Environmental Governance

Human beings, human societies, and the human economy are entirely integrated into the Earth system and into the Earth systems' economy—the geosphere, the biosphere, the atmosphere, and the ecosystems that knit it all together. Governance of that integration is one of the most important challenges of the 21st century

Allotment gardens offer urban dwellers the opportunity to grow their own food. This small allotment in Bavaria lies on the northern bank of the Danube River near the town of Donaustauf. *Source: Klaus Leidorf*

INTRODUCTION

Earth's ecosystems are under threat. Twenty per cent of the earth's land has been significantly degraded by human activity and 60 per cent of the planet's assessed ecosystems are now damaged or threatened. The irrefutable pattern is one of natural resource overexploitation while creating more waste than ecosystems can process (See Ecosystem Management, Chapter One).

The chemicals we use to produce energy, to control pests, to enhance productivity, to catalyze industrial processes, and to meet human health needs—as well as the chemicals we just discard—continue to weaken ecosystems and to imperil human health (See Harmful Substances and Hazardous Waste, Chapter Two).

The changing climate is pushing many Earth systems towards critical thresholds that will alter regional and global environmental balances and already threaten stability at multiple scales. Alarmingly, we may have already passed tipping points that are irreversible within the time span of our current civilization (See Climate Change, Chapter Three).

In recent decades, the growing threat of climate change is demonstrated by a significant increase in the number and severity of storms, floods, and droughts while the average number of seismic disasters, as devastating as they are, remained steady. New and ongoing conflicts can be both the result and cause of environmental degradation. (See Disasters and Conflicts, Chapter Four).

Industrial and environmental mismanagement is not a necessary component of development. Tools to minimize overexploitation and pollution are available. Using principles of industrial ecology, such as life cycle analysis and industrial symbiosis, can serve the public good and cultivate healthy communities (See Resource Efficiency, Chapter Five).

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and the ecosystems that knit it all together. Governance of that integration is one of the most important challenges of the 21st century.

Environmental degradation and industrial development were coupled during the industrial revolution and into modern times, but that relationship is not necessary and it cannot continue. Firm, informed, and enlightened environmental governance is necessary. The economic system that encouraged overexploitation of natural resources and production of waste is undergoing a complete redesign. This is the moment to ensure the next economic system does not repeat the mistakes of over exploitation and pollution.

ACHIEVING THE MILLENNIUM DEVELOPMENT GOALS

The Global Monitoring Report 2008 on progress towards achieving the United Nations Millennium Development Goals 2008 marks the midpoint toward the 2015 deadline for achieving the Millennium Development Goals (MDGs). The report finds that urgent action is needed to combat climate change that threatens the well-being of all countries, but particularly of poor countries and poor people. It also emphasizes that the goals of development and environmental sustainability are closely related and the paths to those goals have important synergies (World Bank 2008).

In the current global economic downturn, questions have arisen about priorities: Will environment and development objectives be lost in the new economic paradigm? But at a United Nations High-level Event held in September, member states re-committed to the MDGs (UN 2008a). In late December, United Nations member states attending a Conference on Financing for Development to Review the Implementation of the Monterrey Consensus agreed that development aid would not be cut in the face of the current recession. At that conference, the European Union vowed that all its members will provide by 2015 the 0.7% of gross domestic income for official development assistance that OECD countries had first committed to in 1970. Since then, only Denmark, Luxembourg, Netherlands, Norway, and Sweden have all met, and actually exceeded, their 0.7% commitment (UN 2008b, OECD 2008). Despite this renewed commitment on the part of some OECD countries, the Millennium Goals may still be severely challenged by imminent environmental constraints—putting even more importance on responsible environmental governance.

Pressures expected to increase

With business-as-usual policies, the proportion of people who suffer from hunger or whose income is less than US$1 a day will not be halved between 1990 and 2015 as expected in the targets set of the MDGs. The rate at which biodiversity is globally being lost will not be reduced by 2010. The impacts of climate change will not remain within agreed limits. The targets for water supply and especially sanitation will be nearly impossible to reach (UNDP 2008, UNFCCC 1992, World Bank 2008).

The environmental limitations ahead are exacerbated by additional pressures: The continuing growth of the world's population, their increasing material aspirations, and the natural resources that are being and will be exploited to satisfy those aspirations have major implications for ecosystem health, land use, and energy consumption.

Box 1: A parable?

In 2007 a story was told in a meeting on migration and the environment: In one country...

"... agriculture is extremely important because of rapid population growth. Women have an average of twelve to sixteen children each, creating a huge strain on the ecosystem in spite of government programs designed to mitigate environmental degradation.

In the past few decades, the trees that grew on agricultural land belonged to the state, so farmers had no motivation to protect trees. After much discussion, the government transferred ownership of the trees to the users and the number of trees multiplied. Now, trees are protected and the people harvest bark, fruits, and other products. The trees, in turn, retain water, moderate the climate, and shelter the agricultural land from erosion.

However, the average number of children per woman negates the productive capacity of the ecosystem. If you look at the environmental improvement in isolation, the area is a model. When you look at the social system, it is difficult to say that environmental improvements are enough. When the dynamic between the two is considered, the situation is revealed as quite critical."

Source: IOM 2008

The challenge is to meet these growing aspirations while ensuring environmental sustainablity (UN 2004, UN 2006a). Projecting population trends and devising methods to minimize the effects of rising population on resources cannot proceed outside of the environmental constraints or remain oblivious to the approaching thresholds that human activities have already provoked.

These aspirations could be met with less material input. The transition towards dematerialization of consumption could help decouple development from resource exploitation and associated environmental degradation (Ausubel and Waggoner 2008).

Advancements in understanding Earth systems

Process patterns that have emerged from system and chaos theories and that have been applied to ecosystems at various scales over the last two decades show the importance of understanding the dynamism of Earth systems.

Part of that understanding involves Earth system and ecosystem tendencies to cross critical thresholds, to shift regime, to oscillate, or to respond to changing conditions by changing phase—sometimes transitioning to phases that are irreversible within time scales relevant to humanity (Scheffer and others 2001).

For instance, Earth's ice is undergoing a classic phase change: ice is ablating—melting into water and sublimating into the atmosphere. Particles that became airborne during Roman Empire lead mining fell on glaciers and are re-entering the environment in melt water runoff today (Branan 2008). If we stopped all greenhouse gas emissions today, that ice might re-accumulate within 50 human generations, if at all. The effects that climate change is having on species distribution and adaptation may bring a similarly radical transition to ecosystems and to their services (**Figure 1**) (See Ecosystem Management, Chapter One).

