways that are not harmful to the environment and local resources. There are many cases of successful community action leading to changes in both local practices and those originating from outside. Success in actions by civic groups and community groups requires strong leadership, consensus, and transparency. It usually requires some amount of financial backing for leaders to attend meetings and other activities.

Business / Private sector, including the media

The private sector has a greater role to play in the environment now more than ever. With globalization of the world's economy, the practices of corporations have far-reaching effects, and with deregulation in many sectors business is left to their own devices to meet environmental standards. Thus, it is of utmost importance to mainstream the principles of environmental sustainability into industrial and business practices worldwide.

Although local communities and governments are very important stakeholders and actors, the private sector is most important in that this is where much of the economic power lies. In addition, the nature of business activities – manufacture, resource extraction, energy production, etc – can be the most damaging to the environment. First and foremost, the entrepreneurial model of chasing the monetary profit bottom line needs to change. Business enterprises must realize that, in most cases, their own survival depends on a healthy environment and a healthy workforce. And also that doing "good" for the environment may, in fact, be profitable.

The environmental principles of the UN Global Compact provide an entry point for business to address the key environmental challenges[13]. The three principles of the UN Global Compact related to the environment are the following: business should support a precautionary approach to environmental challenges, undertake initiatives to promote greater environmental responsibility, and encourage the development and diffusion of environmentally friendly technologies. These principles direct activity to areas such as research, innovation, co-operation, education, and self-regulation that positively address problems of environmental degradation brought about by human activity.

Public accountability, transparency and the enlightened self-interest of companies, labor and civil society are key characteristics for success in this area. The key element of a precautionary approach, from a business perspective, is the idea of prevention rather than cure. Tools that businesses can use include:

- environmental risk assessment - establishes the potential for unintended environmental damage alongside other risks
- life cycle assessment (LCA) - explores the opportunities for more environmentally benign inputs and outputs in product and process development
- environmental impact assessment - ensures that impacts of development projects are within acceptable levels
- strategic environmental assessment - ensures that impacts of policies and plans are taken into account and mitigated
- process and product certification (e.g., ISO standards, forest products certification)

Responsible approaches to addressing environmental issues include replacing traditional practices with more enlightened practices as outlined below:

inefficient resource use	→	resource productivity
end-of-pipe technology	→	cleaner production
public relations	→	corporate governance
reactive	→	proactive
management systems	→	life-cycles, business design
one way, passive communication	→	multi-stakeholder, active dialogue
extractive approach	→	sustainable use approach

Market competition can spur innovations in technology, education, and other fields, and, if advances are based in the principles of environmental sustainability, then we could see advances in the ways we address environmental problems. In an atmosphere of healthy competition industry should develop and use environmentally sound technologies (ESTs), education facilities can teach children and adults alike about the role of the environment in their lives, and science can be driven by the need to provide evidence of the links between ecosystem function and human well-being.

[13] Information on the UN Global Compact, launched in July 2000, can be accessed through the UN website.

Print and broadcast media has an enormous role to play in shaping public knowledge about and attitude towards the environment in both wealthy and developing nations. The messages people should be receiving would encourage the use of environmentally-sound technologies and practices, and pro-environment information. Local radio broadcast stations transmitted over short-wave or battery-operated radios is sometimes the only source of outside information for rural communities. How these broadcasts are shaped can have major implications for effective interactions between humans and their environment.

Academia

The role of academic institutions has traditionally been to provide education to the public and training to future engineers, educators, policy-makers, and researchers. These institutions can be a source of innovative thinking in all those fields. Unfortunately, much of the training, information, innovations generated in academies do not reach the ground. One of the challenges in the coming decade will be to make academic scientists more connected with the problems facing society, getting them to contribute directly to creating and implementing the solutions to environmental problems.

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6 Appendices

6.1 The Mission of Millennium Project Task Force 6

The Mission of Task Force 6 is to specifically address MDG 7 targets and to :

(1) Define principles and practices of sustainable development including

- Sustainable management of renewable resources;
- Manage non-renewable resources in a way that does not damage ecosystems, and develop substitutes for these resources;
- Sustain and restore the provision of ecosystem services that regulate and sustain human livelihood, health and security, and ensure proper recognition of their importance for human well-being through the valuation of these services;
- Maintain integrity of ecosystems to ensure adaptability to changing conditions;
- Remove threat of contamination (e.g. air pollution, waste water, land-based activities) of the environment and its negative impacts on human health and ecosystems; and
- Protect ecosystems through integrated management of land, water and living resources.

