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Ecosystem under Pressure

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The Commission is an international commission initiated and financed by the Swedish Government. The purpose of the Commission is to propose ways to integrate risk reduction and adaptation to climate change into the development and poverty reduction plans of poor countries. It is also to present proposals for how to design development cooperation programs that take account of climate impacts and the risk of disasters. The Commission will issue its report in spring 2009. The commissioners serve in their personal capacity. The Commission is supported by a Secretariat based in Stockholm, Sweden.

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ECOSYSTEMS UNDER PRESSURE

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ECOSYSTEM SERVICES SAVE LIVES AND SUPPORT LIVELIHOODS

Ecosystems are fundamental for human well-being and provide crucial services and options for communities to buffer the impacts of environmental disturbances, extreme events and change. For example, storm surges and extreme waves can generally be moderated (though not entirely prevented) by healthy coastal ecosystems, such as salt marshes, coral reefs and mangrove forests. Wetlands provide a number of important ecosystem services, and have the ability to buffer droughts and floods. Coral reefs underpin local shore protection, fisheries and tourism, and are a vital source of food and income in many regions of the developing world.

Ecosystem services are environmental functions that benefit humans through water and air purification, flood and erosion control, generation of fertile soils, detoxification of wastes, regulation of climate, and pollination. They also provide aesthetic and cultural benefits. The contributions of ecosystem services to national economies are substantial, yet are generally ignored or underestimated by decision-makers. The costs associated with loss of ecosystem services tend to be considerable. The cost of the Newfoundland cod-fisheries collapse has been estimated at USD 2 billion and tens of thousands of jobs.

Ecosystem change and human well-being

The changes that have been made to ecosystems have contributed to substantial net gains in human well-being and economic development, but these gains have been achieved at growing costs in the form of the degradation of many ecosystem services, increased risks of non-linear changes, and the exacerbation of poverty for some groups of people. These problems, unless addressed, will substantially diminish the benefits that future generations obtain from ecosystems.

What is resilience?

Resilience is the capacity of a system, such as an ecosystem, to cope with disturbances (like floods, fire and pollution) without shifting into a qualitatively different state. A resilient system has the capacity to withstand shocks and surprises and, if damaged, to rebuild itself. Resilience depends not only on ecological factors such as biodiversity, but also social factors, such as diversity in institutions and knowledge; learning from disturbance and change; social capital and social memory; ecological knowledge; and adaptive multi-level governance structures.

LOSS OF RESILIENCE INCREASES HUMAN VULNERABILITY TO CLIMATE CHANGE

An unprecedented combination of climate change and associated disturbances (e.g. flooding, drought, wildfire, insects, and ocean acidification) and other global-change drivers (such as land-use change and pollution) will reduce the resilience of many ecosystems during the course of this century. Human impacts have over the past few hundred years increased species extinction by as much as 1000 times the typical background rate over the planet's history. This is alarming as biodiversity plays a crucial role in sustaining the capacity of ecosystems to cope with disturbance and change: biodiversity allows species to replace or compensate for one another in times of disturbance and insures against loss of ecosystem functions.

Widespread environmental degradation and climate change, as well as population growth, rapid urbanisation and globalisation, are also key drivers of human vulnerability to natural disasters. For example, changes in land use have enabled humans to appropriate an increasing share of the planet's resources, but they also potentially undermine the capacity of ecosystems to sustain food production,

maintain freshwater and forest resources, regulate climate and air quality and ameliorate infectious diseases.

The clearance of forested land and its subsequent use for crop production and cattle is a case in point. Clearance releases carbon stored in the trees and soil and depletes the forest's potential as a CO₂ sink. Fragmented forests are also more prone than intact forests to periodic damage from climate variability and change (e.g. droughts). In addition, deforestation reduces plant evapotranspiration, which can potentially constrain regional rainfall thereby increasing the vulnerability of forests to fire.