Researchers of ecosystem change suggest that the likelihood of a regime shift is increased by lower resilience. The approach of a threshold may be anticipated by the observation of a critical slowing in the recovery rate from a small perturbation (Van Nes and Scheffer 2007). This critical slowing down has been demonstrated in a model of thermohaline

circulation approaching a critical threshold (Held and Klienen 2004).

Early in 2008 a review introduced the concept of 'tipping elements' into discussions of abrupt climate induced change. Tipping elements are large scale components of Earth systems that demonstrate a possibility of abrupt change, crossing a tipping point (Lenton and others 2008). Previously, much of the critical threshold work emerged from observations and experimentation at the ecosystem scale of a lake or a savanna or a riparian reach. Now those concepts are being applied at scales of one thousand kilometres and more, and are focused on conditions affected by climate change (**Box 2**).

The Earth system tipping elements examined were chosen in part on whether they could be influenced within a political time frame, a 100 year span assumed for decision makers' concern about their children and grandchildren; whether that influence was called for within an ethical time frame, a 1000 year span assumed for the life time of a civilization; and whether society cared enough, elicited from expert opinion.

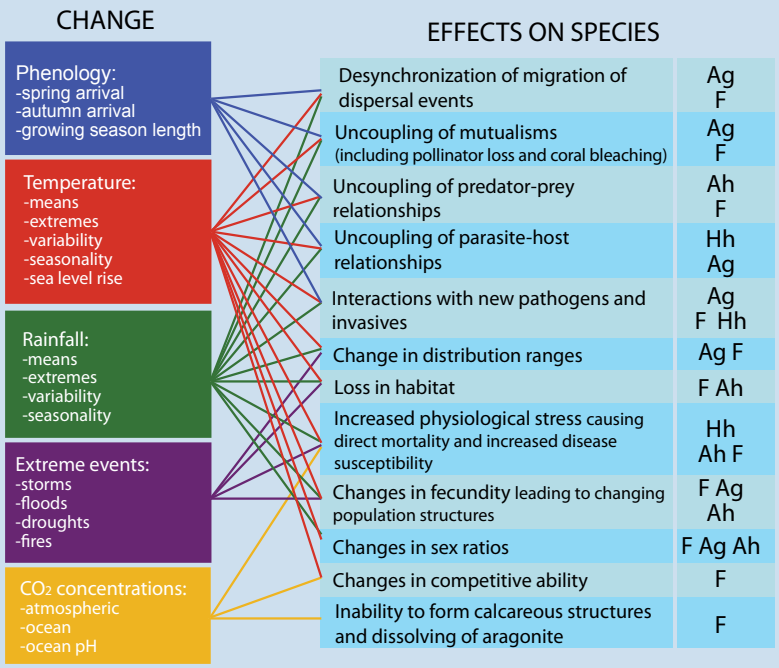
The tipping elements also involve some dependent sequences: For instance, melting Arctic sea ice and Greenland ice sheet loss deliver significant proportions of fresh water to the ocean's surface that affect thermohaline convection. As well, enhanced El Niño Southern Oscillation will affect the dieback of the Amazon rainforest (Lenton and others 2008).

One of the observed and accelerating climate change induced Earth systems that the tipping elements research does not consider is the loss of mountain glaciers. That loss in the Andes will also affect the availability of water and humidity to the Amazon rainforest and influence potential dieback. As well, loss of Himalayan-Hindu Kush ice, attributed to black carbon from the atmospheric brown cloud and to climate change, will likely contribute to Indian summer monsoon phase transition.

The work on weakened resilience was published in 2007 and that on tipping elements was published in January of 2008. Since their writing, a plethora of new scientific information has reinforced and even accentuated the urgent call for environmental governance to respond and to coordinate global and international prevention measures. (See Previous Chapters).

We are already obligated to the loss of mountain glaciers and all the repercussions this entails—loss of irrigation, hydropower, consistent potable water supply, agricultural capacity, and likely onset of conflict and migration. We are already witnessing diminished Arctic sea ice, increased tundra thawing, dissipation of the Greenland ice sheet, and breakups of the West Antarctica ice cover (See Climate Change, Chapter Three).

Figure 1: Interlinkages among climate changes, plant and animal response, and economic activity



Ag - Agriculture, F - Fisheries, Ah - Animal husbandry, Hh - Human health

The changing climate is affecting the timing and quantity of water availablity, the length of growing seasons, and the life cycles of pest and pathogens. These in turn put pressure on various species of plants and animals, with ultimate consequences for a variety of economic and development activities.

Source: Adapted from Foden and others 2008

Box 2: Tipping elements

Nine tipping elements considered as Earth systems subject to possible abrupt change. The time frames presented here will likely be modified as new data and information track characteristics and rates of change:

Indian summer monsoon—The regional atmospheric brown cloud is one of the many climate change-related factors that could disrupt the monsoon. Possible time-frame: One year.

Sahara and West African monsoon—Small changes to the monsoon have triggered abrupt wetting and drying of the Sahara in the past. Some models suggest an abrupt return to wet times. Possible time-frame: 10 years.

Arctic summer sea-ice—As sea-ice melts it exposes darker ocean, which absorbs more heat that ice does, causing further warming. Possible time-frame: 10 years.

Amazon rainforest—Losing critical mass of the rainforest is likely to reduce internal hydrological cycling, triggering further dieback. Possible time-frame: 50 years.

Boreal forests—Longer growing seasons and dry periods increase vulnerability to fires and pests. Possible time-frame: 50 years.

Atlantic Ocean thermohaline circulation— Regional ice melt will freshen North Atlantic water. This could shut down the ocean circulation system, including the Gulf Stream, which is driven by the sinking of dense saline water in this region. Possible time-frame: 100 years.

El Niño-Southern Oscillation (ENSO)—El Niño already switches on and off regularly. Climate change models suggest ENSO will enter a near-permanent switch-on. Possible time-frame: 100 years.

Greenland ice sheet—As ice melts, the height of surface ice decreases, so the surface is exposed to warmer temperatures at lower altitudes which accelerates melting that could lead to ice sheet break up. Possible time-frame: 300 years.

