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21 Issues for the 21st Century

Results of the UNEP Foresight Process on Emerging Environmental Issues

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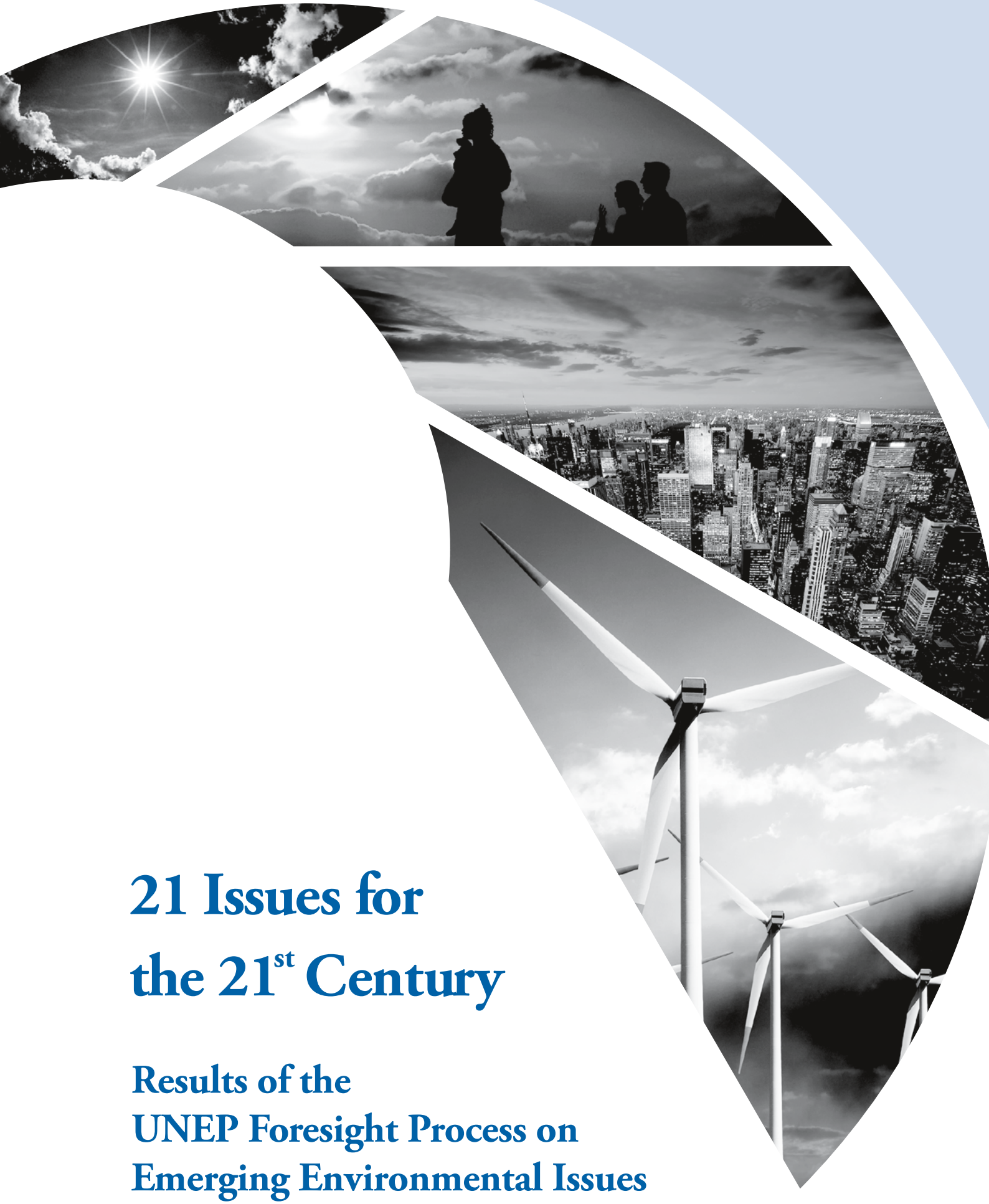

21 Issues for the 21st Century

Results of the UNEP Foresight Process on Emerging Environmental Issues

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Foreword

Sound science is critical to UNEP's work in terms of advising governments on the challenges and the opportunities of a rapidly changing world.

In order to achieve sustainable development, nations and their citizens need to know how the policies of the past are impacting the present: equally the judgements and assessments of likely future trends need to be kept high on the international radar screen.

In 2010, in support of the road to Rio+20 and UNEP's work towards an inclusive Green Economy, a unique and transformational consultative process was instigated to answer a set of critical scientific questions on what will be the big emerging issues over the coming years.

The UNEP Foresight Panel, involving over 20 distinguished scientists from around the world, spent close to a year discussing and consulting with some 400 other scientists and experts globally via an electronic survey.

The goal was to deliver an international consensus and a priority list of the top emerging environmental issues alongside options for action.

Emerging environmental issues were defined as "issues with either a positive or negative global environmental impact that are recognized by the scientific community as very important to human well-being, but not yet receiving adequate attention from the policy community".

The issues chosen were termed as "emerging" based on newness, which can be the result of: new scientific knowledge; new scales or accelerated rates of impact; heightened level of awareness; and/or new ways of responding to the issue.

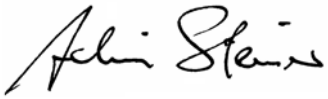
This report is the outcome of that process and presents the identified issues titled: *21 Issues for the 21st Century.* These issues cut across all major global environmental themes including food production and food security; cities and land use; biodiversity, fresh water and marine; climate change and energy, technology and waste issues.

Meanwhile, another cluster of issues were chosen that essentially cut across sectors and individual themes.

These address questions surrounding such issues as the governance required to more effectively tackle 21st century sustainability challenges, including the urgency to bridge the gap between the scientific and policy communities and the relevance of social tipping points to sustainable consumption.

The findings of the report, which was coordinated by the Office of the UNEP Chief Scientist and the UNEP's Division of Early Warning and Assessment, are aimed at all sectors of society committed to realizing a more intelligent, decisive and forward-looking response to challenges of our times.

While the initial focus was to inform the Rio+20 Summit taking place in Brazil in 2012, *21 Issues for the 21st Century* will be clearly relevant to environmental policy-making and scientific priority setting for many years to come as well as the trajectory of UNEP's future work programme.



Achim Steiner
United Nations Under-Secretary-General, and
Executive Director United Nations Environment Programme

Executive Summary

The purpose of the UNEP Foresight Process is to produce, every two years, a careful and authoritative ranking of the most important emerging issues related to the global environment. UNEP aims to inform the UN and wider international community about these issues on a timely basis, as well as provide input to its own work programme and that of other UN agencies, thereby fulfilling the stipulation of its mandate: "keeping the global environment under review and bringing emerging issues to the attention of governments and the international community for action".

The concept of 'emerging issues' is subjective. It is used in this report to describe issues that are recognized as very important by the scientific community, but are not yet receiving adequate attention from the policy community. Definitions of 'very important' and 'adequate' are left open to those identifying the issues. Emerging issues are further defined as those that are:

- Critical to the global environment. The issue can be either positive or negative but must be environmental in nature, or environmentally-related.
- Given priority over the next one to three years in the work programme of UNEP and, or, other UN institutions and, or, other international institutions concerned with the global environment.
- Have a large spatial scale. Issues should either be global, continental or 'universal' in nature (by 'universal' we mean an issue occurring in many places around the world).
- Recognised as 'emerging' based on newness, which can be the result of: new scientific knowledge; new scales or accelerated rates of impact; heightened level of awareness; and, or, new ways to respond to the issue.

The UNEP Foresight Process has been designed so as to encourage the creative thinking of participants and to be inclusive at the same time. At the core of the process is a Foresight Panel consisting of 22 distinguished members of the scientific community from 16 developing and industrialized countries, covering all world regions and internationally recognized because of their expertise in one or more environmental or related issues.

Important steps in the process included:

- A canvass of ideas from the UNEP community to obtain a first list of emerging issues.
- Two facilitated meetings, during which the Foresight Panel expanded, debated and ranked the list of issues in a structured and systematic process. Some issues were combined and redefined, resulting in the selection of 21 priority issues.
- An extensive electronic consultation of scientists worldwide, in which more than 400 scientists provided feedback on the preliminary issues selected by the Panel during their first meeting.

The Issues: 21 Issues for the 21st Century

The output of the UNEP Foresight Process is a ranked list of 21 emerging issues described in a way that reflects their linkages to the various dimensions of sustainable development. The issues relate to the major themes of the global environment, as well as important cross-cutting issues. Below, a summary description of the issues is provided according to the different clusters rather than their ranking.

Cross-cutting Issues

001: Aligning Governance to the Challenges of Global Sustainability (Ranked #1). The current system of international environmental governance, with its maze of interlocking multilateral agreements, evolved during the 20th century, and is believed by many to be unsuitable for the 21st century. Some commentators believe that this system lacks the necessary representativeness, accountability and effectiveness for the transition to sustainability, and that a much higher level of participation and transparency is needed. New models of governance are being tested, ranging from public-private-community partnerships to alliances between environmentalist and other civil society groups. However, the effectiveness of novel governance arrangements is unclear and requires further scrutiny.

002: Transforming Human Capabilities for the 21st Century: Meeting Global Environmental Challenges and Moving Towards a Green Economy (Ranked #2). Adapting to global change and attaining a green economy will require a variety of new capabilities, in particular new job skills, modes of learning, management approaches and research efforts. Action is needed to close the skills gaps in the green sector; update educational institutions to better meet educational needs for sustainability work; train managers to better identify and respond to global environmental change; and encourage research to address the sustainability challenge.

003: Broken Bridges: Reconnecting Science and Policy (Ranked #4). To cope with global environmental change, our society needs strategies and policies that are underpinned by a strong science and evidence base. But many believe the linkage between the policy and science communities is inadequate or even deteriorating, and that this 'broken bridge' is hindering the development of solutions to global environmental change. This problem requires a new look at the way science is organized and how the science-policy interface can be improved.

004: Social Tipping Points? Catalyzing Rapid and Transformative Changes in Human Behaviour towards the Environment (Ranked #5). New social science research has articulated the way in which damaging human behaviour

can be transformed by public policy in a positive direction within a relatively short period of time. An example is the transformation of the public view of cigarette smoking which switched from being a fashionable activity to a dangerous health hazard within one generation in many countries. Can these insights also be applied to transforming habits of consumption that lead to destructive environmental changes? What public incentives – economic, informative or prohibitions – would work best to achieve this transformation?

005: New Concepts for Coping with Creeping Changes and Imminent Thresholds (Ranked #18). Many human interactions with the natural environment cause a slow, incremental and cumulative degradation of the environment; e.g., stratospheric ozone depletion, acid rain, tropical deforestation, mangrove destruction, and biodiversity loss, among others. Ironically, these 'creeping changes' are typically overlooked in their early stages when they can be most easily addressed. They only become noticeable when their negative consequences appear, by which time they are irreversible or more costly to mitigate. Hence, effective early warning monitoring systems are needed to spot them early on, before they become environmental "hotspots".

006: Coping with Migration Caused by New Aspects of Environmental Change (Ranked #20). A growing body of studies suggests that environmental change will become an increasingly important factor in the displacement of people. Environmental change includes both rapid-onset events, such as more frequent or intense coastal and river flooding, and slow-onset processes such as land degradation and sea level rise. Among the response options to environmental migration are: improving prediction of migration, incorporating plans for coping with migration into national adaptation plans, extending national and international immigration policies to include environmental migrants, and trying to mitigate the underlying causes of environmental migration.

Food, Biodiversity and Land Issues

007: New Challenges for Ensuring Food Safety and Food Security for 9 Billion People (Ranked #3). Although food security is a longstanding issue, the world needs to confront a new set of challenges such as climate change, competition for land from bioenergy production, heightened water scarcity, and possible shortfalls of phosphorus for fertilizer. Food safety also faces new challenges from increasing disease transmission from animals to people and food contamination. There is an urgent need to increase the security and safety of the world's food supply by setting up more comprehensive early warning systems, supporting smallholder farmers, reducing food waste, and increasing agricultural efficiency.

008: Beyond Conservation: Integrating Biodiversity across the Environmental and Economic Agendas (Ranked #7). In recent years, two important threads of research have documented how biodiversity is intertwined with other aspects of society and nature. One thread has articulated the linkages between biodiversity and other environmental issues (impact of climate change on ecosystems; interaction between ecosystems and the water cycle); and the other, the interrelationship between biodiversity and economics (valuation of ecosystem services; the role of biodiversity in underpinning economic activities). It is time to act on these new scientific insights and treat biodiversity as more than a nature conservation issue. It is time to fully integrate the issue of biodiversity into the global environmental and economic agendas.

009: Boosting Urban Sustainability and Resilience (Ranked #11). The issue of sustainability of cities has to do with both the environmental quality within cities that city residents have to live with, and the environmental changes caused by cities outside of their borders. Today neither aspect is particularly sustainable, especially in developing countries. The key to sustainability lies in the concept of 'green cities' or 'eco cities' which differ from conventional cities in that they are more compact, have a vital mix of land uses within their boundaries, provide many different low-energy transportation opportunities, and produce some of their own renewable energy. Such cities would provide their citizens with a high level of environmental quality and liveability, and have a lower environmental footprint outside their borders.

010: The New Rush for Land: Responding to New National and International Pressures (Ranked #12). Concerns over future energy and food supplies have led to a new rush for acquiring lands in developing countries by both foreign and national investors. Research shows that the rate of land acquisition has greatly accelerated over the past few years. There is a need to better understand the scale of the phenomenon, the main countries at risk, and the trade-offs involved. It is also important to grasp how this trend will affect livelihoods, food security, ecosystem services, and conflicts. Putting safeguards in place, such as assessing the potential environmental, economic and social impacts of land deals before they are finalized, could minimize the drawbacks to the host country while allowing the investing countries to gain the food and energy security they aim for by acquiring land.

Freshwaters and Marine Issues

011: New Insights on Water-Land Interactions: Shift in the Management Paradigm (Ranked #6). Recent scientific research has provided a new view on how water and land interact, locally to globally. For example, scientists now better understand the extent to which changes in land use profoundly affect downwind rainfall patterns, and have computed the huge volumes of water appropriated (transpired or evaporated) by society to produce rainfed crops ('blue' versus 'green' water flows). This new knowledge provides a new impetus for bringing water and land management closer together. The result could be a boost in water productivity and higher food production per litre of water, as well as new ways of maintaining the quality of water.

012: Shortcutting the Degradation of Inland Waters in Developing Countries (Ranked #15). Water quality degradation, channel modifications, and overfishing are some of the factors posing a growing threat to the freshwater ecosystems and inland fisheries of developing countries. But

as developing countries stand on the brink of large-scale degradation of their inland waters, they have the option of shortcutting this degradation by taking advantage of forward-looking water technologies and management techniques that were not available to countries in Europe and North America at the time they began contaminating their waterways.

013: Potential Collapse of Oceanic Systems Requires Integrated Ocean Governance (Ranked #13). Oceans provide many earth system functions including the regulation of climate and the hydrological cycle, as well as provide habitat for a rich diversity of organisms, and food, materials and energy for human use. But the oceanic environment is faced with increasing threats to its long-term integrity, including: acidification, overfishing, land and marine-based pollution, widespread habitat destruction, and the proliferation of invasive species. There is a growing presumption that the current approach to managing oceans will be unable to prevent a collapse of some oceanic systems. This is because, among other reasons, responsible bodies are dispersed across UN agencies. Reforms are needed and new forms of governance should be considered and evaluated, including the option of establishing a new coordinating body for integrated ocean governance.

014: Coastal Ecosystems: Addressing Increasing Pressures with Adaptive Governance (Ranked #19). Increased pressure from the exploitation of coastal resources is significantly affecting coastal ecosystems. Settlements, industries, agriculture, fisheries and trade are concentrated in coastal zones; hence sensitive and highly valuable coastal ecosystems are subjected to on-going degradation. Present management approaches are inadequate for halting the tide of degradation. Therefore, an adaptive governance approach is needed that involves the delegation of management, rights, and power in such a way that encourages the participation of all stakeholders.

Climate Change Issues

015: New Challenges for Climate Change Mitigation and Adaptation: Managing the Unintended Consequences (Ranked #7). When scaled up, mitigation and adaptation measures may have unintended consequences. For example, large scale wind farms may disrupt the migratory behaviour of birds; new massive sea walls will protect the populations but may also eliminate valuable natural wetlands; and large scale geoengineering schemes could have many unintended impacts. These potential negative side effects should be assessed, and then minimized or avoided in order to maintain support for climate policies.

016: Acting on the Signal of Climate Change in the Changing Frequency of Extreme Events (Ranked #16). A spate of new scientific studies have compared climate modelling results with observational evidence and confirmed the hypothesis that climate change could alter the frequency, strength and distribution of extreme events. For example, studies have linked global warming with increased risk of flooding in England and Wales; with increased summer rainfall variability in Southeast United States; and with the intensification of heavy precipitation events over much of the land area of the Northern Hemisphere. These new findings underscore the need to adapt to a changing frequency of extreme events, and suggest that 'medium term' early warning systems might be possible.

017: Managing the Impacts of Glacier Retreat (Ranked #21). Recent research shows that many glaciers are in retreat and some have an accelerating rate of melting. These changes pose threats to many people and ecosystems, especially in the Himalayas, Central Asia and Andes. Threats include the risk of flooding from the bursting of natural dams holding back glacial lakes, as well as the eventual decline of runoff during the dry season in some regions. A much better understanding of the hydrological consequences and economic and social impacts of glacier retreat is needed, and the development of adaptation strategies is equally urgent.

Energy, Technology, and Waste Issues

018: Accelerating the Implementation of Environmentally-Friendly Renewable Energy Systems (Ranked #7). As the world seeks solutions to climate change, it looks increasingly towards renewable energy. But regardless of the large potential for renewable energy worldwide, this potential has not been realized due to many barriers. An important task is to identify the means to eliminate the economic, regulatory and institutional barriers to renewable energy that undermine its competitiveness with conventional energy sources.

019: Greater Risk than Necessary? The Need for a New Approach for Minimizing Risks of Novel Technologies and Chemicals (Ranked #10). We are fixed in a pattern by which society first produces new technologies and chemicals and then *ex post facto* tries to evaluate the impacts of what it has produced. The latest examples are the questions raised by applications of synthetic biology and nanotechnology. With the accelerated pace by which novel technologies and chemicals are being deployed, a new approach should be considered by which their implications are systematically and comprehensively assessed *before* they reach the production phase with the aim to minimize their risks to society and nature. While this is happening in some parts of the world for some technologies and chemicals, it is worth making this a universal approach and this may require new forms of international governance.

020: Changing the Face of Waste: Solving the Impending Scarcity of Strategic Minerals and Avoiding Electronic Waste (Ranked #14). Increased demand for high-tech and renewable energy equipment is contributing to a depletion of strategic minerals, including rare earth metals. This is compounded by planned obsolescence and other wasteful manufacturing habits. The increased exploitation of minerals is also causing greater waste management problems, in particular, the build-up of electronic wastes (e-wastes). A promising option is to maximize the recovery of metals and other materials from electronic and other waste streams (so called "waste mining"). This will slow down the extraction and depletion of minerals, reduce the quantity of their wastes, and thereby lessen their associated environmental and other impacts.