(2) Identify how these principles can be integrated into policies and practices of the public and private sectors, such as

- Create enabling conditions, including provision of financial and technical resources, for full implementation of Multilateral Environmental Agreements;
- Build responsibility for environmental sustainability into economic sectors;
- Build the precautionary approach into management;
- Develop environmental standards for practices and technologies, and oblige reporting and assessment on performance and achievements toward those standards;
- Integrate environmental considerations into the process of achieving MDG Goals 1-6;
- Promote education and capacity building related to environmental sustainability;
- Develop integrated water resources management and water efficiency plans by 2005; and
- Improve scientific understanding and assessment of marine and coastal ecosystems.

The objective of the Task Force is to put forward operational recommendations to:

1) Ensure that development planning at all levels incorporates, by 2015, the principles of the sustainable management of ecosystems, their constituent species, and the ecosystem services they provide, specifically in the sectors of water management, agriculture, forestry, fisheries, energy, transportation, health, and industrial production;

2) Minimize the loss of biodiversity and threats to the provision of ecosystem services by 2010; and
3) Integrate environmental considerations, securing organized ways of tradeoffs, into the process of achieving Millennium Development Goals 1 through 6.

6.2 Glossary

Biodiversity, a shortened term for biological diversity, is defined in the Convention on Biological Diversity (CBD) as the variability among living organisms from all sources including, *inter alia*, terrestrial, marine and other aquatic ecosystems and the ecological complexes of which they are part; this includes diversity within species, between species, and of ecosystems. This variability is continuously distributed from large regional biomes to the individuals in local populations. Conventionally, biodiversity is measured at three levels: ecosystem, species, and gene. At each of these levels, we have witnessed considerable decline in variability.[14]

Community refers to a group of individuals or institutions sharing a common location, belief, history, interests or characteristics. The term is by no means limited to describing local or indigenous groups of people.

Ecosystem means a dynamic complex of plant, animal and micro-organism communities and their non-living environment interacting as a functional unit (CBD).

Ecosystem goods and services[15] as defined by the Millennium Ecosystem Assessment are the benefits people obtain from ecosystems. These include provisioning services such as food, clean water, shelter and biomass for energy generation; regulating services such as flood and disease control; cultural services such as spiritual, recreational and cultural benefits; and supporting services such as nutrient cycling and climate stability that maintain the conditions for life on earth.

Environmental sustainability refers to the ability of ecosystems to maintain themselves indefinitely and to provide their constituent species, including humans, with critical ecosystem goods and services. To use and manage ecosystems sustainably, humans must act in ways that do not impair the self-perpetuating maintenance and service functions of these systems.

[14] There is some debate about ecosystem diversity. Arguably, by creating human-modified ecosystems diversity at that level may have actually increased.

[15] Throughout this document ecosystem goods will be subsumed under the term "ecosystem services".

6.3 Task Force 6 Members

Yolanda Kakabadse Navarro,
co-Coordinator
Don Melnick, co-Coordinator
Patricia Balvanera Levy
Alicia Barcena
David Brackett
John Buccini
Damayanti Buchori
Malin Falkenmark
Jose Goldemberg
Geoffrey Heal
Claudia Martínez
Jeff McNeely
Charles McNeill
Rodrigo Medellín
Patrick Milimo
Paulo Moutinho
Shahid Naeem
Abdoulaye Ndiaye
Jonathan Patz
Mary Pearl
Ellen Pikitch
Ravi Prabhu
Walter Reid
Peter Schei
Chikako Takase
Robert Watson
Douglas Williamson
Kaveh Zahedi

Please address comments to:

Robin Sears, TF6 Manager
email rrs26@columbia.edu
tel +1.212.854.8253
fax +1.212.854.8188

post mail
Columbia University – CERC
1200 Amsterdam Av, MC 5557
New York, NY 10027 USA

6.4 Commissioned Issue Papers

Measuring Biodiversity – The State of the Planet in 2003
David Brackett, Rodrigo A. Medellín, Carolina Caceres and Sue Mainka

Ecosystem Services: The basis for global survival and development
Patricia Balvanera and Ravi Prabhu

Economic Policy Interventions for Sustainable Development and Nature Protection
Robert Repetto

Human and Institutional Capacity Building Through Education and Training
Mary Pearl,[a] Damayanti Buchori[b], and Suzana Padua[c]

Policy Interventions for Environmental Sustainability
Jeffrey A. McNeely and Patrick Milimo

Environmental Impact of Energy Extraction and Consumption
Robert Watson and José Goldemberg

Impact of Chemicals Production and Use on Health and the Environment
John Buccini and Cristina Cortinas de Nava