West Antarctic ice sheet—Ice sheet is frozen to submarine mountains, so high potential for sudden release and collapse as oceans warm. Possible time-frame: 300 years.

Source: Lenton and others 2008

Calendar of selected events for 2008

JANUARY

15 January Conservation International, Cozumel's Department of Tourism, and the Florida-Caribbean Cruise Association sign agreement to protect endangered biodiversity in the world's most visited cruise destination. The agreement focuses on awareness, traffic, waste, regulation, and law enforcement.

21 January The US National Oceanic and Atmospheric Administration (NOAA) and Environment Canada sign a cross-border agreement creating a meteorological service partnership. Goals include improving weather and climate monitoring and forecasting, and supporting research in climate change.

FEBRUARY

7 February Norway authorizes a take of 1,052 minke whales in the 2008 season. The Ministry of Fisheries and Coastal Affairs says the quota will not threaten the overall minke whale population.

S.MORGAN/ STILL PICTURES

20-22 February At the 10th special session of the UNEP Governing Council, governments discuss UNEP's Medium-Term Strategy for 2010-2013. Topics include six thematic priority areas as well as the GEO-4 report, chemical and waste management, sustainable development of the Arctic region, and the International Decade for Combating Climate Change.

26 March The First African Water Week opens in Tunis, hosted by the African Ministers' Council on Water and the African Development Bank. Participants agree to accelerate progress on water security and set out plans for the Africa Groundwater Commission.

JORGEN SCHYTTE/ STILL PICTURES

31 March 1 100 delegates from 163 countries meet in Thailand for the first formal talks on a climate agreement to replace the Kyoto Protocol. The new treaty should be in place by the end of 2009, allowing time for ratification before Kyoto's expiration in 2012.

APRIL

8 April The European Parliament's Legal Affairs Committee proposes that damaging the environment be considered a criminal offence. EU member states could apply criminal charges to behavior likely to damage air, soil, waters, plants, and animals.

17 April Australian federal and state environment ministers fail to reach a national agreement, six years in the making, on banning plastic bags. South Australia State will move ahead with a ban from January 2009. Some four billion plastic bags a year go into landfill in Australia.

12-16 May The fourth Meeting of the Parties to the Cartagena Protocol on Biosafety in Bonn agrees on a timetable and framework for negotiations. Legally binding rules and procedures will be established for liability and redress for potential damage from transboundary movements of living modified organisms.

14 May UN Secretary-General Ban Ki-moon addresses delegates at the 16th UN Commission on Sustainable Development. He urges them to offer new ideas and concrete action on land, agriculture, rural development, desertification, and Africa in the quest for sustainable development.

S.P. APIKU/ IRIN

14 May The US lists polar bears as threatened under its Endangered Species Act because their sea ice habitat is disappearing due to climate change. US government scientists predict that two-thirds of the global polar bear population of 25 000 could disappear by 2050.

B. LICHTENBERGER/ STILL PICTURES

7-12 June The twelfth session of the African Ministerial Conference on the Environment (AMCEN) and first extraordinary meeting of the parties to the Abidjan Convention are held in Johannesburg. AMCEN adopts "Africa's Climate Roadmap, from Johannesburg through Africa to Copenhagen".

24-28 June Scientists and policy makers meet in Uganda at the first international conference on groundwater and climate in Africa After discussing the role of groundwater in improving livelihoods in Africa, they adopt the Kampala Statement urging development of legal and institutional frameworks.

JULY

2-10 July At its 32 nd session, UNESCO's World Heritage Committee adds eight new natural sites to its World Heritage List. These include part of the New Caledonia lagoon.

L.G. ROGER / STILL PICTURES

AUGUST

26-29 August UNEP and the World Health Organization (WHO) organize the first African Inter-ministerial Conference on Health and Environment, in Gabon. Goals include building a strategic health and environment alliance, and establishing a network for addressing diseases.

27 September The US Senate approves legislation allowing a longstanding ban on offshore oil drilling to expire on 30 September. Most\ of the US coastline is opened to hydrocarbon exploration as a result.

B. EVANS & P. ARNOLD/ STILL PICTURES

29 September California Governor Arnold Schwarzenegger signs two green chemistry bills, providing a comprehensive program to regulate chemicals linked to cancer, hormone disruption, and other health effects. The new measures encompass 80 000 chemicals now in use.

30 September The inaugural World Ocean Council meeting is held in New York. Representatives from shipping, oil and gas, fisheries, cruise ship tourism, aquaculture, ports, and other ocean industries meet to improve dialogue between industrial sectors dependent on the sustainable use of the world's oceans.

OCTOBER

15 October At the 3rd Summit of the India-Brazil-South Africa Dialogue Forum, leaders stress the importance of access to genetic resources and sharing of benefits, urging a timely and successful conclusion to negotiations on a legally binding international regime.

B. DAEMMRICH/ STILL PICTURES

16-19 November Participants meet at the International Conference on Water Resources and Arid Environments, and the First Arab Water Forum, in Saudi Arabia. Discussions cover climate change and its impact on water resources and arid environments, advancement of Arab water policy, and management of water crises in the Arab world.

17-18 November The international conference Water Unites – Strengthening Regional Cooperation on Water Management in Central Asia is convened in Kazakhstan. The shrinking of the Aral Sea, and need for agreement between upstream and downstream countries on water release regimes and water distribution are discussed.

27 November The UK announces agreement on its Marine and Coastal Access Bill. The Bill will provide the first coherent national legislative framework for marine policy by establishing systems for delivering sustainable development of marine and coastal environments.

S. PARIS/ UN

21 February Costa Rica, Iceland, New Zealand, and Norway become the first countries to join the Climate Neutral Network (CN Net), a joint initiative of UNEP and the UN's Environment Management Group. The global information exchange network is focused on reducing emissions in all sectors of society.

MARCH

9 March Several Asia-Pacific countries announce phase-out of CFCs ahead of the 2010 deadline prescribed by the Montreal Protocol for Substances that Deplete the Ozone Layer. Indonesia reports that illegal import of these ODSs persists.

11 March Australia's ratification of the Kyoto Protocol enters into force, with a commitment to reduce greenhouse gas emissions by 60 per cent under 2000 levels by 2050. Comoros, the Central African Republic, Tonga, São Tomé and Principe, Saint Kitts and Nevis, and Serbia also enter the Protocol in 2008.