021: The Environmental Consequences of Decommissioning Nuclear Reactors (Ranked #17). Many of the world's nuclear reactors are aging and will need to be decommissioned very soon. This is of concern because decommissioning is a major operation which produces large amounts of radioactive waste that need to be disposed of safely. There is an inadequate number of trained professionals to handle these operations, even though the number of plants needing decommissioning will at least double within the next 10 years. The Fukushima nuclear accident in March 2011 has further accelerated the plans of some countries to close their nuclear plants. International interventions, procedures, policies and cooperation are needed to minimize the potential danger posed by decommissioning activities to society and the environment.

1. Introduction

Why a Foresight Study?

The world today is confronted with many different emerging environmental issues including new problems to solve and new solutions to evaluate and possibly implement. Which emerging issues are most important? Which require our attention? These are the questions dealt with in this report.

At the outset it is important to point out that 'emerging issues' is a subjective concept. What qualifies as 'emerging' to one community may be yesterday's news to another. Here emerging is meant to apply to those issues already recognized by the scientific community but thought to be insufficiently attended to by the policy community and the rest of the society.

Box 1. Guidelines for 'Emerging Global Environmental Issues'

An emerging issue in the UNEP Foresight Process is defined as *'an issue with either a positive or negative global environmental impact that is recognized by the scientific community as very important to human well being, but has not yet received adequate attention from the policy community'*. The definitions of 'very important' and 'adequate' are left open to those identifying the issues.

The recognition of an issue as 'emerging' is based on newness. Newness of an issue can be as a result of new scientific knowledge, new scales or accelerated rates of impact, a heightened level of awareness, and, or new ways to respond to the issue.

The emerging issue must be critical to the global environment and must be environmental in nature or environmentally-related.

The issue has to be of a large spatial scale. It should either be global, continental or "universal" in nature (by "universal" we mean an issue occurring in many places around the world).

The issue should be given priority over the next one to three years in the work programme of UNEP, and, or other UN institutions and, or, other international institutions concerned with some aspect of the global environment. However, this does not mean that the issue should be resolvable in this time period.

In the Foresight Process, UNEP recognized the need to:

- select issues that if not addressed now will have significant future impacts
- focus on threats and direct causality as well as possibility of response due to new technologies
- address cumulative - often local - effects that are chronic in nature
- appreciate that extremes are often more important than average changes, and
- give attention to vulnerable people and places

The UNEP Foresight Process

The approach used to identify and rank emerging issues is called the 'UNEP Foresight Process'. The goal of the process is to produce a careful and authoritative ranking of the most important emerging global environmental issues. Through this process UNEP aims to inform the UN and the wider international community about emerging issues as well as provide input to UNEP's own Programme of Work, thereby fulfilling the stipulation of its mandate: "keeping the global environment under review and bringing emerging issues to the attention of governments and the international community for action".

Considering the rapidity at which new issues emerge, it is intended to repeat the Foresight Process every two years.

The process was designed to encourage the creative input of participants by stimulating debate and examining issues from different angles. Therefore the scientists involved in the process were intentionally selected to represent a wide range of disciplines and parts of the world. This wide variety of scientists also contributed to the legitimacy of the process.

At the core of the process is a Foresight Panel consisting of 22 distinguished members of the scientific community from developing and industrialized countries (see Acknowledgements), who are internationally recognized because of their expertise in one or more environmental or related issues. The Panel covers a wide spectrum of disciplines from environmental governance to marine sciences. Five Panel members were from Africa; six from Asia and the Pacific Region; three from Latin America and the Caribbean; five from Europe; and three from North America. Fourteen of them work primarily in the natural sciences and eight in the social sciences or economics. There were fifteen men and seven women on the Panel.

The Foresight Process consisted of a set of alternating 'open' and 'closed' steps. The 'open' steps opened up the process to a wide range of views, while the 'closed' steps allowed the

relatively small Foresight Panel to debate the issues in depth and select a limited set of priority issues. The Foresight Panel was guided through the process by a professional facilitator and the UNEP Secretariat. The entire process took eight months.

The process was divided into six phases:

- *Canvass of UNEP Community.* The Process began with a canvass of the UNEP community to solicit their views and insights about important emerging issues. This canvass resulted in a list of 68 issue which were described in a background report sent to the Foresight Panel members before their first meeting.

- *Preliminary List of Issues.* Before the first Panel meeting, Panel members added their own ideas of emerging issues to the list of 68 issues from the UNEP community, resulting in a preliminary list of 95 issues. The Panel then scored the issues based on their perception of their importance and the scores were used to rank the 95 issues. This ranked list was a main input to the first Panel meeting.

- *First Panel Meeting.* At their first meeting, Panel members debated the 95 issues in a structured and systematic way, giving more attention to the higher ranked issues. Some issues were combined and redefined. The output of the first meeting was a list of ***21 priority issues.***

- *Electronic Consultation.* An interactive electronic questionnaire was prepared with descriptions of the 21 priority issues from the first Panel meeting. This questionnaire was sent to 933 scientists around the world who were asked to score the issues between 1 and 10, and to suggest additional issues and issues to be dropped. The distribution list had a balanced representation of regions and expertise. The response rate and regional distribution of respondents was considered excellent (see Appendix 2).

- *Second Foresight Panel Meeting.* The Panel considered the results of the Electronic Consultation, especially the scoring of issues and the suggestions for adding and dropping issues. They rearranged and redefined some issues and settled on a list of 'top ten', 'middle five', and 'bottom six' issues, close to the results of the Electronic Consultation. After the meeting, the Panel scored each of the issues within the 3 groupings and thus produced a final ranking of 21 issues.

- *Final Documentation.* The issues were then documented with short descriptions and references.

This report presents descriptions of the 21 issues. The Foresight Process itself is described in more detail in Appendix 2.

2. Emerging Themes – 21 Issues for the 21st Century

While many of the issues identified through the Foresight Process can be categorized according to the major themes of global environmental change – water, climate change, the marine environment, and so on – the Foresight Panel felt that this sectoral view is becoming increasingly obsolete (see Box 2). Hence, the descriptions of the issues mention their linkages to other issues or themes and their linkages to the various dimensions of sustainability. For example an issue related to biodiversity (Issue 008) refers to the linkage of biodiversity with other environmental and economic factors. Likewise, one of the issues pertaining to the water sector (Issue 011) refers to the impacts of water-land interactions. Furthermore, about one-third of the issues are truly cross-sectoral and address such concerns as the governance needed to contend with 21st century sustainability challenges, the relevance of social tipping points to sustainable consumption, and the migration flows following from new aspects of environmental change. These clearly cannot be put into any one thematic box.

As described in Box 2, the Foresight Panel emphasized the need to think in a holistic and cross-cutting manner. In the following description of the issues we begin with the cross-cutting issues and then follow with the thematic (but still integrative) issues concerned with food, land, and biodiversity; freshwater and marine environment; climate change; and finally energy, technology and waste. Table 1 presents the entire list of emerging issues together with their rankings.

Box 2. Global Change and the New Generation of Emerging Issues

It is natural and appropriate to identify issues in terms of familiar, important themes such as managing food systems; creating more effective systems governing the uses of freshwater; stimulating environmentally friendly energy sources; or regulating the development of novel but potentially dangerous technologies. But all these issues take on new dimensions when we consider how comprehensively humanity is unintentionally transforming the earth system. Indeed, the earth system is entering a new era that differs sharply from the last 10,000 years, the relatively stable period that has supported the emergence of human civilizations. While the last 10,000 years are known in geology as the Holocene, scientists increasingly refer to the emerging epoch in planetary history as the Anthropocene, an era defined by the role of the human species as a core driver of earth system evolution.

Today human actions have become major forces in the operation of the earth system. They increasingly challenge the system boundaries of the planet, which will result in fundamental, unprecedented and unpredictable changes in the earth system.

This is a new situation. It calls for a fundamental shift in perspectives and world views as well as a new paradigm to guide action. It calls for reconnecting human development and progress to the capacity of the earth system to sustain our own development. It requires planetary stewardship.

It is time to redirect the existing policies that still focus on sectoral approaches, on steady-state perspectives, and on a view of the environment as something that is 'outside society'. Decision-makers need to recognize people and societies as integrated parts of the biosphere, depending on its functioning and life-support while shaping it globally.

These changes have multiple elements and dimensions. To name a few:

- Levels of connectedness from local to global scales are increasing
- Rapid interactions and dynamics between domains are pervasive
- Processes of change are accelerating
- More changes are non-linear, abrupt, and irreversible

In short, we are moving into a world that differs in fundamental ways from the one we have been familiar with during most of modern human history. This transition has profound consequences. It calls for the development of a new paradigm to guide thinking about emerging environmental issues.

Issues that previously could be addressed individually must now be examined together. Instead of thinking about land, water, energy or biodiversity as distinct issues, for example, we realize that these issues interact extensively with one another. Many emerging issues - such as the production of biofuels, the spread of marine dead zones, and the emergence of green water teleconnections - are products of these interactions. This requires us to re-evaluate old issues in a new light. It informs our understanding of what the new emerging environmental issues in the 21st century are.

Shocks and surprises that arise as emergent properties of the dynamics of the earth system are becoming regular occurrences. The consequences of tipping points in the climate system and other planetary boundaries with environmental chain reactions resulting in the loss of ecosystem services are cases in point. The pursuit of resilience - the capacity to deal with the interplay of gradual and rapid change and continue to develop - in a setting marked by high levels of uncertainty coupled with the turbulent behaviour of large social-ecological systems is emerging as an overriding concern.

None of this reduces the importance of addressing familiar issues like managing food systems, creating more effective systems governing the uses of freshwater, stimulating environmentally friendly energy sources or regulating the development and use of novel but potentially dangerous technologies. In fact many of the 21 issues we identify in this report have a thematic nature, but others broaden our view of emerging issues to encompass more than the sectors we are used to looking at. Our comprehensive role in changing the earth system calls for a new, more comprehensive and cross-cutting perspective. We must reinvent policies and governance systems to foster stewardship of our future, as humans in collaboration with the biosphere.

Table 1: The 21 Emerging issues

Issue ID	Issue Title	Ranking*
	Cross-cutting issues	
001	Aligning Governance to the Challenges of Global Sustainability	**1**
002	Transforming Human Capabilities for the 21st Century: Meeting Global Environmental Challenges and Moving Towards a Green Economy	**2**
003	Broken Bridges: Reconnecting Science and Policy	**4**
004	Social Tipping Points? Catalyzing Rapid and Transformative Changes in Human Behaviour towards the Environment	**5**
005	New Concepts for Coping with Creeping Changes and Imminent Thresholds	**18**
006	Coping with Migration Caused by New Aspects of Environmental Change	**20**
	Food, biodiversity and land issues	
007	New Challenges for Ensuring Food Safety and Food Security for 9 Billion People	**3**
008	Beyond Conservation: Integrating Biodiversity Across the Environmental and Economic Agendas	**7**
009	Boosting Urban Sustainability and Resilience	**11**
010	The New Rush for Land: Responding to New National and International Pressures	**12**
	Freshwater and marine issues	
011	New Insights on Water-Land Interactions: Shift in the Management Paradigm?	**6**
012	Shortcutting the Degradation of Inland Waters in Developing Countries	**15**
013	Potential Collapse of Oceanic Systems Requires Integrated Ocean Governance	**13**
014	Coastal Ecosystems: Addressing Increasing Pressures with Adaptive Governance	**19**
	Climate change issues	
015	New Challenges for Climate Change Mitigation and Adaptation: Managing the Unintended Consequences	**7**
016	Acting on the Signal of Climate Change in the Changing Frequency of Extreme Events	**16**
017	Managing the Impacts of Glacier Retreat	**21**
	Energy, technology, and waste issues	
018	Accelerating the Implementation of Environmentally-Friendly Renewable Energy Systems	**7**
019	Greater Risk than Necessary? The Need for a New Approach for Minimizing Risks of Novel Technologies and Chemicals	**10**
020	Changing the Face of Waste: Solving the Impending Scarcity of Strategic Minerals and Avoiding Electronic Waste	**14**
021	The Environmental Consequences of Decommissioning Nuclear Reactors	**17**

* Ranking based on scoring by the UNEP Foresight Panel and after considering the polling results of more than 400 scientists worldwide.

Cross-cutting Issues

Issue 001 Aligning Governance to the Challenges of Global Sustainability (Ranked #1)

Where we stand

By all accounts, governance for global sustainability is already a major enterprise. Presently, more than 900 intergovernmental agreements with provisions on environmental protection are in force. Major environmental summits – such as the Conferences of Parties to the UN Framework Convention on Climate Change – regularly draw several thousand participants and observers. Global environmental policy has become a core item on the agenda of the UN system and of regional organizations alike.

Despite the size of the effort, it is not clear that the current system of global governance is adequate for the necessary transition to sustainability. In an October 2011 report, Biermann and many other social scientists argue that a core challenge for environmental policy is to align and revitalize governance, at all levels, to the pressing needs of global environmental change and the possible disruption of the earth system.

In what way does environmental governance need to be revitalized? Firstly, on the national and local levels, experts have found that sustainability concerns are, in general, not well integrated into the energy, water and other sectors of the economy (see the discussion of governance in the coastal zone in Issue 014). Several experts, including Jordan (2008) have pointed out the need for better integration at these levels.

A question being debated by scholars is whether the current approach to international decision-making (decisions by consensus), borrowed from the 19th century, is appropriate or adequate for dealing with today's environmental challenges. Some say that qualified majority voting, for example, would be more appropriate.

Some also argue that governance is, to a degree, fragmented at the international level and that more could be accomplished if different institutions would work together more closely on sustainability issues. (See, for example, the discussion of governance of oceans in Issue 013). Several studies, including one by Young and colleagues (2008), show that the plethora of intergovernmental environmental agreements lacks overall integration and effective coordination, as well as effective means of foresight, early warning, and proactive development of policies.

Other researchers, including Newell and Bulkeley (2010), have argued that intergovernmental decision-making today is marked by too little representation, accountability, and effectiveness in addressing the fundamental challenges of global environmental change and the needed transition to sustainability.

Regarding the UN, scholars argue that the UN system has not sufficiently addressed the challenge of sustainability. A number of studies, including those by Young and colleagues in 2008, and Biermann and colleagues in 2011, have asserted that the UN Environment Programme and the UN Commission on Sustainable Development could provide stronger leadership on sustainability issues if they received stronger international support. Although many specialized programmes and agencies of the UN system incorporate sustainability issues in their agendas, a strengthening of coordination across these organizations would make their work more effective.

Other experts believe that the current global governance system lacks sufficient means and mechanisms to help the most vulnerable countries carry out sustainability programmes. Some believe that the reality of global environmental change, which every country is affected by and which cannot be localized, provides a new ethical motivation for richer countries to assist poorer countries in adapting to climate challenges and other global changes.

Credit: UN Photo/Mark Garten

Importance/relevance

In general, national governments typically lack the capacity to support strong policy actions on environment at the global level. Yet the numerous emerging environmental challenges facing the world today are unlikely to be resolved without major, new efforts by governments in addressing the fundamental governance challenges that lie ahead.

Incrementalism and piecemeal approaches to global governance may not guarantee the urgently needed transition to more sustainable means of production and consumption. It appears that we may be seeing the emergence of a 'constitutional moment' in the development of international relations and governance, comparable in recent times only to the major constitutional moment of 1945 'post World War II' that saw the emergence of a multitude of new, and often unprecedented, international norms, institutions, and agencies. Similar fundamental revisions in norms, processes and mechanisms of global governance would help address the global sustainability challenge.

Options for action

Policymakers have many options for better aligning governance to the sustainability challenge. A first step would be to raise awareness about this issue through a public debate about the actions to be taken.

One action to consider is to streamline intergovernmental decision-making by moving towards a qualified majority vote, which as it turns out, is already common in the 20-year old regime on stratospheric ozone depletion and several other treaty regimes. This could help speed up decision-making processes.

Another option is to agree on a constitutional framework for sustainable development, for example, comparable to the strong one existing for trade liberalization. This could help minimize overlaps between existing institutions and stimulate the development of new institutions in areas such as water or new technologies.

Stronger international institutions could help foster compromises in international negotiations, initiate the negotiation of new norms, and encourage the implementation of sustainability policies in smaller and poorer countries.

A stronger and more institutionalized involvement of civil society in intergovernmental decision-making could provide broader support for norms on sustainable development and environmental protection, and better protect the interests of marginalized groups and future generations. Governance in the 21st century may also require new types of involvement and participation of civil society and other stakeholders in decision-making. The founding of numerous public-private partnerships has provided examples of novel ways of governance, including the institutionalized representation of stakeholders in decision-making – from farmers to environmentalist organizations. The overall effectiveness of such novel governance arrangements, however, is not yet clear, and further research on the comparative advantages of different types of governance mechanisms is urgently needed.

Consequences of inaction/action in the next 10–20 years

Business as usual in global politics is likely to result in further deterioration of negative environmental trends. The protection of global climate, for example, was already declared more than twenty years ago as a 'common concern of humankind' by the UN General Assembly, and all nations were requested to take forceful action on reducing emissions. Twenty years later, many believe that the actions taken have been ineffective in forestalling major climate change impacts.

However, should governments and other actors take the path of fundamentally realigning and revitalizing global governance in the area of sustainable development, the transition to sustainability may succeed.

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Issue 002 Transforming Human Capabilities for the 21st Century: Meeting Global Environmental Challenges and Moving Towards a Green Economy (Ranked #2)

Where we stand

Society has already confronted a host of global environmental challenges including loss of biodiversity, climate change, water and land degradation among others, and, through persistence and ingenuity, has found many solutions to these challenges. Now the question is whether society has the right capabilities to implement these solutions, meet the global environmental challenge and support a burgeoning Green Economy.

Many commentators believe that the answer to the capabilities question is simply "no", and that a huge effort is needed on all fronts before society is adequately equipped to deal with the sustainability challenge of the 21st century. 'Capabilities', in this sense, means the necessary job skills, modes of learning, management approaches and research efforts. Starting with *job skills*, a UNEP report in 2008 noted that the US, Germany, Brazil, China and other countries, were already suffering from a shortage of skilled workers in the 'green' sector of the

Credit: Still Pictures/VISUM/Wolfgang Steche

economy (as noted in Issue 018). With regards to *modes of learning,* Beddoe and others (2009), argue that our current pedagogic methods, from schooling to professional training, are unsuited for achieving sustainable development. Not only are more training programs needed to provide workers for the green workforce, but background education in sustainability principles is needed for virtually all professions, so that these principles can be built into the day-to-day affairs of government and commerce. Current *management approaches* also have their drawbacks when it comes to building a Green Economy. The aforementioned UNEP report also notes that 'new perspectives, awareness, and managerial capacities' are needed for the green sector of the economy. Finally, many question the adequacy of traditional *research efforts* in meeting global environmental challenges. Experts advocate a shift from independent, curiosity-driven research to a much deeper level of engagement of science with society. As put by the International Council of Science (2010) '…the global scientific community must take on the challenge of delivering knowledge required to support efforts to achieve sustainable development in the context of global environmental change…'

Importance/relevance

There are already indications that the paucity of job skills in the green sector may be holding back society's ability to cope with global environmental change. Lack of personnel, for example, is apparently slowing the growth of the renewable energy industry, which has the knock-on effect of slowing the control of greenhouse gas emissions and air pollutants. Hence, society has a more difficult time coping with climate change and air pollution impacts. More generally, UNEP (2008) suggests that current shortages in skilled labor may 'frustrate efforts by governments to transition to a Green Economy and deliver the expected environmental benefits and economic returns.' In addition to the gap in job skills, similar deficiencies in modes of learning, management practices, and research efforts all undermine efforts to deal with adverse global environmental change.