Ecosystem change could have global consequences. Vast areas of peat and tundra are reservoirs of stored organic carbon and methane. Global warming and land-use change brings a risk of unexpected and sudden increases in the atmospheric levels of CO₂ as these areas are transformed from being sinks of carbon to sources of greenhouse gases. This could create a "runaway climate change" effect. The Amazon Basin also has important functions in the global climate system. Research suggests that deforesting the Basin will change atmospheric circulation patterns in the Western Hemisphere and rainfall patterns in both Central Africa and Southeast Asia.

POOR AND MARGINALISED PEOPLE ARE THE MOST VULNERABLE

Regions facing the greatest challenges in achieving the Millennium Development Goals (MDGs) also face the greatest risks related to abrupt and irreversible loss of ecosystem services and impacts of climate change. More than 90% of the people exposed to disasters live in the developing world and more than half of disaster deaths occur in countries with a low Human Development Index.

Within communities affected by hazards, certain individuals and social groups are considered to be more vulnerable than others. These tend to be women, children, the elderly, ethnic and religious minorities, single-parent households, people engaged in marginal livelihoods, and socially excluded groups such as 'illegal' settlers and others whose rights and claims to resources are not officially recognised. Many poor and marginalised people, such as farm labourers and fishermen, are directly dependent on ecosystem services for their livelihoods,

Expect the unexpected: catastrophic shifts

Human and environmental systems do not respond to change in a smooth fashion. "Tipping points" occur when the cumulative effects of both slow and fast environmental changes and disturbances reach thresholds that result in dramatic and often rapid negative changes in ecological systems. Small events such as droughts, floods, or pest outbreaks, might trigger ecological changes which are difficult or even impossible to reverse. This phenomenon has been observed in ecosystems such as coral reefs, freshwater resources, coastal seas, forest systems, and savannah and grasslands. Accumulated stresses may lead to catastrophic shifts, such as loss of coral reefs and their ecosystem services. Fast-onset surprises, such as invasive species and emerging infectious disease, are likely to become more common. Institutions ranging from global to local are poorly prepared to deal with these sorts of abrupt and cascading environmental, technical and social changes.

Predicting future catastrophic shifts in social-ecological systems is impossible. However, efforts to identify "early warning signals" of approaching critical ecological thresholds and sudden losses of ecosystem services are being explored. Early warning systems are an essential strategy for preparing for the impacts of climate change on vital ecosystems, their associated services, and important livelihoods.

and are therefore particularly vulnerable to changes in environmental conditions and factors which may limit their access to resources. If the vulnerability of ecosystems to the impacts of climate change is not reduced, poverty is likely to increase and the likelihood of achieving the MDGs will diminish.

ENVIRONMENTAL CHANGE INCREASES THE RISK OF HUMANITARIAN CRISES

Climate-related stressors combined with ecosystem change is likely to become an increasingly common causal factor in population movements. People may be forced to migrate because of sea-level rise, or because national governments plan to relocate communities because of increasing risks or to expand development infrastructure. Displaced people may lack the specific local knowledge that is needed for adaptive management of resources. A range of maladaptive activities can drive desperate migrants to place further stresses on ecosystems (e.g. defor-

estation and over-exploitation of water resources, which can affect potable water and degrade soil), which could result in a number of secondary environmental crises.

Estimates of the number of environmentally displaced people in the coming decades range from 24 million to almost 700 million. The social and economic costs of this uprooting, accounting for both losses and responses, have not been calculated. It is estimated that drought, desertification and other forms of water scarcity will affect as much as one-third of the world's population and could contribute to people leaving affected areas to secure their livelihoods. Current projections of temperature and sea-level rises and increased intensity of droughts and storms suggest that population displacement on a large scale will take place within the next 30–50 years, particularly for populations in coastal

Vulnerability complexes

The emergence and re-combination of stresses at different temporal, economic, social and institutional scales cause 'vulnerability complexes', which are the result of interaction between ecosystem change and human activity. Vulnerability complexes threaten human welfare and security in a range of ways. For example:

- In the Lesotho highlands overgrazing and loss of wetlands, climate change, and human displacement are interacting to create feedbacks pushing the human-environment system toward increased vulnerability.
- Loss of forest cover, construction of water systems, urbanization and demographic change can intersect with climate change to spawn zoonotic pathogens, which are a significant cause of emerging and re-emerging infectious diseases, such as severe acute respiratory syndrome (SARS) and the West Nile virus.
- Sea-level rise or rapid-onset floods as a result of climate change can drive migration, and combined with droughts or abrupt ecosystem change may force people to over-exploit natural resources.