KLEIN, J.L. & HUBERT, M.L. / STILL PICTURES

20 March The Convention on International Trade in Endangered Species (CITES) suspends Nigeria for alleged breaches of its provisions. Nigeria is banned from importing or exporting any animal or plant species under the convention.

J. JABBOUR/ UNEP

19 April The European Commission backs away from its proposal for a compulsory 10% bio-fuel content in petrol and diesel. Scientists warn that the target, a key component of the EU's drive to cut GHG emissions 20% by 2020, could have unintended effects on food production.

MAY

13 May Brazil's environment minister, Marina Silva, hailed as a champion of the green movement but scorned by powerful farming groups, resigns after losing key battles in her efforts to protect the Amazon rain forest.

L. ANTOINE/ STILL PICTURES

12 May The Marshall Islands, one of the world's largest shipping nations, accede to five International Maritime Organization conventions, including the London Protocol. The number of ratifying States reaches 35, accounting for 29.73 per cent of the world fleet's tonnage.

15 May The EU and Ghana announce that they will formalize a Voluntary Partnership Agreement in June to curb illegal logging and promote certification of timber exports. Some US$10 billion in public assets is lost in developing countries due to illegal logging.

19-30 May Delegates at the ninth Conference of the Parties to the Convention on Biological Diversity in Bonn adopt a roadmap for negotiations on access and benefit-sharing, scientific criteria for marine protected areas, and caution against ocean fertilization.

JUNE

3-5 June High-Level Conference on world food security convenes in Rome. It warns that food prices will remain high for years and calls for urgent, coordinated action to combat the negative impacts on the most vulnerable countries and populations.

4 June The US calls for an international agreement for managing Arctic fisheries, and establishes a national policy halting the expansion of industrial fishing into the region, pending better management data.

SEGUNVANDIA /STILL PICTURES

27 August Ghana's Environmental Protection Agency bans the import of 25 agrochemicals deemed not suitable to local conditions or posing risks to human health, animals, crops, and the environment. Banned chemicals include toxaphene, aldrin, endrin, chlordane, captafol and DDT.

29 August China adopts law promoting a 'circular economy' coming into force on 1 Jan 2009, to promote energy conservation and reduce pollution. 2010 targets include energy consumption down by 20 per cent per unit of GDP, and major pollutants down by 10 per cent from 2005 levels.

SEPTEMBER

15-19 September The Spoonbill Action Plan is adopted at the fourth Meeting of the Parties to the African-Eurasian Migratory Waterbird Agreement, in Madagascar. Migratory waterbird populations have declined 41 per cent along main migration routes.

H. PIERRE / STILL PICTURES

24 September UN Secretary-General Ban Ki-moon and Norwegian Prime Minster Jens Stoltenberg announce new UN Reduced Emissions from Deforestation and Forest Degradation (UN-REDD) Programme. Tropical deforestation produces nearly 20 per cent of all human-induced carbon emissions.

27-31 October Parties at the 30th consultative Meeting of Contracting Parties to the Convention on Prevention of Marine Pollution by Dumping of Wastes and Other Matter, and the third meeting of its London Protocol, adopt a non-binding resolution to allow ocean fertilization only for legitimate scientific research purposes.

29 October The Ramsar Secretariat, the Danone Group, and IUCN form a partnership targeting climate change at the 10th Conference of Contracting Parties to the Ramsar Convention on Wetlands, in Korea. Danone commits to minimize its emissions and to offset those that remain through wetlands restoration.

J. SIMS/ STILL PICTURES

NOVEMBER

11-15 November Delegates to the first World Conference on Marine Biodiversity, in Spain, discuss progress towards completion of the first-ever census of marine life in 2010. The census will list up to 250 000 named species with maps, DNA barcodes, and biomass estimates.

12 November President elect, Barack Obama announces that energy is going to be one of his top priorities. Once in office, he plans to phase out coal-based electricity generation, switch to renewable energy, and follow Europe's lead on climate change.

29 November Delegates at the International Conference on Financing for Development, in Qatar, stress the need to maintain aid commitments in face of economic downturn. They express concern at the linked challenges of food security, energy and commodity prices, climate change, global financial crisis, and multilateral trade negotiations.

DECEMBER

1-12 December The UNFCCC COP-14 Climate Change Conference in Poland sets the agenda for international efforts to tackle climate change, leading up to COP-15 in Copenhagen, Denmark, in 2009. There, negotiations for a post-2012 climate agreement are set to conclude.

5 December Brazil's new Environment Minister, Carlos Minc, announces plan to combat climate change by reducing deforestation 70 per cent over the coming decade. Goals include reducing the annual rate of deforestation from 7 300 to 1 900 square miles by 2017, preventing some 4.8 billion tonnes of CO_2 emissions.

8 December Protestors from the Maldives tell delegates at the UNFCCC COP-14 that their island country will be destroyed by sea level rise and storms unless global warming is curbed.

C. GLUCK/ OXFAM

Doing the sums

While each of these chapters addressed themes that allow separate entry points for understanding global environmental changes and critical thresholds, relationships among the individual themes continually emerge. Climate change affects disasters and conflicts; ecosystem mismanagement delivers toxic chemicals that harm human and other creatures. Disasters can precipitate regime shifts in ecosystems. Accumulation of harmful substances can create ocean dead zones that wipe out marine ecosystems. Agricultural wastes and climate change destroy coral reefs. Ultimately, lack of resource efficiency is a root cause of all the problems represented in the chapters.

These relationships create difficulties when the individual themes are considered alone. The themes can only be understood as components of the larger Earth systems that support all human activities The cumulative effects originate from the same phenomenon as the recent pulse of globalization: We are no longer isolated and living beyond the influence of others. Today, in our interconnected world, massive social or environmental disruption in one region affects the entire system (Costanza and others 2007). Awareness of such interconnection and even interdependency leads to the requirement for wise environmental governance that considers needs over mutiple scales and many generations: Human beings, human societies, and the human economy are entirely integrated into the Earth's systems and into the Earth systems' economy—the geosphere, the biosphere, the atmosphere, and the ecosystems that knit it all together (Ehrlich and Erhlich 2008).

RE-TOOLING

Recent global environmental assessments have emphasized that new, innovative forms of policy and institutional arrangements have to be developed to deal with persistent environmental problems. Sufficient financial and human capacity is required within countries to implement policy and to monitor and enforce compliance. There needs to be sufficient attention to local situations and local people, for example by strengthening local rights and securing access to and maintaining natural resources to reduce vulnerability of people (WRI 2008). At the international level the improved conditions for this could be created by rationalizing the large number of environmental treaties, by strengthening international organisations, and by developing more coherent international mechanisms (UN 2006b).