Options for action

What steps can be taken to build up society's capabilities to meet the sustainability challenge of the 21st century?

One obvious and important step would be to train workers to fill in the gaps in the green workforce, as discussed above. In its 2008 report, UNEP defines green jobs as 'work in agricultural, manufacturing, research and development, administrative, and service activities that contribute substantially to preserving or restoring environmental quality.' New green jobs include various technical, administrative and engineering positions in the renewable energy industry, as well as jobs retrofitting residential and commercial buildings to improve their energy efficiency. Coupled to the need for smarter and 'greener' technologies are new employment opportunities in the fields of housing and spatial planning, and sustainability-related legal and policy issues. Many new managerial and administrative positions will be needed for handling cross-cutting issues such as integrated water resources management, ecosystem services accounting, and ecosystem-based adaptation to climate change

How can we improve our modes of learning to make them better suited for the sustainability challenge? One way is for educational systems to extend their curricula and programs to better prepare students for jobs in the Green Economy. It is particularly important to provide interdisciplinary and multi-disciplinary training that equips students to deal with the cross-cutting nature of sustainability-related jobs. Before specializing in a particular field, say climate science or wind power mechanics, students should be taught the fundamentals of both the natural and social sciences that underlie global environmental change. Based on a poll of professionals, the International Society of Sustainability Professionals also identified other skills crucial to working in the sustainability field such as strategic planning, systems thinking, and project management.

What role do managers play in the sustainability agenda? First of all, managers are needed across the board to manage sustainability-related projects in areas such as renewable energy development, integrated water management, and urban ecological planning. Second, they are needed within many larger firms, not necessarily within the green sector, to manage their corporate programs on 'Social Responsibility' or 'Sustainability'. What new capabilities do they need? In both cases, managers need training beyond standard interpersonal management skills to encompass a strong understanding of local to global sustainability issues. They also need a grasp of the methods to assess the sustainability benchmarks of a firm, such as ecological footprint analysis, life cycle analysis, and others, as well as a strong capability in systems thinking.

Credit: Still Pictures/argus/Peter Frischmuth

The research community must also build up new capabilities to address global environmental change and support the Green Economy. The International Council of Science (2010) argues that this will require basic changes in the structure of current research that promote interdisciplinary research, that allow for more regional-based research, and that strengthen the interaction of science with decision-makers and other stakeholders. The form of these changes is now being debated within the scientific and funding communities, but could include a new governance structure for the organizations that coordinate global change research and new research priorities for the scientific community.

Consequences of inaction/action in the next 10–20 years

What are the consequences of not acting to build up human capabilities? The International Council of Science (2010) has stated that the 'pace and magnitude of human-induced global change is currently beyond human control and is manifest in increasingly dangerous threats to human societies and human well-being'. Extrapolating a decade or more from now, we might logically assume that the adverse impacts of climate change, land degradation and other global environmental changes will be even more serious. Then, perhaps, we will regret our lack of capabilities to deal with these threats.

On the other hand, society could follow an alternative pathway to the future and make a special effort to fill in the skills gaps in the green sector. It can also update educational institutions to better cover educational needs for sustainability work, and train managers to better respond to global environmental change, and retool research efforts to better address the sustainability challenge. If society follows this pathway, then it is likely that a decade from now we will be in a much stronger position to contend with global environmental change.

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Issue 003 Broken Bridges: Reconnecting Science and Policy (Ranked #4)

Where we stand

Meeting the challenge of global environmental change requires, among other things, a strong base of knowledge about environmental issues. This knowledge largely comes from the scientific community but also from many non-scientists. The important point is that this knowledge has to be communicated to a wider audience of decision-makers and the general public. It is this larger community that has to make the difficult decisions about how to contend with climate change, deforestation, water scarcity, and other global environmental changes facing society. Because these decisions could be costly and have many other implications for society, decision-makers need to have a high level of confidence in the science behind their choices.

Unfortunately, some experts including Upham and others (2009) believe that public confidence in environmental science is diminishing. Others see signs of a deepening distrust of environmental scientific outputs, such that scientific advice is sometimes resisted by economic and policy actors, even on critical issues. A signpost for this is the questioning of climate change science set off by 'Climategate' and the controversy over a few errors in the 2007 climate change assessment of the Intergovernmental Panel on Climate Change. Some attribute the inability to produce a new binding agreement on emission reductions at the 2009 Copenhagen climate summit to a new scepticism about climate change science. Others point to a 2010 Gallup poll which shows a general slump in concern over global warming amongst US citizens since 2008. The poll shows a 13% increase, between 2008 and 2010, in the number of those who believe that the issue of climate change has been exaggerated, and a 9% decrease in the number of those who believe that the issue is generally correct. Moreover, the president of the US National Academy of Sciences, Ralph Cicerone remarked at a conference in 2010 that he thought the damage to climate change science "has spilled over to other kinds of science."

As to the cause of the "broken bridges", some scholars such as Holmes and Clark (2008), believe that failed communication is at the root of the problem. The Arctic Climate Change and Security Policy Conference noted that, 'a communication gap persists among scientists and policy makers' (Yalowitz et *al.*, 2008). This is not too surprising since scientific results are usually difficult to translate directly into actionable policy options. The situation is further aggravated by the fact that

few scientists are trained to communicate results in a non-technical way. When scientists do try to communicate their findings they sometimes lean too heavily on alarming results – on the growing water crisis, or rapidly disappearing number of species. But this may work against effective communication because, as noted by scholars such as Garnett and Lindenmayer (2011), people tend to discount bad news.

Campbell and others (2007) suggest that the relative inaccessibility of scientific results is another factor. Although scientific outputs are increasing, many of them are embedded in grey literature not widely distributed, or in costly scientific journals which are too expensive for organizations in developing countries and many individuals across the world. Another problem is that it is often difficult to retrieve needed data or information because it is spread out across many institutions and databases.

Importance/relevance

What are the consequences of the recent (or continuing) lack of confidence or concern for environmental science shared by policymakers and the public? Some believe that scientists continue to talk mainly amongst themselves and rarely with policymakers such that the number of meeting points between scientists and policymakers is relatively limited. Whether this number has decreased in recent years or not has not been documented, but it appears that most environmental research is still instigated, designed and delivered by scientists with little appreciation for how it can be useful to policymaking. The upshot, as articulated by Juntti and others (2009), is that relatively few policy decisions are based on a balance of environmental, economic and social considerations. To close the circle, this reinforces the opinion of scientists, as observed by Choi and others (2005), that research is not particularly useful or of interest to policymakers. Hence, on one hand only a small amount of science is driven by requests from policymakers, and on the other, science is seldom used in the policy arena where it is needed, or at times it is 'cherry-picked' to legitimize decisions already taken. This is a dilemma because it seriously hampers the uptake of urgent environmental information by policymakers and stakeholders at a time when solving environmental challenges require, more than ever, scientific results with a high level of clarity, accessibility, credibility and legitimacy.

Options for action

A high priority for repairing bridges is to analyze which factor or factors are contributing the most to the lack of confidence. The task of strengthening or rebuilding bridges between science and policy requires a new look at the way science is organized and how the science-society-policy interface can be improved.

On the issue of communication, this can be improved by organizing more substantive meetings between scientists and policymakers. Examples of such meetings are the regular briefings given by researchers to the ministerial advisors in the Subsidiary Body for Scientific and Technological Advice of the climate convention, and the regular 'Science-Policy Dialogues' on climate issues organized by the International START secretariat.

Credit: Shutterstock/olly

Communication and an exchange of views can be also be enhanced using the method of *integrated assessment* which is a process by which knowledge about a particular topic is assessed by scientists in a multi-disciplinary and policy-relevant way. During the assessment, scientists work closely with policymakers and other stakeholders to scope the assessment, review and critique drafts of the report, and agree upon its summary and main messages. Major integrated assessments such as the UNEP Global Environment Outlook and the Millennium Ecosystem Assessment have been carried out for climate change, ecosystems services, water and the global environment.

Another method for enhancing communication between scientists and policymakers is *environmental scenario analysis*. This approach involves scientists, policymakers and other stakeholders working closely together to elaborate alternatives on how an environmental situation may evolve into the future. As just one example, the 'Great Transitions Scenario', developed by experts and stakeholders as part of the Rwanda State of Environment and Outlook Report, pointed out the policy steps leading to 'social regeneration' and natural resources management with participation of all stakeholders.

There is also a good argument for framing some science in more optimistic and positive ways – an 'actively-promoted culture of hope'. Furthermore, uncertainties need to be clearly communicated, and ways found for more nuanced predictions to be factored into policy.

On the issue of accessibility of scientific results, there are many options to increase access including making international scientific journals available at an affordable cost to individuals and institutions in developing countries. This is being done, for example, through the 'Online Access to Research in the Environment' Programme. Another example is establishing open clearinghouses to make information more accessible - an example here is the "Conservation Commons" hosted by the UNEP World Conservation and Monitoring Centre.

Consequences of inaction/action in the next 10–20 years

Not acting to repair the bridge between environmental science and policy will stifle vital cooperation between science

and policy communities. Tension may increase between the two communities, thereby further hindering communication. The likely outcome is that decision-makers will not have adequate knowledge to intervene in environmental problems, scientists will have few incentives to make their outputs policy-relevant, and the public will not support the expense of intervening. In sum, society will be less equipped and less successful in managing the risks of global environmental change.

Taking action to improve communication, access to scientific information, and other underlying causes of broken bridges, will provide an atmosphere by which the scientific community can respond better to the needs of society. Policymakers will be better informed, and the public will benefit from evidence-based policies. The scientific community will take its rightful place as an integral part of society, providing valuable contributions to the handling of important issues of our day such as climate change and environmental degradation.

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Issue 004 Social Tipping Points? Catalyzing Rapid and Transformative Changes in Human Behaviour towards the Environment (Ranked #5)

Where we stand

The World Business Council for Sustainable Development (2008) and a growing number of scholars including John (2004), Conger (2009), and Schwerin (2010) argue that technological breakthroughs and efficiency gains alone will be inadequate for achieving environmental sustainability. According to this way of thinking, it may also be necessary for society to shift away from its current high consumption levels and polluting activities to a more sustainable mode of behaviour. If this is true, how can the necessary changes to human behaviour be efficiently and rapidly triggered? An answer to this question may lie in recent social science findings about 'social tipping points', i.e., rapid and purposeful transformative social change.

Credit: UN Photo

An often-cited example of a social tipping point is the transformation within one generation of cigarette smoking from a widely accepted activity to a social anathema in many countries. This transformative change was brought about, or at least supported, by public policy. This included a successful mix of economic incentives such as taxation, public awareness campaigns, unambiguous statements about health hazards, public-private covenants in areas such as advertisement or entertainment, and a ban on smoking in some public spaces. An environmental example is the emergence of wide-spread changes in public perceptions and behaviour in many countries in areas such as waste separation and recycling, as well as water and energy conservation. Other transformative changes include the shifting attitude regarding the consumption of whale meat within one or two generations, or the use of animal furs for clothing. Some argue that the current growth of vegetarianism or the slow-food movement might signal further transformative changes from highly consumptive to more sustainable ways of life.

Importance/relevance

The key idea behind social tipping points is that societal change is non-linear. As documented in the case of phasing

out nicotine abuse in many countries, stronger governmental policies might influence certain 'tipping points' in social behaviour that lead to a more fundamental and rapid transformation of societal norms and standards of behaviour than might otherwise be expected.

As noted above, many experts believe that behavioural change is at the core of many environmental problems. Behavioural transformations support more effective systems of governance and help build human capacities for change. Such changes are also vital in addressing many other issues, from the depletion of water resources by overconsumption, to the mitigation of climate change by modifying mobility patterns and life-styles. The support of behavioural change is not new *per se*, and it has been part and parcel of environmental and health policies for decades. Yet, Lucas (2008), Crompton (2009) and others believe that previous efforts to encourage sustainable behaviour were not sufficient. The much desired sustainability transition is less likely, or more difficult, without a substantial transformation in modern lifestyles, from the rich industrialized countries to the rapidly developing mega-cities in the South.

Options for action

What can public policy learn from recent research about how to encourage positive, rapid and transformative changes in human behaviour? What incentives – e.g., economic, informative, or prohibitive – work best to initiate such changes? How can international environmental agencies help governments and other actors trigger transformative change? No definitive answers exist to these questions and it would be worthwhile for members of the policy and scientific communities to work together to uncover what knowledge there is to gain. But part of the answer lies in information-exchange, joint programmes, and public-private partnerships. For example, the public sector can encourage positive change in consumer attitudes through more concerted information campaigns, more effective economic instruments, and legislative action. Governments can also further strengthen civil society organizations in their activities on public engagement and behavioural change. Also public-private covenants can help develop new products and serve as agents of change.

Consequences of inaction/action in the next 10–20 years

If public policy and other efforts are unable to move consumption patterns in a more positive direction, it is likely that an unsustainable culture of material consumption will continue to spread to all countries with a burgeoning middle class. The upshot will be a continuation, and perhaps intensification, of the environmental pollution and resource depletion caused by this consumption pattern.

On the other hand, society has the option of using its new-found knowledge about social tipping points to encourage more sustainable consumption habits. Eventually, perhaps soon, the combination of sustainable consumption, together with low-impact technology and efficiency improvements, will lead to a more sustainable rate of resource usage, a smaller pollution load on the environment, and a more sustainable society.

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Issue 005 New Concepts for Coping with Creeping Changes and Imminent Thresholds (Ranked #18)

Where we stand

Researchers including Glantz (1999) and Kelman (2006) have labeled a special category of environmental change as 'creeping changes'. These are human interactions with the natural environment that have a slow onset, advance incrementally, and eventually pass a threshold and quickly lead to changes in the environment.

A classic example is the decimation of Central Asia's Aral Sea (the fourth largest inland sea in the world). The problem began with the incremental diversion of water from the region's two major rivers to grow crops in fertile desert soils. The slow build up of diversions from the rivers, over time, led to a situation in which the rivers' substantial flows into the Aral became trickles and the evaporation rates from the sea's surface greatly exceeded the amount of water reaching the sea, and it began to shrink. By 2000, the Aral Sea as a major inland body of water had essentially disappeared. This caused an outmigration from its coastal areas; a loss of ecosystem services (fish, forest, grazing, wildlife); toxic dust storms emanating from the heavily contaminated, now exposed, seabed; and a

Credit: UN Photo/Martine Perret

change in regional climate with hotter summers and colder winters.

Some environmental changes that could also be labelled as creeping changes include acid rain, stratospheric ozone depletion, desertification, tropical deforestation, mangrove destruction, soil erosion, biodiversity loss, water pollution, overfishing, and groundwater contamination by leaky landfills.

Importance/relevance

Of particular importance to policymaking is the fact that creeping changes are easily overlooked in their early stages because of their slow onset and incremental nature. However, when left unchecked, they often build up over time and can have local to global impacts. Yet, it is in their early stages that creeping changes are easiest and cheapest to cope with. An early intervention to acid rain in Europe would likely have avoided the expensive later costs of liming soils and lakes to compensate for acid deposition, and the costly retrofits of filters on power plants to reduce acidifying emissions.

Options for action

It turns out that most creeping environmental changes that occur because of human interactions with the environment are foreseeable. The challenge, then, is how to anticipate, monitor, and manage creeping changes early enough to avoid their emergence as costly problems.

Glantz (1999) and other researchers believe this would require a shift in the focus of environmental policy from crisis management to effective early monitoring and timely precautionary action. Along these lines, early monitoring systems could be customised to detect different slow-onset environmental changes. Lenton and others (2008) highlight the need for systems with improved capacity for real-time monitoring, e.g., effective signal detection and precision predictions. They also note the need for backward extrapolation of existing monitoring data in order to develop better predictive models for anticipating creeping changes.

Another option to prevent the consequences of creeping changes is to raise the awareness of policymakers and other stakeholders, and convince them that action is needed to avert a crisis. They could be informed about places in the world where creeping changes have already led to environmental turning points, as in the case of acid rain in Europe and ozone depletion of the stratosphere. But action is not likely to be taken unless scientists can make a clear connection between a particular creeping change and an important consequence of this change such as the loss of a 'keystone' species or a threat to food security.

Consequences of inaction/action in the next 10–20 years

If environmental policymaking continues to center on crisis management rather than trying to anticipate the likely outcome of creeping changes, we may find ourselves solving one newly emerging environmental crisis after another. In effect, one generation is shifting responsibility for handling environmental problems to the next generation, or the one after that.

On the other hand, effective early warning systems and timely responses can help policymakers keep ahead of potentially damaging changes. "An ounce of prevention is worth a pound of cure" is a cultural adage that applies as well to environmental changes in which human activities are involved. Applying the early detection of seemingly harmless small changes provides that 'ounce of prevention.'

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Issue 006 Coping with Migration Caused by New Aspects of Environmental Change (Ranked #20)

Where we stand

Mass migrations of people have been a longstanding feature of humanity and have had many causes including civil conflict, war, religious intolerance, and economic opportunities. In the 1970s and 80s, the new term 'environmental refugee' came into use. Recently environmental migrants were defined by the International Organization for Migration (2009) as 'persons or groups of persons who, for compelling reasons of sudden or progressive change in the environment that adversely affects their lives or living conditions, are obliged to leave their habitual homes, or choose to do so, either temporarily or permanently, and who move either within their country or abroad'.

It is important to note that environmental factors are usually mixed up with social and other factors so it is difficult to unequivocally deem someone an 'environmental migrant'. Nevertheless, since the 1970s there has been increasing efforts, e.g., by the UN Office for the Coordination of Humanitarian Affairs, to monitor migration where environmental factors play a significant role. There is also a growing body of studies that suggests that environmental change will become an increasingly decisive factor in the displacement of people. Hence, this is an old but intensifying issue that merits renewed attention. What are the new and ongoing aspects of environmental change that will contribute to future migration?

Firstly, there are rapid-onset events related to climate change, such as more frequent or intense coastal and river flooding, hurricanes, or wind storms that can permanently drive people from their settlements. Under this category fall violent conflicts due to competition for resources such as water and land, which may be depleted by climate change or other environmental pressures (see Issue 016 for a description of the increasing evidence for changing frequency of extreme weather events).

Secondly, there are 'slow-onset' processes that gradually make conditions untenable for people, causing them to consider migrating (see Issue 005 for a description of "creeping changes" in the environment). Included here is sea level rise which will inundate coastlines and island states, and warmer temperatures and more frequent droughts in some areas which will pose new risks to agriculture. Another such slow-onset process is land degradation (or 'desertification' when it pertains to dryland areas) especially connected with intensive land use and prolonged drought.