Many of the people and places affected adversely by vulnerability complexes are ill-equipped to cope with further loss of ecosystem services. Policymakers need to address not only known risks, but also fast-evolving vulnerability complexes.

Ecosystems and forced migration

"As the effects of climate change join and exacerbate the conflicts, natural disasters and development projects that drive displacement, we fear that an emerging migration crisis will spiral out of control. Unless urgent action is taken, it threatens to dwarf even that faced by the war ravaged world all those decades ago.... We believe forced migration is the most urgent threat facing poor people in developing countries. The time for action is now."

Human Tide: The Real Migration Crisis, Christian Aid, May 2007

zones. Although constituting only 2% of the total land surface of the earth, these regions host 10% of the current world population and 13% of the urban population. About 75% of all the people residing in low-lying areas are in Asia, and the most vulnerable are the poor. One of the world's poorest countries, Bangladesh, may lose up to a quarter of its surface area due to rising sea levels. Large-scale migration is expected to result from this negative spiral.

It will be too late to respond to future crises if we wait to see the results of climate change in vulnerable regions. Climate-related migration will profoundly affect the global economy, international development resources, and national budgets.

ENTRY POINTS FOR CHANGE

Stabilising greenhouse gas concentrations is essential. To reduce the risk of new vulnerability complexes and tipping points of ecological and humanitarian crises, the rate and magnitude of climate change must be capped.

Yet the challenge for a climate policy agreement in Copenhagen in 2009 includes more than mitigation. The potential for abrupt negative changes in ecosystems and associated ecosystem services, their ability to trigger large-scale crises and human migration, and to cause rapid-onset shocks with serious economic and social repercussions, should be among the main priorities for the international climate-policy community. However, the combined impacts of climate change and global environmental change – such as land-use change and large-scale loss of biodiversity – are currently not being monitored in a systematic way.

Understanding of potential vulnerability complexes and win-win policy synergies (particularly between ecosystem management and climate adaptation and mitigation) should be developed to support both climate and development policy.

Human vulnerability to climate impacts can be ameliorated through economic, social and political means. Well-functioning ecosystems must be maintained and degraded services restored where practicable. Reducing emissions by avoided deforestation and degradation (REDD) is also an important policy, and would expand the coverage of carbon credits. Adaptation funding, which might reach USD 1 billion per year within current development planning horizons, should take on a wider agenda on baseline vulnerability, and acknowledge the need to build resilience as a way to buffer or steer away from abrupt ecosystem changes and loss of ecosystem services. Future climate change policy should support moni-

Adaptive capacity

Adaptive capacity is intimately connected to social and economic development but is unevenly distributed across and within societies. The capacity to adapt is dynamic and is influenced by natural and man-made capital assets, social networks and entitlements, human capital and institutions, governance, national income, health and technology. Even societies with high adaptive capacity remain vulnerable to climate change, variability and extremes.

toring of changes in climate conditions and other circumstances to preempt sudden catastrophic ecosystem shifts.

The alternative is a world unprepared for a range of fast-evolving and escalating ecological and humanitarian crises.

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Stockholm Resilience Centre advances transdisciplinary research for governance of social-ecological systems with a special emphasis on resilience – the ability to deal with change and continue to develop. The centre is a joint initiative between Stockholm University, Stockholm Environment Institute and the Beijer Institute of Ecological Economics at the Royal Swedish Academy of Sciences. The centre is funded by the Foundation for Strategic Environmental Research, Mistra.

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