Many solutions to these challenges are already known and the measures that could be taken are theoretically affordable. The persistent character of these problems requires consistent long-term policies. This will provide markets with more certainty, so that the private sector can prepare

Table 1: Cumulative effects (constantly under revision with new science and other enquiries)

Themes	Ecosystem management	Climate change	Disasters and conflicts	Harmful substances and hazardous wastes	Resource efficiency
Ecosystem management	Feedback: Deforestation leads to loss of critical mass that initiates further dieback, i.e. Amazon	Agricultural resource inefficiencies from erosion of soils and scarce water resources lead to ecosystem damages	Disasters can precipitate regime shifts in ecosystems; warring parties conduct scorched Earth policies destroying crops and fouling water leads to disaster and famine, etc	Accumulation of harmful substances can create ocean dead zones that wipe out marine ecosystems. Agricultural wastes and climate change destroy coral reefs	Mismanagement of fertilizers leads to over-nitrification and ocean dead zones
Climate change	Ocean acidification leads to coral reef collapse and loss of ecosystem that nurtures fisheries	Feedback: Melting of ice exposes darker surfaces that absorb more solar radiation which further warms local conditions	Slow onset disasters lead to conflicts over scarce resources; increased exposures to pests and pathogens in new locations	Release of hazardous substances into environment as ice melts; scouring of sequestered wastes during flash floods; Flooding of containment receptacles for hazardous, toxic, medical wastes	Need for airconditioning drives power plants to brown-outs and black-outs
Disasters and conflicts	Soil degradation and ecosystem loss propmpts migration and possible conflict	More frequent and intense cyclones hitting populated coasts; More competition for locations beyond sea level rise threat, leading to migrations and conflicts	Feedback: Damage from one disaster increases vulnerability to another	Sudden and massive spills from waste containment sites enter water, soils, and atmosphere requiring immediate and expensive clean-up response	Migrating populations forage ecosystems, leaving swathes visible from observing satellites
Harmful substances and hazardous waste	Release of nanoparticles could threaten ecosystem health, radioactive leaks could affect mutation rates	Flooding of containment fields for hazardous, toxic, and medically dangerous substances	Informal and dangerous mining methods fuel conflicts, wealth discourages legal governance	Feedback: Industrial pollution lowers resistence to other diseases and increases occurances of birth defects and cancers	Resource inefficiencies pollute water, soils, and atmosphere
Resource efficiency	Food production, processing, handling, and distribution leading to contamination and disruptions in the food supply chain	Altered climate patterns lead to desertification and loss of water and soil resources	Civil unrest and political mismanagement lead to malnutrition, cholera outbreaks, breakdown of infrastructire for water and sanitation	Adding coal ash to concrete cuts amount of GHG producing cement and also sequesters hazardous waste	Feedback: Overexploitation and pollution destroy or foul landscapes and settlements so enterprises and settlements move on when resources are ruined

to make the required investments (OECD 2007). Moreover, such long-term policies need to include concrete ambitious goals and measurable indicators of progress. This also includes those areas of policy in which there are no goals yet, such as energy supply, or areas in which only short-term goals have been set as in the case of biodiversity.

Upscaling lessons for multiple benefits

There are new initiatives underway that integrate across sectoral and issue-oriented international agreement concerns attempting to suggest solutions at multiple scales and with diverse positive outcomes. Two of these initiatives, the global marine assessment process and the avoided deforestation scheme, hope to demonstrate lessons learned from smaller scale assessments and projects and to result in benefits at global and local levels.

Seas and oceans provide two thirds of the value of all the natural services provided by the planet, including climate controls and water cycling. Despite the obvious economic benefits, the world's oceans are being degraded and continue to be threatened by factors that include climate change, pollution, physical alteration, and increased pressures on ecosystems from over fishing and from population growth.

The oceans cover seventy per cent of the planet but we do not understand what is happening to them as a whole. In response to commitments undertaken at the 2002 World Summit on Sustainable Development, the Intergovernmental Oceanographic Commission of the UN Educational, Scientific, and Cultural Organization and the UN Environmental Programme are establishing a process to ensure that global marine systems are monitored and assessed on a regular basis.

The reporting process under consideration will define baselines, trends, and outlooks for marine environmental change and set a schedule for regular assessments of the state of the world's ocean system as whole, particularly the interactions between the marine system and society at multiple scales. The process will build on existing regional and global assessments and will provide a framework for integrating sectoral and thematic assessments, especially those carried out at regional and sub-regional levels and that include the influence of rivers on the coastal and marine environment.

The process will organize, analyze, and communicate information so that policymakers and other stakeholders can make informed choices to reduce human impacts on the oceans and preserve future options. It intends to improve ocean monitoring and observing practices and incorporate the use of indicators, including identification of particularly worrisome conditions. Finally it will provide advice, networking, support, and capacity building to strengthen ongoing thematic, regional, and national assessments (UNEP 2008).

Tropical forests are among the most threatened ecosystems on the planet. They provide essential

Table 2: Drivers, themes, and interlinkages (constantly under revision with new science and monitoring and evaluation of projects and programmes)