Importance/relevance

The UN Office for the Coordination of Human Affairs (2009) estimated that, in 2008 alone, at least 20 million people worldwide were displaced by 'climate-induced sudden-onset natural disasters'. Although these natural disasters cannot be unequivocally linked to long term climate change, the people they displace are sometimes called 'environmental migrants' and give a hint of the risk of human displacement due to future changes in climate. Estimates of future environmental migrants range upwards from 200 million by 2050 according to various studies reviewed by the International Organization for Migration (2009). These estimates are, however, highly uncertain and depend greatly on the definition of environmental migrants. But regardless of the exact numbers, the message is that there is a high risk that environmental change will become an increasingly important factor driving migration.

Credit: UN Photo/UNHCR/Alexis Duclos

Options for action

One response option is to address the root causes of environmental migration. Some rapid-onset events can be better dealt with through enhancement of early warning systems and well defined hazardous area zoning. The slow-onset events can be coped with through improved coastal protection, drought planning, land restoration, and other measures.

Another option is for governments to assess their capacity for dealing with climate-related migration as part of their National Adaptation Programmes of Action, being developed under the Framework Convention for Climate Change. Some countries, such as the Solomon Islands and the Maldives, are

already looking into resettlement options to safer quarters for their populations threatened by sea level rise.

Another option is for countries to broaden their immigration policies to include environmental migrants, as Sweden and Finland have done. On the international level, Biermann and other scholars (2010) argue that environmental migrants should be protected under specific international legal agreements, for example a protocol under the UN Climate Convention.

There is also a need to improve the prediction of environmental migration. One source of uncertainty is that migrations due to environmental factors have a different character than those propelled by political persecution or economic opportunities. Hence, there is a need for more reliable data about the environment-migration nexus and more research about likely migration scenarios and pathways.

Consequences of inaction/action in the next 10–20 years

If no decisive action is taken to address the issue of environmental migration, the number of people displaced, either within their own countries or across borders, will likely increase as climate change and other pressures on the environment grow in intensity. We might also expect an increase in the human suffering, social disruption and international tension that accompanies large migration flows.

Credit: UN Photo/Paul Banks

But society can choose to follow an alternative pathway. By combining short-term and long-term planning and research, countries and institutions would be able to anticipate and cope with new environmentally-related population displacements and help minimize the suffering involved. Large migrations might be avoided through public policies that reduce the vulnerability of their populations, for example by improving early warning of coastal and other floods, and by enforcing the zoning of river flood plain areas. With advanced planning, much can be done to avert or alleviate environmental disasters that cause people to leave their homes and join the sad stream of internal and cross-border migrants.

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Food, Biodiversity and Land Issues

Issue 007 New Challenges for Ensuring Food Safety and Food Security for 9 Billion People (Ranked #3)

Where we stand

Although food security is an age-old preoccupation of humanity, new threats to this security are constantly arising. The most recent list includes climate change, competition for land from bioenergy production, heightened water scarcity, and possible shortfalls of phosphorus for fertilizer. Many of the older challenges still remain, including degradation of agricultural land, competition for land with cities, and increasing demand for food due to growth in population and affluence.

The US Department of Agriculture (2011) estimates the number of 'food-insecure' people (as of 2010) in 77 developing countries at 861 million. Meanwhile, the UN says that the world population is likely to reach 9 billion by 2050. Most of these billions will live in developing countries and have higher incomes, which in turn will further increase the demand for food. The implication is that food production has to grow still further over the next half-century to cover this new demand.

When the effects of climate change are taken into account (higher temperatures, shifting seasons, more frequent and extreme weather events such as floods and droughts), the challenge for food production becomes even more daunting. For instance, the Intergovernmental Panel on Climate Change (2007) noted that some African countries could face reductions in yield of up to 50% by 2020 if they fail to adapt to the changing climate.

In addition to the combined pressures of a larger population and climate change, farmers will compete for land with both old competitors, such as expanding cities, and perhaps new competitors, such as reforestation and nature conservation projects, and energy cropping for bioenergy. The Food and Agriculture Organization (FAO) and International Energy Agency (2008) have estimated that the global area devoted to bioenergy crops could grow from around 13.8 million hectares in 2004 to between 34.5 and 58.5 million hectares in 2030, depending on scenario assumptions (see Issue 010 on the new rush for land in developing countries for bioenergy and other crops). Meanwhile, den Biggelaar and others (2004) estimate that around 2 to 5 million hectares of land continue to be lost each year to land degradation, mostly related to soil erosion. The availability of water is already taken to be a limiting factor in many agricultural areas. Another possible limiting factor is phosphorus, which is a critical fertilizer input to modern agriculture. The remaining lifetime of worldwide phosphorus reserves is being hotly debated, as noted in a recent UNEP report (2011). Although, reserves might last for 300 years at current production rates, the supply of cheap and easily accessible phosphorus is ultimately limited, raising questions about the sustainability of world fertilizer supplies.

Apart from food security, food *safety* is also an essential aspect of a sustainable and secure food system, and is of concern to both consumers and industries. According to the World Health Organization (WHO) (2007), each year up to 30% of the population in high-income countries may suffer from food-borne diseases. A recent example is the case of *E. coli*-contaminated vegetables which resulted in 15 deaths and over 1000 hospitalized people across Europe. The contamination situation could be as bad in low-income countries but is not well documented. Furthermore, Miraglia and others (2009) estimate that global warming could, under some circumstances, increase food contamination and lead to more rapid spreading of diseases.

The WHO reported (2004) that about 75% of all diseases emerging during the last two decades have been "zoonoses", or diseases caused by microorganisms of animal origin that can be transmitted to humans. This is of particular concern to food safety considering there have been several recent outbreaks of domestic animal-related diseases such as swine flu, bird flu and mad-cow disease. Furthermore, wild animals and plants are still a fundamental part of the diet of many rural communities. The FAO (2008) estimates that about one billion people consume wild foods; and a World Bank report (2000) states that wild game and fish provide 20 per cent of dietary protein in at least 60 low-income countries. Wildlife trade may be a main source of zoonoses and provide a pathway for disease evolution and transfer. Recent research by Chaber and others (2010) suggests that about 270 tons of potentially contaminated illegal bushmeat may be passing unchecked through a single European airport each year.

Credit: UN Photo/Eskinder Debebe

Importance/relevance

Food safety and food security are important aspects of human well-being. A decline in the existing level of food security threatens lives and social stability. Hunger and poverty are closely linked, and addressing both will go a long way in achieving the Millennium Development Goals. Inadequate food safety can also pose enormous dangers as shown by the lives lost and economic costs of past episodes of food contamination.

Options for action

There are many options for enhancing global food security. One general approach, sketched out in the UN Secretary General's 'Comprehensive Framework for Action' (2008), has the first goal of covering the immediate needs of those already suffering from hunger, and the second goal of building up the resilience of vulnerable populations.

To cover immediate needs, the Framework recommends that 'emergency food assistance, nutrition interventions and safety nets are enhanced and made more accessible; that smallholder farmer food production is boosted; that trade and tax policies are adjusted; and that the macroeconomic implications are managed.'

To go beyond the immediate hunger crisis, and to build-up food security over the longer term, the Framework calls for 'social protection systems to be expanded; for smallholder farmer-led food availability growth to be sustained; for international food markets to be improved; and for an international biofuel consensus to be developed.'

Over and above what the Framework calls for, food security can also be enhanced by strengthening the long term ecological foundation of the world's food supply. This includes ensuring the long-term sustainability of fish stocks, promoting ecologically-sound cropland intensification, and reducing waste such as post-harvest losses in the food system. A viable option for enhancing both food security and food safety is to introduce or expand sustainable agriculture. As described by UNEP (2011), sustainable agriculture involves a wide range of actions, including: water conservation and water harvesting; soil and nutrient management; restoration of degraded landscapes; efficient plant harvesting; and early transformation of products to reduce post-harvest losses. All of these steps would strengthen the ecological basis of the food supply and make it safer and more reliable for consumers.

To better ensure global food safety, greater attention should be given to the dangers of zoonotic diseases. Early warning systems could enable an early response to food contamination episodes. Meanwhile, 'clean production techniques' could be applied across the board to the food processing industry to ensure the safety of food products going from farm to fork.

Credit: UN Photo/John Isaac

Consequences of inaction/action in the next 10–20 years

Failing to act to improve food security and safety will leave vulnerable populations susceptible to increased hunger and malnutrition, related civil unrest and perhaps further migration (see Issue 006 on new causes of migration). Marine ecosystems will continue to be depleted by overfishing and pollution. The public will be threatened by zoonotic diseases, as well as other types of food contamination.

Acting now will increase the resilience of millions, if not billions, to cope with new challenges to food security and food safety.

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Issue 008 Beyond Conservation: Integrating Biodiversity across the Environmental and Economic Agendas (Ranked #7)

Where we stand

The traditional approach to nature conservation and preserving biodiversity tries to minimize human interference with nature by isolating nature from society. But globally, only about 130,000 protected areas, with varying degrees of protection, have been designated, covering around 13.9% of Earth's land area. An even smaller area of the marine environment is protected, with 5.9% of territorial marine surface under some form of protection (CBD, 2010). Either the area protected is too small or the approach itself is insufficient because the 2010 target of the Convention on Biological Diversity, calling for no significant loss of biodiversity, has not been achieved.

However, two important new threads of research suggest a novel approach to maintaining biodiversity. They suggest that nature usually cannot, and should not, be isolated from humanity and this idea points to new solutions for addressing human-induced biodiversity decline.

Importance/relevance

The first thread of research provides new insights into the *linkages between biodiversity and the environmental agenda.* It articulates the important role of biodiversity and ecosystem functioning in the global biogeochemical cycles vital for sustaining life. For example, biodiversity plays a role in the carbon sequestered and stored by natural ecosystems, which in turn helps regulate the climate. Changes in climate, in turn, feed back to biodiversity. Another example of the linkage between biodiversity and the rest of the environment is the interaction between natural ecosystems and the water cycle, in which forests exchange vast amounts of moisture with the atmosphere, which is important in controlling local and regional climate, especially precipitation. Biodiversity also plays an important role in a whole range of other ecosystem services, such as the production of food, the control of disease, flood regulation, coastal protection, crop pollination, and recreational benefits. These and other research results make a strong case for integrating nature conservation and preservation of species into the rest of the environmental agenda.

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The second thread of research provides new understanding about the *close relationship between biodiversity and economic activity and value*. For example, the 2010 'TEEB' study on the economics of ecosystems and biodiversity has conservatively estimated the global economic impact of biodiversity loss at between $US 2 to 4.5 trillion, equivalent to about 7.5% of global gross national product. The report suggests that supposedly 'free' ecosystem services should be inventoried and priced by nations and businesses as part of the asset base that underpins economic activity and thus supports stable consumer prices. A conclusion of this second thread of research is that the biodiversity and economic agendas should be integrated more closely.

An overriding conclusion of both threads of research is that, making a stronger linkage between nature conservation and the environmental and economic agendas will lead to policies that more effectively conserve ecosystems while promoting human well-being.

Options for action

How, then, can the biodiversity issue be better integrated into the environmental and economic agendas? Starting with the environmental agenda, one answer is to more vigorously pursue the integrated management of land, water, marine, forest and other environmental resources. A second answer is to promote sustainable agriculture, which involves the multi-use of land, water, and other environmental resources, and tempered use of substances that could damage biodiversity (e.g., pesticides and herbicides) (see Issue 007 on the link between sustainable agriculture and food security.) Third, current and future environmental change (e.g., climate change) could be incorporated as factors into biodiversity planning, and vice-versa. For example, plans for mitigating climate change through use of renewable energy systems should consider the potential effects of these systems on biodiversity.

With respect to integrating biodiversity issues with economics, one idea is to introduce environmental accounting, i.e., inventories of the economic value of ecosystems, to all levels of governance. This includes the incorporation of natural capital (water supply systems, mangrove and other coastal forests, and so on) in national economic accounts. Another option is to have the public gradually pay for the ecosystem services that are undervalued. An example of this would be a municipality paying for the conservation of upland forests in order to maintain the reliability and quality of downstream water sources used by the city. Still another option is to phase out 'perverse subsidies' i.e., subsidies that have a significant negative impact on biodiversity and the sustainable use and equitable share of ecosystem resources. Examples of perverse subsidies are agricultural price supports that lead to deforestation, and fuel subsidies that support offshore oil drilling in sensitive marine areas. There is also a need for further research to understand the linkages between biodiversity and economic systems and to raise public awareness about these fundamental linkages. As a general conclusion there are many options for integrating biodiversity into the economic system as part of a new 'Green Economy'.

Consequences of inaction/action in the next 10-20 years

If action is not taken to link biodiversity issues with the broader environmental and economic agendas, there is the risk that nature conservation will be viewed only as a method for saving charismatic species. Moreover, we may see a continuation of the undervaluing of ecosystems and the important goods and services they provide, from food and fuel to water and climate regulation. If the public and government do not recognize the value of ecosystems, we may continue to lose these ecosystems and their services, along with their habitats and species.

By contrast, linking biodiversity with the broader environmental and economic agendas will lead to greater public awareness that natural ecosystems have high environmental and economic value, and that they play a vital role in human well-being. This, in turn, will lead to the development of effective policies for conserving ecosystems, and the goods and services they provide.

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Issue 009 Boosting Urban Sustainability and Resilience (Ranked #11)

Where we stand

The issue of urban environmental sustainability has two important aspects: there is the environmental quality within cities that city residents have to live with, and the environmental changes caused by cities outside of their borders. Neither is particularly sustainable. Consider the case of motor vehicles in cities: they pollute the air and water in cities and threaten the health of urban residents, but also contribute to air pollution outside of city limits and to global climate change.

Within cities, it comes as no surprise that air and water pollution levels often exceed recommended limits, especially in lower income countries. A 2007 UNEP report indicated that levels of particulate matter in the air over cities in many developing countries are many times the public health guidelines of the World Health Organization. Likewise, the level of nitrogen dioxide exceeds guidelines in most large urban areas. Cities, of course, entirely alter the natural environment within their borders and at their edges. Alberti (2010) pointed out that the interaction of humans and the natural environment within cities may even be creating a unique biochemistry of the environment.

It is also easy to understand that the concentration of people, industry, infrastructure and energy in urban areas has a major influence on the environment outside of cities. UNEP (2007) pointed out that this impact can be greater than proportional; whereas cities contain about half of the world's population, they consume about 60 to 80% of its energy and emit about 75% of its carbon dioxide emissions. And outside their boundaries, cities have a large ecological footprint. In addition to the air and water pollutants transported to the surrounding countryside and beyond, cities require an area much larger than their own for the food, materials and other

resources needed for their existence. As one example, Rees and Wackernagel (1996) estimated that the city of Vancouver requires a land area 178 times greater than its own area for its resource needs. The impact of cities may be even greater by mid-century when two-thirds of the world's population is expected to live in urban areas. On the other hand, not all cities or city designs have the same impact, as discussed below.

The issue of boosting sustainability goes beyond improving environmental quality within cities or reducing their outside impact. Sustainability also implies that cities should be resilient themselves to global environmental changes. Certainly one of the most important environmental changes that cities will have to cope with will be climate change, which is likely to increase the frequency of heat waves, and in some regions, the frequency of droughts and river and coastal flooding.

Importance/relevance

As urban areas become the home of a larger and larger percentage of humanity, the sustainability agenda will become increasingly intertwined with cities. The question then becomes: how can cities become more sustainable and resilient within their boundaries and reduce their impact on the outside world?

Options for action

There are, in fact, many different ways of achieving sustainability and resilience in urban areas. These ideas have been compressed into the concept of 'green cities', also known as 'ecological cities', 'eco-cities', or 'sustainable cities'. Green city concepts usually include the following features:

Compactness – Research has shown that a denser settlement pattern can reduce average trip distances and make walking, bicycling, and energy-efficient public transportation a more practical option for travellers. This reduces the dependence of urban dwellers on private vehicles which tend to use more energy and produce more air pollution per passenger-km than alternative modes of mobility. Higher density also brings lower costs for water and sewage systems, streets and other infrastructure, as well as lower per capita demands for land. The multi-story buildings typical of denser cities have a lower surface-to volume ratio, which can reduce heating and cooling loads compared to those of single story buildings. Such buildings often use less building materials per person than single story buildings. However, all of these economies depend on the income levels of city inhabitants. Usually the lower the income level, the lower the level of per capita consumption.

Mixed-use settlement patterns – Allowing or encouraging a mixture of residences, businesses and other services within the same neighbourhood can also reduce dependence on vehicles and thereby reduce energy use. This has been coined 'access by proximity' by Richard Register (2006).

Urban greening – Expanding the area of green in cities has many benefits. Greater park areas provide more absorptive surface for rainfall, and thereby increases resilience to floods. More trees provide shading which tends to cool city streets and so increase the resilience of city inhabitants to heat waves. More vegetation, in general, tends to improve air quality because plants absorb or adsorb air pollutants.

Renewable energy production – At first glance, the smaller roof areas per person in dense cities would suggest that cities are not ideal locations for using solar energy. Nevertheless, there are many successful examples of supplying a significant fraction of energy requirements through solar energy in cities. One of many examples is the city center of Rizhao in China where UNEP (2011) reports that virtually all households use solar water heaters.

Credit: Shutterstock/Noraluca013

Land use planning – Zoning and planning within cities or their surrounding areas can promote various sustainability goals. Using zoning to preserve coastal wetlands adjacent to a city helps maintain the services provided by these wetlands including protection against coastal flooding, recreation, and habitat for fish and other wildlife. Land use policies can restore natural vegetation and parkland along the banks of an urban river and this land can serve as a natural floodway during high water and make a city more resilient to river flooding.

There are many ways of realizing these ideas. Certainly one major route is mainstreaming them into urban planning. In a 2007 report, Cities Alliance and other organizations identified various planning tools that can be used for this purpose including Integrated Development Planning; City Development Strategies; Eco City Planning; ecoBUDGET; and Strategic Environmental Assessment.

Consequences of inaction/action in the next 10–20 years

If no action is taken, cities are likely to continue on their unsustainable pathway, with an increasing urban population subjected to poor environmental quality while cities themselves exert a large environmental impact on the rest of the world.

The other option is to build 'green' or 'sustainable' cities which are more compact, have a vital mix of land uses within their boundaries, provide many different low-energy

transportation opportunities, and produce some of their own renewable energy. Such cities would provide their citizens with a high level of environmental quality and liveability, and have a lower environmental impact outside their boundaries. Sustainability is also an option for cities.

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Issue 010 The New Rush for Land: Responding to New National and International Pressures (Ranked #12)

Where we stand

Although the area of agricultural land has been expanding in developing countries for decades, a boom in commodity prices in 2008 led to a surge in investments from abroad. The size of the surge is uncertain, but a 2011 Oxfam report stated that up to 227 million hectares have been sold or leased worldwide since 2001, with the bulk of the acquisitions occurring in the past two years. Another report in 2010 by the World Bank says that investors expressed interest in around 56 million hectares of land in 2009 alone, with about two-thirds of the investments taking place in Sub-Saharan Africa. In the same vein, the Global Land Project estimated in 2010 that between 51 and 63 million hectares of land were either part of finalized land deals or under negotiation in 27 African countries in 2009. By comparison, agricultural land worldwide grew by around 1.8 - 4 million hectares per year before 2008. Deininger and others (2011) stated that the 2009 demands for land in Africa equates to more than the total land development on the continent over the previous 20 years. It should be noted, however, that not all land deals have been converted to farmland.

As for the motivation for these investments, a main driving force is the aim of countries to enhance their food security because it is not economically or otherwise viable to sufficiently boost agricultural production at home. In this case, investing in and exploiting productive land abroad is a way of hedging against food shortages. Another important factor is the interest of many countries in cultivating energy crops abroad for import into their own countries. Bioenergy would help them satisfy their growing demand for energy, provide an alternative to increasingly expensive oil, and perhaps help them reduce greenhouse gas emissions. Meanwhile, the developing countries marketing their land look forward to the income from such land deals, as well as to the employment and other opportunities often promised by land purchasers.

Credit: UN Photo/B Wolff

On top of these international pressures come national pressures for land development, such as continued urbanization, expansion of infrastructure, and demand for new cropland to satisfy growing domestic food requirements.

Importance/relevance

Despite the advantages of selling land to investors abroad, there are sometimes undesirable side effects. In a 2010 report, the World Bank noted that recent land deals 'too often, …have included a lack of documented rights claimed by local people and weak consultation processes that have led to uncompensated loss of land rights, especially by vulnerable groups; a limited capacity to assess a proposed project's technical and economic viability; and a limited capacity to assess or enforce environmental and social safeguards.' The report goes on to say that action is needed in some countries to protect vulnerable groups from losing land on which they have 'legitimate, if not formally recognized, claims. …Public disclosure, broad access to information on existing deals,

and vigilant civil society monitoring are needed, along with other efforts to improve land governance, including the overall policy, legal, and regulatory framework for large-scale land acquisition.' The report also notes that the employment and training promised as part of a land deal sometimes never happens.

Another downside of large-scale land acquisitions comes from the fact that much of the acquired land is currently unmanaged or lightly settled 'natural land.' The conversion of this natural land to cropland often involves the loss of ecosystem services such as fuelwood supply; control of water supply and flooding in watersheds; supply of medicinal plants; regulation of local climate conditions; and provision of habitat for plants and animals.

A key question then is how to achieve the economic and other benefits a country receives by selling land to foreign investors, while at the same time minimize or eliminate its disadvantages.

Options for action

First of all, there seems to be an immediate need for more concrete information about the scope of land acquisitions and a better understanding of their implications for livelihoods, food security, ecosystem services and other issues. An international and transparent inventory of these acquisitions would be helpful to better assess the situation. It would also be useful to have an ongoing monitoring system for keeping track of new land acquisition contracts and for helping achieve a win-win situation for all parties. This system could help ensure that land development projects produce the promised employment, skills and knowledge gains for local populations.

Another option is to put into place an internationally-accepted procedure for assessing the socioeconomic and environmental costs and benefits of potential land acquisitions.

A further option is to encourage investors to adopt and follow a set of 'Principles for Responsible Agricultural Investment' along the lines suggested by FAO (2009), World Bank (2010) and others. These principles include: respecting land and resource rights; ensuring that investments do not jeopardize food security (see Issue 007 for a discussion of other aspects of food security.); ensuring transparency and good governance of contracts; consulting all those materially affected; and ensuring that projects respect the rule of law, reflect industry best practice, are economically viable, and result in durable shared value. Some civil society groups, such as the Global Campaign for Agrarian Reform (2010), however, consider these principles to be insufficient for protecting vulnerable groups.

Consequences of inaction/action in the next 10–20 years

The consequence of an unbounded rush for land could be growing inequities and injustices in the country selling off its land to foreign investors, including a continuing loss of land rights of vulnerable social groups. Another consequence could be the further depletion of unmanaged natural land which provides various ecosystem services and products ranging from watershed protection to fuel supply.

Putting safeguards in place, such as monitoring investments, assessing the potential impacts of land deals before they are finalized, and adopting a set of principles for responsible investment, could minimize the drawbacks while allowing the investing countries to enhance their food and energy security.

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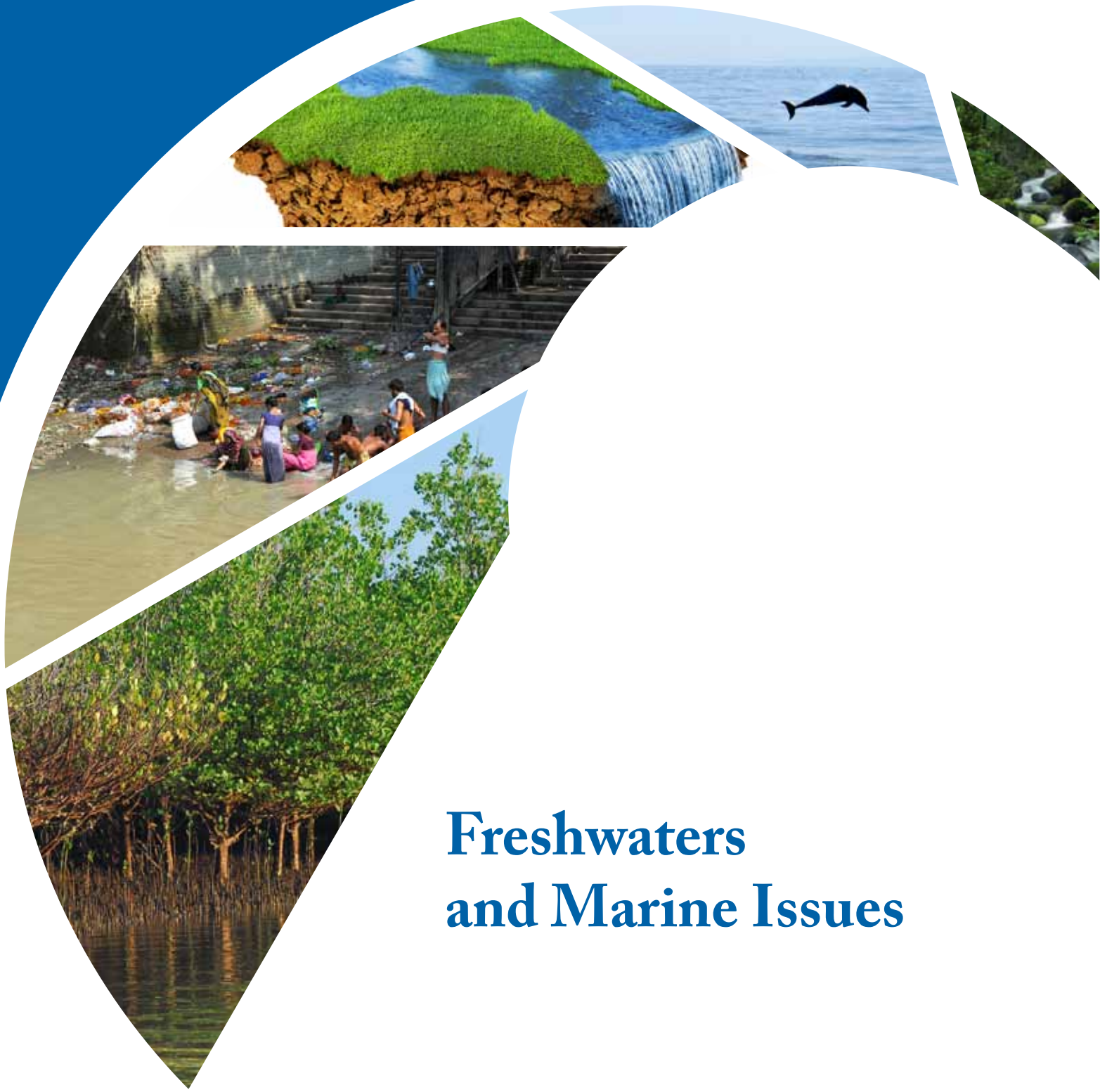

Freshwaters and Marine Issues

Issue 011 New Insights on Water-Land Interactions: Shift in the Management Paradigm? (Ranked #6)

Where we stand

Recent scientific research has provided a new view on how water and land interact, from the local to global level. For example, we are now beginning to appreciate the enormous volumes of water appropriated by society to produce rainfed crops. Weiss and others (2009) found that the water transpired or evaporated each year from Africa's rainfed cropland (sometimes called 'green water' fluxes) is currently about 6 to 7 times greater than the volume of water used in liquid form to irrigate crops (termed 'blue water fluxes'). By 2050, the green water fluxes from African cropland could double and be equivalent to around half of the total current runoff from the entire continent.

Scientists are also providing new knowledge about the relationship between upland forests and downstream water flows. As the FAO (2007) and others have pointed out, woodland areas may be less important for the water they yield downstream, and more vital for maintaining the quality of water by preventing sediment and other substances from being washed downstream. Upland forests also help regulate floods under some circumstances.

Similarly, science has uncovered subtle relationships between land and water as in the case of 'teleconnections' between changing land use in one place and changing precipitation patterns at great distances away. An example is the study of Avissar and Werth (2005) who postulate that deforestation in Amazonia and Central Africa significantly reduces rainfall in the lower U.S. Midwest during critical growing seasons, while deforestation in Southeast Asia alters rainfall patterns on the Balkan Peninsula in Europe and in China.

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Importance/relevance

The new knowledge about water-land interactions has important implications for how we manage water and land. It suggests that the current 'paradigm', in which water and land are managed largely as independent entities, is obsolete. This new knowledge argues for a shift in the management paradigm such that water and land are handled in an integrated fashion.

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Some scholars believe that land and water institutions have not kept pace with the growing intensity of land use and river basin development. This has led to an urgent need for improved governance of land and water resources, and a closer integration of policies targeting food security and poverty alleviation.

Options for action

How can the new management paradigm be enacted? What options do policymakers have?

In view of the strong driving forces at work, some believe that the time is right to put sustainable land and water management at the centre of the global development debate. A first priority might be to develop an integrated shared vision at the global, regional and national levels, reflected in strategies, frameworks and investment programmes.

One specific option is to strengthen the links between land and water management in agriculture by boosting 'water productivity', i.e., the crop yield per unit water. The basic approach here, as explained by Falkenmark and Rockstrom (2006), is to raise crop yields through soil fertility management, to minimize no-productive water losses by tilling soil to improve rainfall infiltration, and to store water for dry periods through rainwater harvesting. In principle, improving water productivity allows the same amount of food to be produced with a reduced amount of water, and hence this approach could improve food and water security in water-short regions.

Another option is to link water and land management through 'payments for ecosystem services' or 'green water credits' as part of watershed management. An example of this approach is the case in which upstream residents of a watershed are paid to maintain the upland forest cover as a service to downstream users, who benefit from higher water quality and in some cases

fewer floods. Similarly, upstream farmers can be paid to change their farming practices in order to reduce sediment runoff to local streams. The FAO (2002) has documented a case in which farmers used a combination of contour-tillage, crop rotation, cover crops, and other measures to reduce the sediment load to the Lajeado-São José creek in Brazil by 69%, which substantially reduced costs downstream for water treatment. Water and land management can also be linked through the implementation of the concept of 'integrated water resources management - a holistic, ecosystem approach to help satisfy competing needs for water and land resources.

Consequences of inaction/action in the next 10–20 years

In view of the widespread production systems at risk, not acting on the new knowledge of water-land interactions will result in continuing inefficiencies in the use of water and land resources. These resources will continue to be managed mostly in isolation of each other without realizing the benefits to be gained by a more integrated approach.

An alternative pathway is for society to use its new knowledge about water and land and incorporate this knowledge into how it manages the environment. Integrating the management of land and water will boost water productivity and could produce more food per litre of water; it will reduce the runoff of sediments and other contaminants and improve downstream water quality. It will allow society to gain greater benefits from both its land and water resources.

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Issue 012 Shortcutting the Degradation of Inland Waters in Developing Countries (Ranked #15)

Where we stand

One of the good news stories over the past decades has been the improvement of the water quality of rivers and waterways in industrialized countries. The story is different, however, in developing countries, where freshwater degradation is increasing as a side effect of increasing population and material wealth, among other factors. A short list of old and new threats to inland water quality include: poor sanitation, agricultural runoff loaded with excess fertilizer and herbicide; residues from medicines and other new chemical products; global climate change, which will elevate water temperature in some world regions and alter the dilution capacity of freshwater systems; and air pollution deposition into aquatic systems from local and distant sources (nitrogen and sulphur compounds and sometimes heavy metals, organic compounds, and other toxic pollutants). Ironically, another growing threat to water quality in many developing countries is the expansion in coverage of public water supply, as this is usually done without making adequate provision for facilities to treat the wastewater produced by the new water supply infrastructure. This is leading to increased and concentrated discharge of untreated sewage from communities to waterways, wetlands and coastal zones. For example, a range of scenarios developed by the Millennium Ecosystem Assessment (2005) point to a factor of four- to eight-fold increase in wastewater loadings within the next four decades over most of Africa.

Credit: Shutterstock/Jan S.

Importance/relevance

The degradation of water quality, together with pressures from overfishing and the alteration of river channels, is placing a tremendous stress on inland fisheries. This is worthy of policymakers' attention because of the importance of inland fisheries to developing countries. First, there is the issue of *food security* since 95% of inland fishery harvests come from

developing countries, where fish are an important part of the protein in the diets of billions (see Issue 007 for more information on food security). Second, there is the question of *livelihood* – The World Fish Center (2008) estimates that freshwater fish production in the tropics has an annual market value of around US $6 billion and that around 2.5 million people derive income from the inland fishery in Africa alone. Third, there is the threat to biodiversity – the IUCN (2011) estimates that more than 1 out of every 5 freshwater fish species in Africa is threatened with extinction.

Apart from the threat to the vital inland fishery, the degradation of water quality makes it more costly to comply with the Millennium Development Goal for access to safe drinking water, since contaminated surface waters have to be treated before they are used in households. Moreover, increasing contamination of surface waters poses a new health risk to those using these waters for bathing, washing clothes and other day-to-day activities.

Options for Action

In the 1950s and decades that followed, many industrialized countries rapidly expanded their material well-being, with the undesirable side effect of discharging a huge volume of untreated wastewater into their waterways. This caused serious degradation of inland water quality, which was only reversed many years later by costly investments in centralized wastewater treatment. As developing countries stand on the brink of a similar large-scale degradation of their inland waters, they have the option of shortcutting this development by taking advantage of forward-looking water technology and management techniques that were not available earlier to industrialized countries. Among the new options is ecologically-based wastewater treatment (e.g., 'artificial wetlands') which can be used to reduce the discharge of pollution. Other options are the techniques of 'cleaner industrial production' which can lessen the source of pollution, and 'zero effluent' technology which can virtually eliminate wastewater flows.

New management approaches are also available to complement these technical options. For example, 'integrated water resources management' takes a holistic, ecosystem approach to help satisfy competing needs within a river basin; it provides a way to balance the preservation of inland fisheries with other uses of a river basin.

Consequences of inaction/action in the next 10–20 years

If no action is taken, it is likely that the inland waters of developing countries will go through a needless cycle of increasing degradation, loss of environmental services and eventual restoration. The implications of degradation include human health impacts and a likely reduction in aquatic production and loss of fish species.

Alternatively, developing countries could pursue the forward-looking water technology and management techniques that were not previously available to industrialized countries. In so doing, they can conserve the vitality of their inland waters, protect public health, and maintain their fisheries.

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Issue 013 Potential Collapse of Oceanic Systems Requires Integrated Ocean Governance (Ranked #13)

Where we stand

The five oceans and the three largest seas cover approximately 71% of the Earth and have long faced threats to their long-term integrity due to human activities. Growing evidence e.g., from Munday and others (2010) and Rogers and Laffoley (2011), indicates that these threats are increasing in number and severity. Some changes have reached tipping points that could have serious and far-reaching social, economic and environmental consequences. This is exemplified by the sobering estimate by FAO (2010) that 85% of marine fisheries in 2008 were either fully exploited, over exploited or depleted. In addition, the unabated land and marine-based pollution of our oceans and seas has prompted changes to their chemistry, temperatures and currents which have led to ocean acidification; biodiversity loss; widespread habitat destruction; proliferation of invasive species; and simplification of ecosystems. The magnitude of the cumulative impact of these changes on oceanic systems is not yet fully comprehended.

Importance/relevance

The world's oceans and seas provide invaluable environmental, social and economic services. These include earth system functions such as regulating climate and the hydrological cycle; affording habitat for a rich and abundant diversity of organisms; providing an important source of food protein to more than 1 billion people; providing a large sink for atmospheric carbon dioxide; and being a major producer of oxygen. Oceans connect countries and continents and provide a wealth of services that benefit human well-being, such as energy, mineral and biotechnology resources and recreational opportunities. Oceanic systems are, therefore, of critical importance to global trade, economy, peace and security. Hence, the need for effective management of oceanic systems cannot be overstated.

Options for action

Rather than leading to effective management, the governance of the oceans now consists of a plethora of binding and non-binding rules and protocols, as well as soft and hard agreements, and a myriad of international, regional and national bureaucracies. Crowder and others (2006) reported that at least 20 federal agencies are responsible for implementing more than 140 federal ocean-related statutes in the United States alone. Some believe this crowded institutional landscape is too fragmented and incoherent to address the challenges facing oceanic systems in the 21st century. Hence, experts including Behnam (2009), Ivanova (2007) and others, suggest that the current ocean governance architecture will need to be re-shaped in order to prevent a collapse of oceanic systems. Such reform is also needed to safeguard ocean resources into the future, and to respond appropriately and effectively to the challenges of climate change and food security. What are the options for re-shaping ocean governance?

One option noted by Alder (2004), Worm (2010) and others is to harmonize fishing laws across countries to prevent the spreading of unsustainable fishing practices from industrialized countries to developing countries where legislation is less stringent.

Another option, as recommended by experts at a workshop convened by the International Programme on State of the Ocean in 2011, is to 'establish a globally comprehensive and representative system of marine protected areas to conserve biodiversity, to build resilience, and to ensure ecologically sustainable fisheries with minimal ecological footprint.'

Credit: UN Photo/Martine Perret

Another option for action, which particularly addresses the fragmentation of current ocean management, is to establish a new coordinating body for ocean governance. This body would provide a platform under which countries could cooperate on critical marine environment issues. Experts at the 2011 workshop mentioned above recommended that this be a 'global body that can ensure compliance with the Law of the Sea treaty' and that the new body be empowered to establish 'new rules, regulations and procedures where necessary to implement these requirements [compliance with the Law of the Sea] in an ecosystem-based and precautionary manner.' This coordinating body would need to have representation and influence at the highest political levels, and at the same time give voice to the wider constituency having interests in the world's oceans and seas.

Consequences of inaction/action in the next 10–20 years

Ignoring the need to reform international ocean governance and failing to embrace interdisciplinary approaches to managing the world's oceans will mean that marine ecosystems will continue to be unsustainably exploited. This will almost certainly lead to the continued decline and eventual collapse of oceanic systems, with inevitable implications for livelihoods and human well-being.

However, if effective coordinated action is taken to reduce exploitation rates of marine ecosystems and otherwise better manage the marine environment, it is still possible to envision a seascape where the rebuilding, conservation and sustainable use of marine resources become unifying themes for science, management and society.