Driver \ Themes	Ecosystem management	Harmful substances and hazardous waste	Climate change	Disasters and conflicts	Resource efficiency	Environmental governance
Population growth	Available cropland per person decrease; population pressures on coastal zones and conservation areas	Toxic substance exposure negatively impact childhood development and pregnant women in particular as well as indigenous people	Displacement of more people due to sea level rise, desertification, intensification and increased frequency of storms	Vulnerable populations in vulnerable area; land reforms; earthquake destroying infrastructures; slow onset disasters	Rapid expansion of the construction sector in developing countries; energy consumption in food production; water stress	Land tenure; equity; improved water access
Increasing resource demand	Factory farming; eco-agriculture;semi-natural landscapes; fisheries collapse; tropical forest loss; destruction of mangrove forests and coral reefs	Nitrification of water; pesticides; e-waste; arsenic in groundwater; mercury contamination; nanotechnology fate;	Biofuel production, forest carbon sequestration, put pressure on availability of food and timber; acidification affects fisheries; no late season water downstream of no glaciers	Destruction from civil unrest; resource wars; mangrove forest loss; changing seasons; extreme weather; landslides; complex emergencies	Consumption growth; biofuel production; China's Circular Economy; dematerialization of industrial output; industrial symbiosis	Rights based catch shares; integrated management systems; Decoupling productivity from environmental degradation; off set payments, REDD; GHG targets; facilitate technology transfer
Economic growth	Rural poor low productivity agricultural practices; valuation of ecosystem goods and services; Amazon rainforest under stress; soaring energy prices; rising food prices	Trade in synthetic fertilizers, pesticides, toxics; export of e-waste; demands for commodities leads to pollution;	Economic loss from disruption of agriculture, shipping, fuel supplies; damages from increased storms affect insurance industry and infrastructure stability	Deforestation induced by poverty and social instability; loss in tourist income; storm taking out crops for loss of food and economic return; technological disasters	Strong growth in extraction of mineral and biological resources in newly industrialized countries; public transportation in urban areas	Financial market downturn; growing biofuel trade; economics of enough
Sustainable development agenda (MDGs)	Deforestation causes loss of forest equivalent in size to Panama or Sierra Leone every year	Economic burden of poor environmental health can be as high as 1.5-4% of GDP annually	Developing countries are most vulnerable to climate change and least able to adapt	Scale up aid and increase its effectiveness; achieve better results in human development	Depletion of natural resources is often associated with declining national wealth	Uneven progress in institutional and policy performance due to gap between policy formulation and capacity to enforce; environment-trade contradictions

Source: adapted from World Bank 2008

environmental functions and ecosystem services upon which all societies depend. They serve as refuge for nearly half of all known plant and animal species, possessing unmatched terrestrial biological diversity. They conserve soil, protect watersheds, and buffer against natural disasters. They provide sources of livelihood to more than 1.5 billion people, many of whom lead subsistence lifestyles and whose very survival hinges on these carbon-rich forests. Aptly termed the lungs of the planet, these ecosystems also play a vital role in filtering and regulating our air, removing carbon dioxide from the atmosphere, and delivering essential oxygen.

Reducing emissions from deforestation and forest degradation (REDD) is one clear way to mitigate climate change. This recognition has given rise to the concept of compensated reduction. The idea was conceived as a way to use new carbon markets to provide a cost-effective and equitable way for developing countries with tropical forests to participate in global efforts to reduce GHG emissions within the UN Framework Convention on Climate Change (UNFCCC) process. The underlying premise is to compensate developing countries that voluntarily commit to reduce and stabilize national deforestation below a previously determined historical level. Thus, REDD may be in part an instrument to enable fair and equitable access to global carbon financing, whether through market or fund-based approaches. Some proponents suggest that REDD offers new incentives for reducing GHGs that could simultaneously accomplish several ancillary goals: biodiversity conservation, watershed protection, poverty alleviation for rural communities, and capacity building in tropical forest nations.

Momentum for REDD has accelerated rapidly in 2008, following a decision in 2007 on the "... urgent need to take further meaningful action..." on an avoided deforestation scheme. This was followed by the formulation of guidance for a two-year pilot phase. While the precise architecture and rules have yet to be settled, it now seems highly likely that an international REDD mechanism of some kind will emerge as a key element of the post-2012 international climate change regime.

2008 saw many demonstration projects and an influx of funding, testifying to governments' and other institutions' increasingly unified position on REDD's potential for delivering multiple benefits. Conversely, as the scientific and political debate evolves, new complexities, uncertainties, and contentious issues continue to surface. One of the most obvious concerns relates to methodological questions. These include how to select and structure deforestation baselines, how to integrate degradation issues into these calculations, how to decide on standards for quantifying and monitoring deforestation rates, how to put the institutional capabilities in place to ensure accuracy, and how to ensure results are available on both spatial and time scales that are relevant to decision-makers.

These all are critical questions and they remain largely unresolved. However, even if they are answered they have the potential to be overshadowed by governance issues. Eventual outcomes may rely less on technical information than on political choices and arbitrations since adopted rules will create winners and losers in what is shaping up to be a new type of ecosystem service payment (Karsenty and others 2008). Thus, the most divisive challenge in REDD implementation may be issues of governance. Pervasive inequities in land use rights and tenure regimes, or limited access to finance and information for marginalized groups, or the appropriation of revenues by elites are but a few governance failures that could effectively nullify both local and global benefits from a REDD scheme (Preskett and others 2008).

Given that REDD will likely be implemented at a landscape scale and that different sites possess varying degrees of ancillary value—biodiversity, fresh water, or local livelihood services—higher implementation costs could disfavor the protection of certain, less immediately lucrative forest values, predicating a need for additional resources (Miles and Kapos 2008). As a result, a small number of recent proposals have focused on valuing the full suite of services provided by the forest utility, not just carbon storage (Gardiner 2008, Trivedi and others 2008). However, these go beyond the scope of the proposed REDD mechanisms under debate and will likely not form part of the upcoming UNFCCC deliberations. Related to this debate is the possibility that carbon-focused forest conservation could shift development pressure to other, lower-carbon ecosystems. If conservation investment is placed squarely on tropical forests while the demand for food and bioenergy crops increases, other locations could come under increased pressure and become new targets for exploitation and land use change.

The potential for REDD to provide innovative and cost effective opportunities to abate GHG emissions while providing biodiversity and social benefits will depend in large part on management and oversight. We may well be approaching an internationally entrenched mechanism to help deliver these multiple benefits by design. It is therefore crucial that scientists, practitioners, and decision-makers recognize, assess, and plan for the unintended adverse side effects of REDD as well as the possible opportunities. While the prospect of REDD in no sense reduces the imperative to address underlying causes of forest degradation, nor can it alone solve our climate crisis, the concept has been a powerful stimulus for new thinking about ecosystem management. To date, forest loss continues and the climate keeps changing, so new ideas need to be discussed, accepted, tested, and rejected or improved. Designing an avoided deforestation scheme to maximize mutiple benefits could set a precedent for meeting environmental challenges with innovative approaches that are efficient, equitable, and effective.

Remains of burnt trees in the Amazon: Deforestation remains a significant contributor to global CO_2 emissions.