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Issue 014 Coastal Ecosystems: Addressing Increasing Pressures with Adaptive Governance (Ranked #19)

Where we stand

The world's coastal ecosystems are coming under increasing pressure from human activities. Among these pressures are: growing coastal development; expansion of capture fisheries and fish farming; increased pollution caused by agricultural and industrial activities (including oil exploration and production); and rising demands on coastal resources from global markets and urban areas. Moreover, the consequences of climate change such as sea level rise, ocean acidification and ocean warming are also becoming apparent.

Credit: UNEP Grid Arendal/Peter Prokosch

Under threat are domestic economies, food security, the well-being of small-scale fishermen, and the integrity of coral reefs and other coastal ecosystems. The Millennium Ecosystem Assessment (2005) reported that over the last few decades approximately 35% of mangroves have been lost or converted, and approximately 20% of coral reefs worldwide have been destroyed and 20% degraded. A UNEP report in 2009 confirmed that key habitats supporting coastal ecosystems are declining in area.

Unfortunately, according to studies by Burroughs (2011), Gelcich and others (2010), current management approaches seem to be inadequate to address these growing pressures.

Importance/relevance

Two-thirds of the world's largest cities are situated in coastal areas and are at the same time the cause and casualty of pressures on coastal ecosystems, with many millions depending on coastal ecosystems for goods and services. In extreme cases, as in the Small Island Developing States, the population fully depends on the coastal and oceanic environment for their livelihoods and lives. Mangroves and coral reef habitats within the coastal regions provide habitat for fish and other seafood, and are an important source of food, in particular protein, to a large fraction of the coastal population. Fish harvesting in the coastal zone is also a significant economic factor, with an estimated market value of US$ 34 billion annually, according to the Millennium Ecosystem Assessment (2005).

In the same vein, beaches and sandy shores provide services such as recreation and tourism which produce a substantial number of jobs for people living in the coastal zone. Coral reefs also support a rich variety of marine life, which in turn supports a thriving and valuable tourism industry.

Globally speaking, mangroves, sea grasses and other so-called 'blue carbon habitats' play an essential role in climate regulation. UNEP (2009) has estimated that the uptake of atmospheric carbon dioxide by these habitats adds up to around 120 to 329 teragrams of carbon per year. When the uptake by estuaries is added, the total carbon dioxide stored is estimated to be between 235 and 450 teragrams of carbon per year – or the equivalent of up to about half the emissions from the entire global transport sector.

These examples highlight the importance and urgency of seeking a workable management approach for coastal ecosystems.

Options for Action

How then to respond to increasing pressures on the coastal environment? One answer lies in the concept of adaptive governance which provides a new way of achieving sustainable management of the coastal zone. This approach has been used on the Great Barrier Reef system in Australia, the Baltic Sea, southern ocean fisheries, and numerous coastal areas.

Adaptive governance is a flexible, integrated and holistic form of governance that takes into account the inherent problems of complexity, uncertainty, change, and fragmentation associated with the interrelated social, economic and environmental systems of the coastal zone. Adaptive governance addresses these problems by creating conditions that:

- encourage integrated planning
- facilitate dialogue between stakeholders
- promote enhanced learning of complex socio-ecological systems
- promote experimentation and innovation, and
- support cross-scale and multi-level institutional linkages

Adaptive governance of coastal ecosystems could provide the flexibility needed for dealing with uncertainties in the coastal zone having to do with climate effects, rapidly developing market demands, or changes to economic subsidies and government policies. The required leadership, trust and vision is provided by key stakeholders, such as policymakers, scientists, private organizations, local communities, networks and other interested parties. If adaptive governance is to

help achieve sustainable management of the coastal zone, stakeholders need to be informed about this approach and trained in its practice.

Consequences of inaction/action in the next 10–20 years

Not acting to create a viable, comprehensive governance structure in coastal areas could mean a continuation of the degradation of coastal ecosystems. This, in turn, could lead to a loss of the goods and services these ecosystems provide including food, livelihoods, tourist income and climate regulation.

But pursuing adaptive governance could help safeguard coastal ecosystems. The future could see a productive coastal zone, sustainably managed with the participation of a wide range of stakeholders. Along the coast there will be a viable fishery, preserved wetlands, and a thriving recreation and tourism industry, all providing valuable goods and services to the large population living on the edges of the continents.

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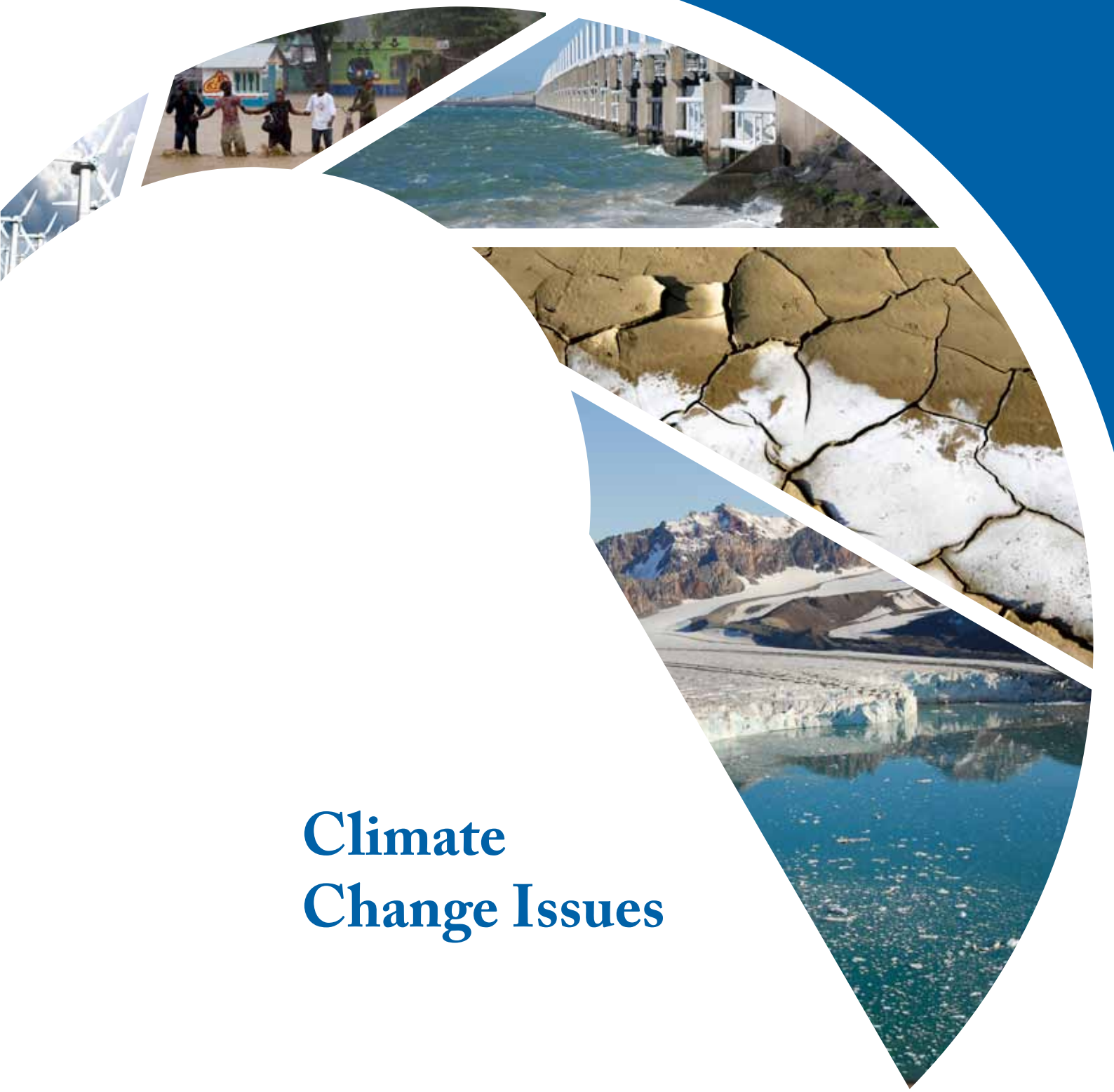

Climate Change Issues

Issue 015 New Challenges for Climate Change Mitigation and Adaptation: Managing the Unintended Consequences (Ranked #7)

Where we stand

There are signs that the tempo of mitigation and adaptation to climate change may be speeding up at all levels. At the city level, many adaptation strategies and policies are being developed in European, North American and Latin American cities. At the international level, progress has been made in several countries to control greenhouse gas emissions, as documented by the Secretariat of the Framework Convention on Climate Change (2011). At the 2011 climate summit in Cancun, countries went further and made substantial pledges to control or reduce greenhouse gas emissions as part of a comprehensive agreement. Countries also agreed to provide substantial international support for climate adaptation by setting up an Adaptation Fund, a Green Climate Fund and the Cancun Adaptation Framework (see Issue 018 about the motivation to accelerate the use of renewable energy in order to reduce greenhouse gas emissions).

As efforts to cope with climate change pick up pace, a new aspect of climate protection is becoming more important: researchers and experts are alerting the policy community that scaling up mitigation and adaptation actions could have unintended negative consequences on nature and society.

There are *scale-up effects* such as those caused by expanding the use of wind generators from a few scattered turbines to large wind parks. Such concentrations of wind generators in the landscape may obstruct bird migration and have other impacts that isolated turbines are less likely to have.

There are *reductions of ecosystem services*, when, for example, sea walls are built to protect the coastal population from storm surges. These sea walls could hinder the landward migration of beaches and coastal wetlands that would normally occur in response to sea level rise. The loss of these wetlands would mean the loss of habitat for fish, birds and other wildlife; recreation; erosion control; access to offshore areas, and other goods and services.

Credit: Shutterstock/megainarmy

Credit: Shutterstock/Wil Tilroe-Otte

There are *economic impacts* associated with the replacement of one service with a more expensive one. An example of this is replacing electricity derived from a coal or oil-fired power plant with more expensive electricity from photovoltaics or wind generators (although the full life cycle costs of electricity derived from fossil fuels, including its environmental and social costs, are usually not reflected in market prices). This replacement could also result in stranded physical, financial and human assets, with varying remaining useful lives. Another case is the replacement of traditional agricultural practices with those better adapted to new climate conditions. These new practices could be more expensive because of new requirements for seeds and irrigation, for example.

There are *social impacts,* such as those which arise when energy crop production in a developing country competes with domestic food production or clashes with the land rights of inhabitants of agricultural land.

There are also possible *risks to the global climate system* posed by various geoengineering schemes. For instance, some concepts, such as enhancing the albedo of the earth by injecting sulphur compounds into the stratosphere or placing platforms in orbit to reflect incoming solar radiation, will have an uncertain and possibly disruptive impact on regional energy balances and weather patterns. This is aside from the ethical, moral and social concerns associated with geoengineering raised by Robock (2008) among others.

Importance/relevance

In sum, climate mitigation and adaptation measures could have a range of possible negative side effects which could lead to a loss of public support for needed climate policies.

Options for action

To protect the climate system and avoid climate impacts, it is in society's interest to find a way for forging ahead with

mitigation and adaptation actions while at the same time avoiding or minimizing their undesirable side effects. How can this be accomplished?

The first option is to anticipate and address these side effects. This can be done by ensuring the social, economic and environmental impacts of a particular policy or measure are evaluated before it is implemented. Many well-developed standard methodologies are available for these evaluations, including integrated assessment, environmental impact assessment, or regulation impact assessment. Which procedure to use will depend on the particular plan for mitigation or adaptation. Once potential negative impacts are identified, policymakers have the chance to take actions to minimize them in advance.

The second option is to consider not only one, but several, mitigation or adaptation alternatives. This would allow policymakers to select an alternative that balances technical effectiveness, with cost effectiveness and minimal negative side effects. For example a pre-assessment may disclose that two prospective wind farm sites are equally effective technically and cost-wise, but one of the two would cause significantly fewer disturbances to birds and other wildlife.

Apart from anticipating impacts and examining different alternatives, another option is to develop general guidelines on how to minimize the undesirable side effects of specific policies and measures. For example, in 2009 the State of Arizona issued guidelines on how to minimize the environmental impacts of wind turbines, suggesting practical measures such as setting up buffer zones with wildlife nesting areas, placing power lines underground and avoiding lighting that attracts wildlife.

Consequences of inaction/action in the next 10–20 years

If society goes ahead with climate mitigation and adaptation in the next few years without accounting for possible undesirable side effects, it is possible that public support for these measures may eventually decline and emission reductions slowed. As a consequence, greenhouse gases may build up in the atmosphere at a higher than expected rate and the lack of adaptation may leave society exposed to future climate change impacts.

If, however, society begins to take a broader view towards climate policies, insisting that any side effects are assessed before going forward, then we may find ways to minimize or avoid these unintended consequences. Likewise, climate policies will have a higher level of public acceptance and society will be in a better position to mitigate and adapt to climate change.

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Issue 016 Acting on the Signal of Climate Change in the Changing Frequency of Extreme Events (Ranked #16)

Where we stand

For some years, the scientific community has used models to demonstrate that climate change could theoretically alter the intensity, distribution, and, or, frequency of occurrence of extreme events. Such events include heat waves, floods, droughts, dust and sand storms, strong winds and hurricanes. In an important new development, theoretical results are beginning to be confirmed by comparing climate modelling results against observational evidence of changes in the frequency of extreme events. Li and other scientists (2011) recently linked anthropogenic global warming to the observed intensification of the 'North Atlantic Subtropical High.' This meteorological event, in turn, is associated with an increase in summer rainfall variability in the Southeast United States from 1978 to 2007.

Credit: UN Photo/UNICEF/Marco Dormino

Credit: UN Photo/Martine Perret

Another study by Pall and others (2011) found it 'very likely that global anthropogenic greenhouse gas emissions substantially increased the risk of flood occurrence in England and Wales in autumn 2000'. Meanwhile, Min and colleagues (2011) found evidence of human influence on 'observed intensification of heavy precipitation events' over much of the land area of the Northern Hemisphere during the second half of the 20th century.

Importance/relevance

These new studies have very important implications.

First, they show that we are beginning to detect the signal of climate change in the changing frequency of extreme events. Put another way, they increase the body of evidence that climate change can/will alter the frequency of these events, and imply that this is already happening.

Second, they add urgency to plans for preparing for an increase in extreme events since these events may result in the loss of lives, cause economic damage and displace populations, as is already being observed. (see Issue 006 for more information on the climate-migration link). For example, in 2011 Munich RE, the world's largest reinsurance company, estimated that hydro-meteorological hazards are responsible for 67% and 85% of economic and insurance losses, respectively. They further reported that in 2010 alone, 874 weather and climate related disasters resulted in 68,000 deaths and US$99 billion damages worldwide. Data from the EM-DAT extreme events database indicate that there were nearly 72,000 deaths in 15 countries resulting from the 2003 European heat wave and more than 138,000 deaths due to the 2008 Nargis tropical cyclone.

However, it is important to note that while evidence is growing about the influence of climate change on the frequency of extreme events, it is still very difficult to attribute individual weather events to long term climate change.

Options for action

An obvious way to prepare for an increase in extreme events is to rethink, as well as further develop and implement early warning systems that alert the population and authorities about an impending event and provide time for evacuation or other actions. Such early warning systems have existed for some time for climate-related threats such as hurricanes, heat waves and droughts. But despite the great strides made in implementing and using climate-related warning systems over the past few years, these systems still have the following limitations:

- Most deal with only one aspect of climate-related risks or hazards, e.g., heat waves or drought.
- Most systems do not cover the entire early warning landscape from monitoring of meteorological data to delivery and response of users.
- The communication of warnings and outreach to users needs improvement in most systems.
- Most systems have large gaps in geographic coverage.

It is now technically possible to address these shortcomings and work towards a comprehensive global climate-related early warning system. The German Committee on Disaster Reduction (2009), UNEP (2011) and other groups have pointed out various options for expanding early warning systems such as:

- Covering many different hazards in a single system including: droughts, floods, wildfires, heat waves, and wind storms.
- Covering the entire early warning landscape end-to-end from data collection to response of users and feedback to those collecting data and issuing warnings.
- Giving special emphasis to improving the efficiency and effectiveness of the dissemination of warnings directly to users and providing assistance to users in developing response plans. People and institutions need to be prepared for how to respond to early warning so that warnings can be easily translated to effective responses. In this vein, adequate public awareness is needed about the existence of early warning systems and effective communication must be put in place.
- Expanding the coverage of early warning systems to all populated continents, with special emphasis on developing countries.

Apart from early warning, other measures can be taken to prepare for an increase of extreme events. Many of these measures are already covered under international efforts at 'disaster risk reduction'. For example, the UN's International Strategy for Disaster Reduction (2008) mentions the planting of mangrove forests to ameliorate the impacts of coastal storm surges; incorporating climate risk-related considerations in macro-economic projection and development planning processes; and building up national institutions for responding to emergencies.

Consequences of inaction/action in the next 10–20 years

Not acting on the new evidence of the changing frequency and magnitude of extreme events will mean a lost opportunity to prevent the loss of lives, protect livelihoods, reduce economic damage and population displacement, and their associated socio-economic consequences.

Taking action now could help reduce the risk to lives, livelihoods and properties. Moreover, it could also enhance economic development in developing countries exposed to climate extremes by helping them avoid damage from climate-related disasters.

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Issue 017 Managing the Impacts of Glacier Retreat (Ranked #21)

Where we stand

Current trends show that a large number of the world's glaciers are undergoing significant retreat. For example, Bury and others (2011) reported that the Yanamarey glacier in Peru is retreating at an average annual rate of 30 m, and Bajracharya and other scientists (2007) noted that Mount Everest's glaciers are receding annually by 10 to 59 m.

There are also indications that the rate of retreat is accelerating. According to a 2007 UNEP report, 30 worldwide glaciers monitored by the Global Terrestrial Network for Glaciers showed an average mass loss of 0.58 m water for the decade 1996–2005, more than twice the rate for the period 1986-1995, and more than four times the rate recorded during the period 1976-85.

Credit: UNEP Grid Arendal/Peter Prokosch

Importance/relevance

These changes are posing various threats to people and ecosystems.

An already existing threat is posed by glacial lakes that are building up below the melting glaciers. The natural dams forming these lakes sometimes collapse causing devastating 'glacial lake outburst floods' (GLOF) that have caused fatalities downstream and extensive property damage. For example, a flood outburst in Norway damaged farmlands, while another in Kyrgyzstan and Uzbekistan caused many fatalities and destroyed numerous livestock, crops, pastures and buildings. Furthermore, glacier retreat uncovers stones and mud and thereby increases the risk of landslides.

Another threat is the long term change to water availability in river basins downstream of glaciers. Initially, as glaciers melt, downstream runoff increases. But as glaciers gradually disappear annual runoff also decreases and become proportional to precipitation in the river basin. The impact of melting on seasonal runoff is particularly important. Glacial melt plays an especially important role in making water available to highland areas that have a pronounced dry season, such as the Peruvian Andes and the Central Asian Pamirs. Here, glacial melt provides water supply to upland, as well as lowland inhabitants throughout the dry season. But as glaciers diminish, this vital seasonal supply of water will also eventually diminish.

The potential decrease in seasonal water supply may strain relations between competing water users. An example is Central Asia, where there is potential for disagreement among the different sovereign states over the distribution of water originating from glaciers. This is equally true for the Himalayan region.

The retreat of glaciers has also been linked by Bajracharya (2009), Immeerzeel (2010), Xu (2009) and their co-authors to various types of ecological degradation including a decrease in biodiversity, shifts in marginal ecosystems, and loss of soil carbon.

Options for action

Although the coverage of glacier monitoring is improving, it needs to be extended to more locations. We also need a better understanding of the hydrological consequences of glacial melt and its impact on individuals, social groups, the economy and institutions. With better knowledge, stakeholders will be able to develop better strategies for coping with glacier melting.

Two technical options are to design early warning systems for GLOFs, and to draw down glacial lakes to lessen the risk of an outburst, as Nepal is doing.

Possible actions for coping with adverse changes in seasonal water supply in upland areas include improving the efficiency of water use, introducing irrigation, or switching to drought-resilient crops. For coping with the possibility of more frequent floods, there are many conventional alternatives, such as building embankments or setting aside land for floodways.

A general strategy for coping with changing glacier melt in a particular river basin would be to follow an 'integrated water resource management' (IWRM) approach. As noted earlier in this report, IWRM provides general guidelines for planning water use in a river basin and affords a framework for incorporating the interests of many different stakeholders in the basin. IWRM helps planners account for many different factors determining the basin's water supply, including changing glacier melt.

Credit: UNEP Grid Arendal/Lawrence Hislop

Consequences of inaction/action in the next 10–20 years

Many glaciers around the world are rapidly melting and over the coming decades the consequences of this melting will become increasingly apparent. Some downstream populations may be threatened by flooding from glacial lakes, and some upland areas will experience a disruption in their seasonal water supply. If preparations are not made for these changes, then the safety and livelihoods of many people may be threatened.

If adaptive action is taken, the population will be better equipped to cope with the consequences of glacier melting. Monitoring and early warning systems will help protect the population from being surprised by lake outbursts or other flooding from rapid ice and snow melt. Glaciers may continue to disappear, but the risk to people will be better managed.

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Energy, Technology, and Waste Issues

Issue 018 Accelerating the Implementation of Environmentally-Friendly Renewable Energy Systems (Ranked #7)

Where we stand

At the 2010 climate summit in Cancun, governments again called for deep cuts in global greenhouse gas emissions and urgent action to meet this goal. How can this goal be reached? One answer is given in the 2007 report of the Intergovernmental Panel on Climate Change (IPCC) which states that '…all stabilization scenarios [of CO_2 in the atmosphere] concur that 60-80% of all [emission] reductions would come from the energy and industry sectors'. Later, in its Special Report on Renewable Sources of Energy and Climate Change Mitigation, the IPCC (2011) asserted that close to 80% of the world´s energy supply could be met by low- or no-carbon renewables by mid-century, if the right enabling public policies are put into place. Hence, renewable energy has a vital role to play in the 'urgent action' on climate protection called for in Cancun. There are, of course, other benefits of renewable energy, including: enhanced energy security due to the reduced dependence of some countries on imported fossil fuels; increased public health protection due to lower air pollution; and new employment opportunities.

Importance/relevance

Despite the key role and high potential of renewable energy in mitigating climate change, it will not automatically replace conventional fuels in the world's energy economy. According to IPCC (2007), 'under the business-as-usual case of continued growing energy demand, renewables are not expected to greatly increase their market share over the next few decades without continued and sustained policy intervention.' Simply put, accelerating the implementation of a renewable energy economy will require special effort.

Credit: Shutterstock/alphaspirit

What is holding back renewable energy? The answer is a variety of economic, institutional, social, and technical barriers. According to the IPCC (2011), these include market failures, up-front costs, financial risk, and lack of data. The list also includes: inadequate public and institutional awareness; incompatibility with energy infrastructure and market regulations; inappropriate intellectual property laws; trade regulations; lack of amenable policies and programs; and land use conflicts. A lack of skilled labour is an additional factor. A UNEP report from 2008 noted that Germany and the USA have a shortage of qualified workers in the renewable energy field, and Brazil, China and other countries suffered from the same in the 'green' sector of the economy (see also Issue 002 on the need for the transformation of human capabilities in order to meet environmental challenges and move towards a Green Economy).

Credit: UN Photo/R Kollar

Options for action

How can these numerous barriers to the implementation of renewable energy be overcome?

One approach is to improve the economic competitiveness of renewable energy, compared to conventional energy sources, through public financing policies (tax credits, incentives and rebates); special pricing and purchasing power rules (low-interest loans, feed-in-tariffs for electricity); lower transaction costs; and improved communication and awareness about renewable energy resources.

There are many other options for providing positive incentives for using renewable energy. These options include: renewable energy promotion policies (e.g., policies supporting cost reductions, public investments and market facilitation activities, and those supporting access to the power grid); transport biofuel policies (e.g., biofuel tax subsidies); emissions reduction policies (e.g., cap and trade, greenhouse gas mitigation); electric power restructuring policies (e.g., privatization and, or, commercialization of utilities; self generation; unbundling of generation, transmission and distribution); and rural electrification policies (e.g., rural electrification extension and energy service concessions, rural business development, and microcredit).

The implementation of renewable energy can also be accelerated by resolving issues of property rights; engaging local communities and authorities in the energy decision-making process; facilitating the integration of renewable energy in the energy grid; increasing technology transfer, including the pooling of technology resources and knowledge among countries; and organizing training programmes to produce the needed skilled workers. Overall, the aim should be to ensure ways of stimulating and promoting changes in the energy system that include government and deployment policies to create a market for renewable energy technologies.

It is important to note that all of these actions would have to be tailored to the unique economic, political, cultural and national circumstances of a particular country.

Consequences of inaction/action in the next 10–20 years

Failure to realize the full potential of renewable energy systems globally, may make it impossible to abide by the climate protection goals of Cancun, including the two degree target. Over the coming decades, this would result in increased environmental, social and economic impacts due to climate change. Furthermore, a slow implementation of renewable energy could also slow progress to a low-carbon or a green economy and sustainable development.

But if we act now, the world will look different in 10 to 20 years. The level of greenhouse gas emissions will be reduced, which will ultimately slow the rate of global warming. A large number of workers around the world will be employed in the renewable energy sector. The world energy mix will be more diverse; many countries will be less dependent on fossil fuels and have a higher degree of energy security. Clean renewable energy will replace some fossil fuel use and this will reduce local and regional air pollution and alleviate its adverse affects on health and crops. Clean renewable energy will also be used in poor rural areas, helping to alleviate poverty. All in all, speeding up the wide use of renewable energy will have a substantial payoff.

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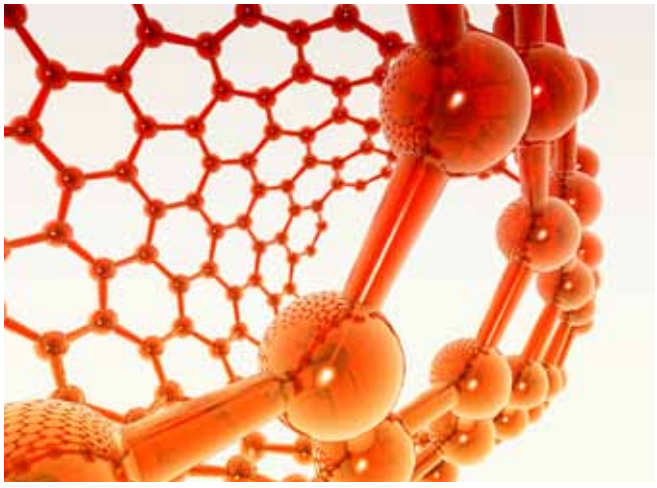
Issue 019 Greater Risk than Necessary? The Need for a New Approach for Minimizing Risks of Novel Technologies and Chemicals (Ranked #10)

Where we stand

There is little doubt that novel technologies and chemicals have contributed to a higher standard of living, at least in industrialized countries. But it is also evident that some technological innovations and chemicals pose risks in the form of unforeseen or unexpected side effects and intentional uses for harmful purposes. Examples of unforeseen side effects include: contamination caused by nuclear accidents and high-level radioactive wastes; airborne and waterborne transport of dioxin and other toxic substances; and stratospheric ozone depletion (see Issue 020 for a description of the risks from electronic waste). Well-known examples of technological applications for harmful purposes include the widespread use of poison gas during World War I and the acquisition of nuclear and biological weapons as a coercive strategy in international relations.



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Although society has experienced many health and environmental impacts of technology and chemicals, we are still fixed in a pattern by which new technologies and chemicals are usually first produced and disseminated, and only afterwards assessed more closely for any negative impacts. Consider the number of toxic chemicals released into the environment and only later found to pose risks to public health and ecosystems. According to an OECD study cited by ChemSec (2011), very few of the 1500 most commonly used chemical substances within the OECD have been adequately assessed in term of their risk to human health and 10 % have not been examined at all. The study further claimed that virtually none have been thoroughly examined in terms of their environmental effects. In a 2007 report, the European Environment Agency asserted that 'only 14% of more than 2000 high production volume chemicals had basic toxicology information; 65% has less than base-set data and 21% had no data at all'. Yet the same report stated that chemical industries are growing worldwide, with global trade in chemicals increasing at an average rate of 14% per year between 2000 and 2005. Furthermore, according to OECD (2008), there has been a shift of chemicals production, including new ones, from OECD countries to the BRIICS countries - Brazil, Russia, India, Indonesia, China, and South Africa and other developing countries, which in many cases lack the capacity, infrastructure and regulatory control for their sound environmental management. The resultant effect of this is the increasing risk of exposure of the population in developing countries to toxic substances.

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Importance/relevance

The question is whether society continues to take a reactive approach to risks of technology and chemicals or, instead, takes a more proactive stance. This is an urgent question because we constantly have to make decisions about new chemicals or innovations such as synthetic biology, nanotechnology, or genetically modified organisms. In fact, Unger and others (2002) argue that the pace of introducing new technologies has increased, while the role of regulatory bodies in protecting the public from consequences of these technologies has diminished. In a similar vein, a US National Research Council report (2002) concluded that federal regulatory efforts have not kept pace with recent advances in animal biotechnology.

Options for action

Society has the option of going beyond it reactive stance, and working towards a more comprehensive and anticipatory management approach by which the implications of novel technologies and chemicals are systematically and comprehensively assessed *before* they reach the production phase. The aim would be to minimize or avoid risks to society and nature. Some institutions are moving in this direction. The amended EU Cosmetics Directive (2009) requires that manufacturers report cosmetic products containing nanomaterials to the European Commission six months prior to releasing such products. Meanwhile, the 2011 REACH regulations of the European Union (Registration, Evaluation, Authorisation and Restriction of Chemical substances) aim to improve the protection of human health and the environment 'through better and early identification of the intrinsic properties of chemical substances.'

Despite some progress, the overall institutional landscape falls short of providing a comprehensive, anticipatory approach to novel technologies and chemicals. The problem is that some areas of this landscape are fragmented, as in the case of the multiple Multilateral Environmental Agreements dealing with toxic chemicals. In other areas institutions are competing rather than cooperating with one another. Elsewhere, there is a vacuum, as in the potential impacts of climate geoengineering, where no international institution is taking responsibility for making ongoing comprehensive assessments.

A comprehensive and anticipatory approach will likely require the modification of existing institutions, or perhaps the foundation of new institutions. Policymakers could consider, for example, organizing a new international governance system which would produce, and potentially oversee, new international procedures to identify dangerous side effects of technologies and chemicals before they are produced. Such a governance system would be:

- Anticipatory, to avoid the difficulties of regulating technologies and chemicals once they move beyond the confines of the laboratory;
- Impartial, to avoid situations in which influential actors sit in judgment regarding matters of safety and security relating to their own products;
- Aware of the need to deal with the risks arising from interactions among multiple technologies developed for different purposes;
- Universal, in order to address the global reach of new technologies, and ensure that individual countries and their corporate interests do not unilaterally make decisions that can have global impacts.

The form of any new governance system should be shaped by policymakers working together with the scientific, business, environmental and other stakeholder communities.

Consequences of inaction/action in the next 10–20 years

If the pace of introducing new products is indeed accelerating, then staying with our current reactive approach to risk

management will result in increasing hazards to society. It is already difficult to keep track of the impacts of the numerous new substances released to the environment. It is possible that at some point, the international regimes regulating dangerous chemicals may not be able to keep up with the number of new risky chemicals being introduced, thereby increasing the presence of dangerous substances in the environment.

On the other hand, building a new governance system based on the foundations of current institutions could help society handle the inadvertent hazards caused by its novel technologies and chemicals. This system would provide internationally adopted procedures for anticipating, assessing and mitigating hazards, and would enable society to reap the benefits of technological innovation while minimizing its risks.

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Issue 020 Changing the Face of Waste: Solving the Impending Scarcity of Strategic Minerals and Avoiding Electronic Waste (Ranked #14)

Where we stand

The growth in the manufacturing of high-tech and green-energy products has had some unexpected consequences. New goods, such as hybrid cars, rechargeable batteries, wind turbines, mobile phones and plasma televisions, have greatly increased the demand for some strategic minerals, including rare earth elements such as lanthanum, cerium, lithium, neodymium, indium and gallium. Global demands for rare earth elements have been reported by the US Congressional Research Service (2010) to be increasing, with current demand (134,000 tons per year) exceeding global production (124,000 tons per year). Global demand is projected to be in excess of 200,000 tons per year by 2014.

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Another consequence is that the disposal of hazardous chemicals and materials from these manufactured products is creating new waste management problems. The waste streams from the manufacturing, use and disposal of electronic products ('electronic waste' or 'e-waste' for short) consist of a hazardous mixture of mercury, lead and other heavy metals; endocrine disrupting substances such as brominated flame retardants; and other toxic substances.

Importance/relevance

The large demand for rare earth elements has resulted in the depletion of some traditional mining sources. For example, the US, once largely self-sufficient in these minerals, is now dependent on China and other countries for its supplies. The depletion of these materials is further aggravated by policies of planned obsolescence and other wasteful manufacturing habits that lead to shorter-than-necessary lifetimes of products and hence greater demand for raw materials and larger flows of wastes. Altogether, many rare earths are becoming rarer still and will remain so until new mines are opened.

Meanwhile, e-waste has become an important risk to health and the environment, especially in developing countries which often lack environmentally sound waste management facilities. Worsening the situation are 'backyard' or crude incineration practices and dismantling of electronic equipment (without the use of personal protective equipment) which not only expose workers to toxic substances but also release hazardous materials

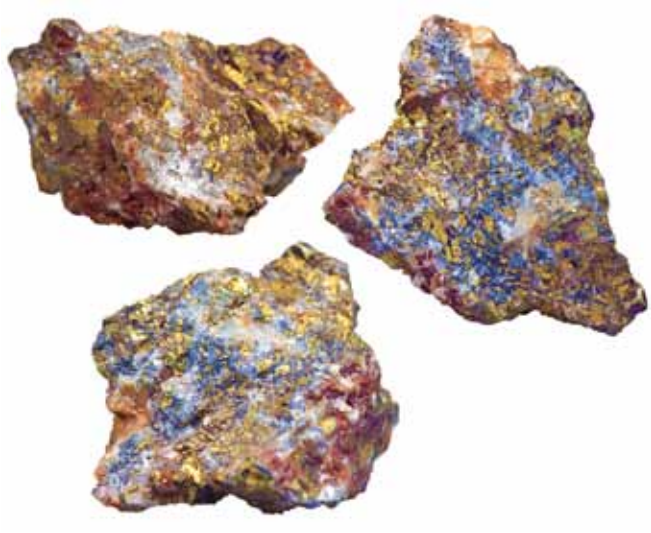
to the environment. Lacking intervention, these risks are likely to grow over the coming years along with the rapid growth in e-waste. UNEP (2009) estimates a possible increase of between 200 and 500% in e-waste volume generated from old computers by 2020 in India, South Africa and China, relative to 2007 levels. This does not account for possible increases from other e-waste sources such as mobile phones.

Options for action

The simultaneous depletion of key minerals and production of new toxic waste streams is certainly a new and risky situation. The solution lies in a shift in thinking – handling the situation as a resource management challenge rather than as a waste disposal problem. This will mean maximizing the safe recovery of key metals and other materials from electronic and other waste streams. Put another way, it means "mining" the waste streams for raw materials. This will slow down the extraction and depletion of minerals, reduce the quantity of their wastes, and lessen the environmental and other impacts associated with the production cycle. E-waste is of special interest because much of it contains strategic minerals that could be cost-effective to recover and recycle. According to a UNEP report (2009), this new thinking requires ambitious, formal and regulated processes for collecting and managing e-wastes, leaving behind the dangerous recycling practices being followed in some countries.

This shift in thinking is already occurring in Europe and in some other parts of the world. The Electronic Industry Market Research and Knowledge Network (2010) estimates an increase in the e-waste recycling market from US $6.9 billion in 2009 to US $21 billion by 2020. Stringent government regulations and policies, such as the 2011 WEEE (Waste Electrical and Electronics Equipment) directive in Europe, play a key role in spreading this new thinking and stimulating the e-waste recycling market.

It would also be helpful for manufacturers to move away from planned obsolescence to 'planned capacity for evolution', thus allowing upgrade and reuse of devices instead of requiring their frequent replacement. Furthermore, by using a life cycle approach to electronic products management, manufacturers would have to adjust the design of products to make it easier to retrieve valuable materials at the end of the product's life. Both of these steps would decrease the overall need for raw materials and the production of waste. At the same time they would encourage a shift in thinking towards green technology and sustainable development.



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Consequences of inaction/action in the next 10–20 years

If current manufacturing trends continue over the next decade or two, we are likely to see an accelerated depletion of key minerals and materials and the continued spread and build-up of electronic and other hazardous waste. This is likely to result in higher risks to public health and the environment and heightened competition for strategic minerals.

Alternatively, new manufacturing procedures entailing green design, comprehensive regulations especially regarding life cycle issues, and new policy measures, could be established to promote the safe recovery of key metals and other materials from electronic and other waste streams. This would slow down the depletion of strategic minerals, reduce the quantity of their wastes, and lessen the environmental and other impacts associated with manufacturing. Spinoff effects would be: lower exposure of the public to hazardous substances; reduced environmental damage due to mining; and new business and employment opportunities revolving around trading and recovering materials from used manufactured products. The result would be a stronger Green Economy, rather than a more dangerous world.

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Issue 021 The Environmental Consequences of Decommissioning Nuclear Reactors (Ranked #17)

Where we stand

Many of the world's nuclear reactors are aging and will need to be decommissioned soon. (Decommissioning involves putting a nuclear facility out of service, dismantling it, decontaminating it, and storing or disposing of its elements). This is of concern because decommissioning is a major operation which poses several technical challenges, especially the disposal of large amounts of radioactive waste, with inherent environmental and safety risks.