Source: UN-HABITAT/ istockphoto

On the benefits of choice

The use of the term 'tipping point' is familiar to most people as there are idioms in nearly every language that describe it: A straw that breaks a camel's back; a drop that makes a container overflow, or a nudge that topples a large object. It presents a system in the midst of a delayed reaction as the 'pressure' builds within the system (Scheffer and others 2001). In geology and engineering, different types of unconsolidated granular material display characteristic angles of repose or stability dependent on the shape of the particles, the density of the material, and other factors. Once this angle is exceeded, slope collapse follows. This concept is applied to the categorization of avalanche threats in mountain regions (Barbolini and others 2004).

This sense of the term was used earlier in sociological circles to include subtle delays, as a causative factor reaches a critical mass before it invokes response within a given population. This phenomenon has been documented in epidemiology, in fashion trends, and in demographic transformation in communities (Gladwell 2000). However the term can be considered from an alternative perspective, one that suggests an opportunity exists to change conditions with minimal effort (Gladwell 2000). In these circumstances a small effort can produce momentum for a desired result. This perspective has inspired a number of projects that aim to create a critical mass to change a larger environment. These include allotment gardens in urban neighborhoods with high crime rates, replanting mangrove swamps, and restoring wetlands (Marten and other 2005).

It is in this sense of a potential opportunity that we argue this is the propitious moment to initiate a deliberate phase transition to an environmentally sound economy. Using 'shock therapy' to pursue macroeconomic objectives is a generally accepted approach (Sachs and Lipton 1990). This economic shock therapy refers to policies that put an economy into free fall, stabilizing only when market mechanisms kick in. It promotes deregulation and the break down of rules and non-market-set standards—an approach severely critiqued in 2007 as 'crisis capitalism' and 'shock doctrine' (Klein 2007).

The current global economy—spurred by cheap hydrocarbon-fueled transportation, globalized goods and services transactions, and split second currency trading—is surely in the midst of a remarkable shock. It presents an unmatched opportunity to revamp and upgrade a system that originated in a world where the industrial revolution had not yet begun, whole continents were divided for colonization, and the total world population equaled that of Europe today.

It is time for a new approach and that opinion is gaining momentum: According to the President of the UN General Assembly, the Follow-up International Conference on Financing for Development on the Implementation of the Monterrey Consensus recognized that the international context has changed profoundly over the past few years. During the Conference, discussants had demonstrated a 'universal rejection' of the model represented by post-World War II arrangements known as the Bretton Woods system or the Washington Consensus (UN 2008b).

This propitious moment calls for an economic system that values those goods and services that keep us alive and enable our wellbeing, based on the thinking and activities from decades of sustainable development efforts. Ecological economics has been applying principles like industrial ecology to the economics sphere for the last two decades. That approach has offered a wealth of data, information, and knowledge about shifting the dominant economic paradigm to one that values ecosystem services, costs the contributions of the commons, and reflects on lessons from history to ensure we have options on whether to relive them or not (Pearce and others 1989, Costanza 2008).

CONCLUSION

If we want to assess the real economy—all the things that contribute to sustainable wellbeing within the economy determined by Earth systems—as opposed to only the market economy as expressed by gross domestic product (GDP), we have to measure and include the non-marketed contributions to human wellbeing from nature and from our society. Ecological economists group these contributions into four basic types of capital that are necessary to support the real economy that produces wellbeing: built capital, human capital, social capital, and natural capital (Costanza 2008).

A better model of an economic system would be based clearly on the goal of sustainable human wellbeing, and It would use measures of progress that explicitly acknowledge this goal. The introduction of a genuine progress indicator (GPI) to replace GDP for tracking economic health is such an alternative measure. This type of measure accounts for the importance of ecological sustainability, social fairness, and real economic efficiency. Ecological sustainability implies recognition that natural and social capital are not infinitely substitutable by built and human capital and that there are real Earth system limits to the expansion of the market economy. Climate change is perhaps the most obvious and compelling of these limits (Costanza 2008).

Social fairness implies recognition that the distribution of wealth is an important determinant of social capital and quality of life. The conventional development model, while ostensibly aimed at reducing poverty, has bought into the assumption that the best way to do this is through growth in GDP. This assumption has not proved to be the case and explicit attention to distribution issues is needed badly (Stiglitz 2008).

Increasing inequality of income actually reduces overall societal wellbeing, not just for the poor but across the income spectrum. Real economic efficiency implies the inclusion of all resources that affect sustainable human wellbeing in the allocation system, beyond current goods and services. Our current market allocation system excludes most non-marketed natural and social capital assets and services, which are huge contributors to human wellbeing (Costanza 2008).

The current development model ignores this fact and therefore does not achieve real economic efficiency. A new, ecologically sustainable development model would measure and include the contributions of natural and social capital and could better approximate real economic efficiency. The new development model would also acknowledge that a complex range of property rights regimes is necessary to adequately manage the full range of resources that contribute to human wellbeing.

For example, most natural and social capital assets are public goods. Making them private property does not work well. On the other hand,

leaving them as open-access resources with no property rights does not work well either, as we recognize from incidents of water, soil, and atmospheric pollution. What is needed is an alternative way to propertize these resources without privatizing them (Barnes 2006). Several common property rights systems have been proposed to achieve this goal, including various forms of common property trusts (Barnes and others 2008).

In addition to a role in regulating the market economy, governance for sustainable development should play a significant role in expanding the commons sector in ways that propertize and manage non-marketed natural and social capital assets. At nested scales governance for sustainability acts as a facilitator in society's development of a shared vision of what a desirable future would look like (Daly 1996) (**Table 3**).

The key to achieving sustainable governance in a globalized context is an integrated approach—across scales, disciplines, stakeholder groups, and generations—based on the paradigm of adaptive management where policy making is an iterative experiment acknowledging uncertainty, rather than a static answer. Six core principles were agreed at a 1997 meeting in Lisbon for sustainable governance of the oceans that embody the essential criteria for a comprehensive environmental governance. Over the last decade, these Lisbon Principles have become recognized as basic guidelines for administering the use of common natural and social resources (Costanza and others 1998).

Responsibility: Access to common asset resources carries attendant responsibilities to use them in an economically efficient, socially fair, and ecologically sustainable manner. Individual and corporate responsibilities and incentives should be aligned with each other and with broad social and ecological goals.

Scale-matching: Problems of managing natural and social capital assets are rarely confined to a single scale. Decision-making should be assigned to institutional levels that should maximize input, ensure the flow of information among those levels and other stakeholders, take ownership and actors into account, and internalize costs and benefits. Appropriate scales of governance will be those that have the most relevant information, can respond quickly and efficiently, and are nested—able to integrate across scale boundaries.