In 2010 the International Atomic Energy Agency (IAEA) noted that many of the 441 currently operating reactors around the world were built in the 1970s and 1980s and had an expected lifespan of around 35 years. Hence, a surge in the number of power plants going out of service and requiring decommissioning is expected soon. The IAEA projects that the peak will occur between 2020 and 2030, and that when it occurs it will 'present a major managerial, technological, safety and environmental challenge to those States engaged in nuclear decommissioning.' After the recent nuclear accident in Fukushima, Germany and Switzerland have decided to speed up the phase out of their nuclear power plants and this is likely to further increase the number of plants that need to be decommissioned over the coming decade.

Importance/relevance

Of the many challenges involved with nuclear decommissioning, of particular concern is the production of high level wastes (HLWs) and low and intermediate level wastes (LILWs). These wastes need to be removed and permanently stored or disposed of. In addition HLWs require reprocessing prior to disposal or permanent storage. The IAEA (2006) estimates that the volume of waste generated during decommissioning can exceed, by 10 to 200 times, the volume generated during the operational life cycle of nuclear plants. Worldwide, nuclear power facilities annually generate about 10,000 m^3 of HLW, including spent fuel designated as waste, and 200,000 m^3 of LILW, most of which is currently stocked in intermediate storage facilities.

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Credit: UN Photo/IAEA/Greg Webb

An important health issue, pointed out by Bylkin and others (2011), is that workers are at high risk of exposure to radiation as they dismantle equipment on the site. Decommissioning also involves handling other hazardous materials such as beryllium, mercury, lead, cyanide and asbestos.

Some unexpected incidents have occurred during decommissioning as reported by Oskolkov (2010), Shimada and others (2010). These include: releases of radioactive elements; fires and floods affecting storage sites; and build-up of living organisms in the Chernobyl cooling pond that can potentially spread radioactivity. Also, Laguardia (2006) and Ramana (2009) have noted that decommissioning costs in some cases have turned out to be significantly higher than first estimated.

Another issue is that an increasing number of trained nuclear professionals will be needed for decommissioning. A report by the American Physical Society Panel on Public Affairs in 2008 noted a possible shortage of workers in the US nuclear industry. Similar demands for new professionals have been identified in the European Union by the Sustainable Nuclear Energy Technology Platform (2010) and by Bock (2010) and others.

Options for action

While the decommissioning of nuclear reactors poses environmental and safety risks, there are many ways to reduce these risks. For example, more effort could be given to the long-term planning of decommissioning, including the provision of adequate funds to cover its costs. Funds for decommissioning could be raised from many sources, including customer fees, investors, or international donors.

International cooperation could help identify and plan for reprocessing facilities and storage sites that can handle the nuclear waste that is expected to be generated. It would also be helpful to involve a wide range of stakeholders, including members of the public, in the planning process for

decommissioning because this could help allay the public's concern about this activity.

Planners and policymakers could also consider developing international guidelines and regulations aimed specifically at ensuring safety during decommissioning activities.

One option for addressing the shortage in nuclear personnel, as discussed by Safief and others (2011), would be to establish public-private partnerships such as the European Nuclear Education Network (ENEN) which supports and funds the training of workers in the nuclear field.

Consequences of inaction/action in the next 10–20 years

Over the next few decades, the world will be confronted with a wave of nuclear power plants going out of service and requiring decommissioning. If no action is taken in advance, decommissioning may be held up because of the lack of facilities for storing or disposing of the vast quantity of nuclear wastes. It could be delayed for lack of funds or by the lack of trained professionals to carry out the decommissioning. And if decommissioning is delayed then perhaps many countries will be dotted with the defunct hulks of nuclear power plants, with each one circled by formidable security structures.

However, if action is taken now; we can proceed with decommissioning and minimize its risks. Society will develop adequate procedures and facilities for disposing of the expected nuclear wastes, and train a new cadre of professionals for the task. Investing in a planning effort now will help society cope later with the challenges of decommissioning.

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Appendix 1 Respondents to Electronic Questionnaire*

Abahussain Asma; Abdel Gelil Ibrahim; Abido Mohammad; Adams Byron; Adejumo Sifau; Adelekan Ibidun; Agbola Babatunde; Aguar Pilar; Aherne Julian; Akaegbobi Izuchukwu Mike; Akanji Bola; Akinsanmi Francis; Akroush Samia; AlAshkar Hiam; Alcafuz Ricardo; Al-Hussieni Ahmed; Ali Ahmed Hamza H.; Ali Lulwa; Aljenaid Sabah; Al-Karadsheh Esmat; Alkemade Rob; Al-Khateeb Mukdad; Allam Hossam; Al-Sheriadeh Mohanned; Al-Sibai Mahmoud; Al-Yamani Faiza; Al-Zaeim Mokhlesa; Amy Austin; Anyaeche Osita; ApSimon Helen; Arico Salvatore; Arslan Awadis; Aw-Hassan Aden; Awiti Alex; Awodoyin Rasheed Olufemi; Ayuba Haruna Kuje; Bai Xuemei; Bakare Adekunle; Baker Joe; Balasubramanian Vethaiya; Baron Jill; Basheer-Salimia Rezq; Bekunda Mateete; Bell Andrew; Benigni Romualdo; Berbara Ricardo; Biggs Reinette; Bleeker Albert; Bobrowsky Peter; Bonnes Mirilia Mirilia; Bourdeau Philippe; Branquinho Cristina; Bringezu Stefan; Britton Nicholas F; Bruce Campbell; Bustamante Mercedes; Caceres Daniel M; Caldeira Ken; Calvo Alvarado Julio; Canziani Pablo; Castellanos Edwin; Christodoulou Symeon; Clothier Brent; Clout Mick; Confalonieri Ulisses; Cory-Slechta Deborah; Costanza Robert; Coutinho Heitor; Couvet Denis; Covich Alan; Cunha Alan; Dagenais Danielle; Dale Virginia; Davidson Eric; Davis Donnell; Dawidowski Laura; Décamps Henri; Di Bella Carlos; Diaz Sandra; Diji Chukwuemeka; Douglas Ian; Du Enzai; Duraiappah Anantha; Elbadawy Omar; Elias Pavol; ElMahgary Yehia; El-Sadek Alaa; El-Sammak Amr; Erisman Jan Willem; Escobar Elva; Farajalla Nadim; Fatlawi Saleh M. Bader; Fedorsky Catherine; Filmer Paul; Finegan Bryan; Fleming Richard; Flitner Michael; Fraga Vânia; Frame Bob; Frossard Emmanuel; Gallardo Laura; Galloway James; Galy-Lacaux Corinne; Gamble Morag; Garfin Gregg; Gbadegesin Adeniyi; Ghaddar Nesreen; Giller Ken; Glaser Marion; Gochfeld Michael; Goldstein Bernard; Greenwood Hamilton; Gupta Joyeeta; Haas Peter; Hadjizadeh Zaker Nasser; Haeberli Wilfried; Hamel Chantal; Hammond Geoffrey; Hardman-Mountford Nicholas; Hassan Ahmed Farghally; Hayhoe Katharine; Hein Lars; Herat Sunil; Herdies Dirceu; Hickman Jonathan; Hicks Kevin; Holland Elisabeth; Howarth Robert; Hu Jianying; Hung Tsu-Chang; Hungspreugs Manuwadi; Hunter-Cevera Jennie; Ibrahim Amir; Iglesias Ana; Ignaciuk Ada; Ingram John; Isiugo-Abanihe Uche; Ittekkot Venugopalan; Janetos Anthony; Jashari Bardhyl; Jesinghaus Jochen; Johansson Matti; Johnes Penny; Joly Carlos; Kabat Pavel; Kanie Norichika; Karanja Nancy; Keen Steve; Keith David; Kempe Stephan; Kentarchos Anastasios; Kershaw Peter; Khalil Anwar; Khalil Ahmed; Khan Amin; Khater Ahmed Rashad; Khater Carla; Khosla Ashok; Khraisheh Majeda; King Peter; Kislov Alexander; Kouyoumjian Hratch; Kremer Hartwig; Krusche Alex; Lateef Agbaje; Lavell Allan; Le Quere Corinne; Lerdau Manuel; Letson David; Li Jinhui; Linden Paul; Liverman Diana; Lloyd Bruce; Lovejoy Thomas; Lu Yonglong; Ma Zhong; Maas Rob; MacCracken Michael; Mace Georgina; Maher Mary; Malkawi Mazen; Manalang Anna Bella; Martinez Rodney; Martinez-Alier Joan; Maynard Simone; McNally Derek; Mezher Toufic; Mkwambisi David; Mol Arthur; Möller Detlev; Montana Elma; Montanari Armando; Moyib Folake; Mugendi Njiru Daniel; Naser Tarek; Nasir Muhammad; Neronov Valery; Nimah Musa; Noellemeyer Elke; Noone Kevin; Nousala Susu; Obot Emmanuel; Ofori Daniel; Oguntunde Philip; Ohlemuller Ralf; Ojedokun Oluyinka; Ojima Dennis; O'Keefe Sarah; Olayinka Abel; Ologunorisa Temi; Olokesusi Femi; Olubode Oluseun; Omar Asem Samira; Ometto Jean Pierre; Oni Feyisetan; Opdam Paul; Osman-Elasha Balgis; Oyekale Abayomi; Panario Daniel; Pfeffer W. Tad; Philippart Catharina; Pierrot-Bults Annelies; Pillar Valério; Pla Laura; Podesta Guillermo; Popoola Labode; Prasad Gisela; Prieto-Gonzalez Ricardo; Qadir Manzoor; Raji Muhabat; Rania Masri; Raupach Michael; Rehman Faiz Ur; Reid Walter; Rice Martin; Richardson David; Richardson Katherine; Richey Jeffrey; Rickerby David; Risser Paul; Ritz Christoph; Rojas Maisa; Romero Lankao Patricia; Rosswall Thomas; Roy Joyashree; Rufino Mariana; Rusek Josef; Saber Mohamed; Saidam Muhammad; Sakellariadou Fani; Sala Osvaldo; Salcedo Ignacio; Salimon Cleber; Sampaio Cristina; Samseth Jon; Sarigiannis Dimosthenis; Savage Nora; Schandl Heinz; Scholes Robert; Schurr Ulrich; Seimon Anton; Sims Ralph; Smichowski Patricia; Smith Kirk; Spehn Eva; Stafford Smith Mark; Stephens Carolyn; Su Jilan; Su Huey-Jen; Tawfik Ahmed; Thonicke Kirsten; Thorman Rob; Tiessen Holm; Tong-Bin Chen; Travasso Maria Isabel; Truffer Bernhard; Turner II Billie L.; Urban Ed; Valentini Riccardo; van der Leun Jan C.; van Ierland Ekko; Varady Robert; Vasconcellos Pérola; Vindimian Eric; Vineis Paolo; Virji Hassan; Visoottiviseth Pornsawan; Vuille Mathias; Wang Jinnan; Wardam Batir; Welford Rod; Whyte Anne; Winkler Harald; Xepapadeas Anastsios; Yagi Kazuyuki; Yazdandoost Farhad; Young Bruce; Yu Gang; Zamora Regino; Zermoglio Maria Fernanda; Zhang Shiqiu; Zubari Waleed; Zurek Monika.

*These are the respondents who explicitly gave permission to include their names. A total of 428 scientists responded to the questionnaire.

Appendix 2 Description of the Foresight Process

The Foresight Process was organized by UNEP's Chief Scientist's Office and the Division of Early Warning and Assessment. The process consists of a set of alternating 'open' and 'closed' steps. The 'open' steps open up the process to a wide range of views, while the 'closed' steps allow for an in-depth debate and selection of priority issues.

At the core of the process is a Foresight Panel consisting of 22 distinguished members of the scientific community recruited from developing and industrialized countries and internationally recognized because of their expertise in one or more environmental and related issues (see Acknowledgements). The Panel covers a wide spectrum of research disciplines from environmental governance to marine sciences. 5 Panel members are from Africa, 6 from Asia and the Pacific Region, 3 from Latin America, 5 from Europe, and 3 from North America. 14 work mostly in the natural sciences and 8 in economics or the social sciences. 15 are men and 7 women.

The entire process, which took eight months (1 December 2010 – 31 July 2011), was divided into six phases as described below:

1. Canvass of UNEP Community

The Process began with a canvass of the UNEP community to solicit their opinions about important emerging issues. The canvass was carried out by the Science Focal Points of UNEP who are located in each of its divisions. The elicitation of views resulted in a list of 68 issues which were described in a background report sent to Foresight Panel members before their first meeting.

2. Preparation of Preliminary List of Issues

Before the first panel meeting, Panel Members took the list of 68 issues from the UNEP community and added their own ideas, which resulted in a preliminary list of 95 issues. The Panel then scored the issues and the scores were used to rank the 95 issues. This ranked list was a main input to the first Panel meeting.

3. First Foresight Panel Meeting: Selecting a provisional list of issues

This phase involved a structured debate and prioritization of the preliminary list of 95 issues by the Panel at a three day meeting.

The Panel met in 3 sessions, each with a set of breakout groups and plenary sessions. At these sessions they systematically debated proposed issues.

In the first breakout group and plenary, the 30 top ranked issues were discussed. The second breakout group and plenary discussed the 30 middle ranked issues. In the third breakout group and plenary, the Panel discussed not only the bottom ranked issues, but they also reconsidered the issues dropped in the previous two sessions. More weight in the selection process was given to the higher ranked issues. This procedure resulted in a provisional list of 27 issues.

To select the 'final' provisional list of issues from the meeting, each Panel Member was allowed to select eight issues to be dropped from the list of 27. The six issues with the highest number of votes for dropping were eliminated, and that yielded a 'final' provisional list of 21 priority issues.

Panel Members then drafted a short description of the final 21 issues. This served as the main input to the next phase of the process.

4. Electronic Consultation.

An electronic consultation was organized in order to obtain input from a wide sampling of scientists worldwide. An electronic questionnaire was prepared with a list and descriptions of the 21 priority issues from the first Panel meeting. This questionnaire was sent to 933 scientists around the world who were asked to score the issues according to their importance (i.e., 1 = not so important, up to 10 = very important, in single digit increments). They were also requested to provide comments on the issues, suggest additional issues, and suggest issues that should be dropped.

The distribution list was prepared by the Scientific Committee on Problems of the Environment (SCOPE) with the help of UNEP and was compiled to have a balanced representation of world regions *(the UNEP regions are Africa, Europe, Asia and the Pacific, Latin America and the Caribbean, North America, and West Asia)*, expertise *(natural sciences, economics, and social science)* and gender. The response rate was considered excellent (428 responses, giving a nearly 1 in 2 response ratio). The regional distribution of responses was also thought to be very good (Africa 17%, Asia/Pacific 16%, Europe 27%, Latin America 13%, North America 18%, West Asia 10%). The disciplinary and gender balance of responses reflected current realities in the scientific community (natural science 76%, social science and economics 24%; male 73%, female 27%).

Data from the electronic consultation were analyzed by computing the average score and weighted scores based on region, expertise, and gender. These scores were used to rank the issues. The issues were grouped into three categories: Top 7, Middle 7 and Bottom 7. The results served as the main input for the second Foresight Panel meeting. Figures 1a, 1b and 1c depict the response data for the electronic consultation.

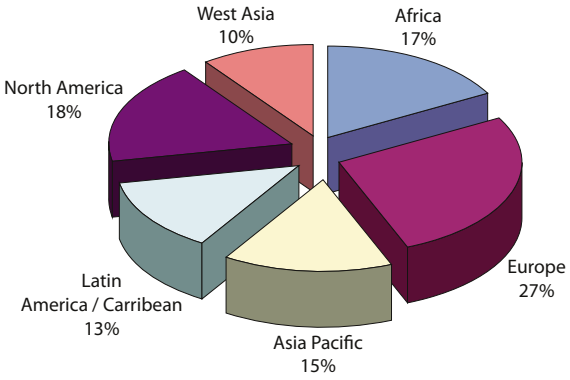

Fig. 1a: Regional breakdown of respondents to electronic questionnaire

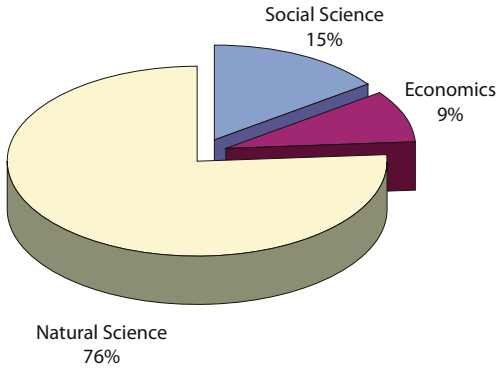

Fig. 1b: Area of expertise of respondents to electronic questionnaire

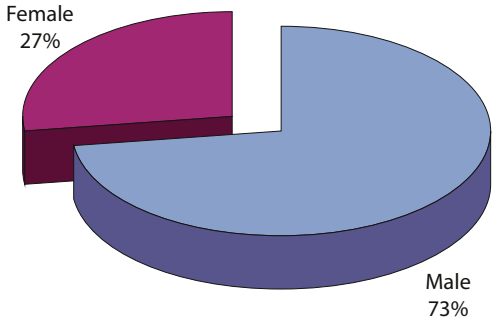

Fig. 1c: Gender of respondents to electronic questionnaire

5. Second Foresight Panel Meeting: Selecting the Final 21 Issues and Prioritizing the Top 10 Issues.

In this phase, the Panel revised the provisional list of 21 issues, based on results of the electronic consultation, including the ranking of issues, comments on issues, and suggestions of new issues.

The main objective of this final phase was to produce a final list of 21 emerging environmental issues and to determine the Top 10 issues among the list of 21.

In breakout groups and in plenary sessions, the Panel considered the new issues suggested by the electronic consultation. 125 new suggestions were considered. Most of the issues were judged to be close to the provisional 21 issues, or were noted to have been dropped during the first Foresight Panel meeting. As a result of this discussion, two new issues were added to the list of 21 making a new provisional list of 23.

In a sequence of breakout groups and plenary sessions, the Panel discussed whether to change the ranking of the 23 issues which stemmed from the electronic consultation. The issues fell into one of three groupings according to their ranking from the electronic consultation – top, middle, and bottom. The Panel discussed the ranking and decided to move some issues from one grouping to another. Also, as a result of the discussion, some issues were merged so that a final list of 21 issues was produced. Another output of this discussion was that all issues were assigned into three final groupings: a group of top 10 issues, middle 5 issues, and bottom 6 issues. These final groupings were relatively close to the groupings arising from the electronic consultation.

After the meeting, the Panel scored each of the issues within the 3 groupings and thus produced a final ranking of 21 issues. This procedure ensured that all the issues remained in the same final grouping determined at the meeting, and also ensured a high level of consistency with the ranking from the electronic consultation.

6. Final Documentation.

Preliminary descriptions of the issues with references were then prepared by the Panel and staff.

Postscript: Comments on the Process

After the process was completed, many Panel Members commented that the rigorous discussion and reconsideration of issues several times over the course of 2 three-day meetings, was an important factor in producing an effective list of 21 issues. The amount of time devoted to open debate eventually allowed a wide range of views to be expressed and considered, and encouraged the creativity of the participants. 'Opening up' the process by canvassing the UNEP community and then conducting an extensive electronic consultation of the worldwide scientific community enhanced the legitimacy of the process.

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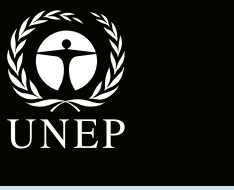

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