Precaution: In the face of uncertainty about potentially irreversible impacts to natural and social capital assets, decisions concerning their use should err on the side of caution. The burden of proof should shift to those whose activities potentially damage natural and social capital.

Adaptive management: Given that some level of uncertainty always exists in common asset management, decision-makers should continuously gather and integrate appropriate ecological, social, and economic information with the goal of adaptive improvement.

Full cost allocation: All of the internal and external costs and benefits, including social and ecological ones, of alternative decisions concerning the use of natural and social capital should be identified and allocated. When appropriate, markets should be adjusted to reflect full costs.

Participation: All stakeholders should be engaged in the formulation and implementation of decisions concerning natural and social capital assets. Full stakeholder awareness and participation contribute to credible, accepted rules that identify and assign the corresponding responsibilities appropriately.

Table 3: A sustainable development model

	Current Development Model the "Washington Consensus"	**Sustainable Development Model** an emerging "Green Consensus"
Primary policy goal	**More:** Economic growth in the conventional sense, as measured by GDP. The assumption is that growth will ultimately allow the solution of all other problems. More is always better.	**Better:** Focus shifts from growth to development in the sense of improvement in quality of life, recognizing that growth often has negative by-products and more is not always better.
Primary measure of progress	GDP	GPI (or something similar)
Scale/carrying capacity	Not an issue because it is assumed that markets can overcome any resource limits via new technology, and that substitutes for resources are always available.	A primary concern as a determinant of ecological sustainability. Natural capital and ecosystem services are not infinitely substitutable, and real limits exist within Earth systems.
Distribution/poverty	Relegated to national policy processes and a trickle down effect: A rising tide lifts all boats.	A primary concern since it directly affects quality of life and social capital and in some real ways is often exacerbated by growth.
Economic efficiency/ allocation	The primary concern, but generally including only GDP-releted goods and services and institutions.	A primary concern, but including both market and non-market goods and services and effects. Emphasizes the need to incorporate the value of natural and social capital to achieve true allocative efficiency.
Property rights	Emphasis on private property and conventional markets.	Emphasis on a balance of property rights regimes appropriate to the nature and scale of the system, and a linking of rights with responsibilities. A larger role for common property institutions in addition to private and public property.
Role of governance	To be minimized and replaced where possible with private and market institutions.	A central role, including new functions as referee, facilitator, and broker in a new suite of common-asset institutions.
Principles of governance	*Laissez-faire* market capitalism.	Lisbon principles of sustainable governance.

Basic characteristics of the current development model and an emerging model based on ecological economics.
Source: Adapted from Costanza 2008

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Acronyms and abbreviations

AFP	Agence France-Presse
AGU	American Geophysical Union
AGRA	Alliance for a Green Revolution in Africa
ASN	American Society of Nephrology
ASCE	American Society of Civil Engineers
ATSDR	Agency for Toxic Substances and Disease Registry
BAN	Basel Action Network
BAS	British Antarctic Survey
BBC	British Broadcasting Corporation
CBD	Convention on Biological Diversity
CCVA	Conservation Corridor Vilcabamba-Amboro
CDIAC	Carbon Dioxide Information Analysis Center
CO2	Carbon Dioxide
COP	Conference of the Parties
CRED	Centre for Research on the Epidemiology of Disasters
CRIIRAD	Commission of Research and Information on Radioactivity
CSA	Centre Stockage l'Aube
DDT	Dichloro-Diphenyl-Trichloroethane
DEPA	Danish Environmental Protection Agency
EC	European Commission
EDF	Electricité de France
EHS	Environment, Health, and Safety
ENSO	El Nino-Southern Oscillation
ESA	European Space Agency
E-waste	Electronic Waste
FAO	Food and Agriculture Organization of the United Nations
FEWS	Famine Early Warning System
FIFA	Fédération Internationale de Football Association
FP6	6th Framework Programme
FP7	7th Framework Programme
GDP	Gross Domestic Product
GEO	Global Environment Outlook
GHG	Greenhouse Gas
GPI	Genuine Progress Indicator
HCTISN	High Commission for Transparency and Information on Nuclear Safety
HFA	Hyogo Framework for Action
IAASTD	International Assessment of Agricultural Knowledge, Science and Technology for Development
ICRC	International Committee of the Red Cross
IEA	International Energy Agency
IMO	International Maritime Organization
INAC	Indian and Northern Affairs Canada
IPCC	Intergovernmental Panel on Climate Change
IRIN	Integrated Regional Information Networks
IUCN	International Union for Conservation of Nature
IWMI	International Water Management Institute
JMA	Japan Meteorological Agency
MA	Millennium Ecosystem Assessment
MCEER	Multidisciplinary Center for Earthquake Engineering Research
MDGs	Millennium Development Goals
mg/kg	Milligram per Kilogram
mg/l	Milligram per Litre
MIT	Massachusetts Institute of Technology
MOE	Ministry of the Environment, Government of Japan
NASA	National Aeronautics and Space Administration (of the United States)
NDRC	National Development and Reform Commission
NERSC	Nansen Environmental and Remote Sensing Centre
NGO	Non-Governmental Organization
NSIDC	National Snow and Ice Data Center
OECD	Organization for Economic Cooperation and Development
OFDA	Office of United States Foreign Disaster Assistance
PES	Payment for Ecosystem Services
PONJA	Post Nargis Joint Assessment
PVC	Polyvinyl chloride
REDD	Reduced Emissions from Deforestation and Forest Degradation
RRI	Rights and Resources Initiative
SCENHIR	Scientific Committee on Emerging and Newly Identified Health Risks
SoVI	Social Vulnerability Index
UCSB	University of California, Santa Barbara
UK	United Kingdom
UN	United Nations
UNDESA	United Nations Department of Economic and Social Affairs
UNDP	United Nations Development Programme
UNEP	United Nations Environment Programme
UNFCCC	UN Framework Convention on Climate Chnage
UN-Habitat	United Nations Human Settlements Programme
USA	United States of America
US BCSD	US Business Council for Sustainable Development
USD	United States dollar
US$	United States dollar
USEPA	United States Environmental Protection Agency
USGS	United States Geological Survey
WEC	World Energy Council
WGMS	World Glacier Monitoring Service
WHO	World Health Organization
WNA	World Nuclear Association
WRI	World Resources Institute
WTO	World Trade Organization
WWF	World Wildlife Fund